Making Money:

Notes on Technology as Environment

by

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Existence precedes essence.

Jean-Paul Sartre (1905–1980)

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Abstract

This thesis focuses on the role of new technologies in current social transformations. It is centered around an exploratory case study of the attempted introduction of Mondex, a smartcard-based electronic cash system, in Canada between early 1997 and early 2001. The case study makes accessible the scope of social and technological transformations associated with the introduction of a new type of money. Methodologically, it is based on document analysis and interviews with key actors in Canada and the UK, as well as observation in the two communities where Mondex has been tested during this period.

The aim of the thesis is twofold. First to advance our conceptual tools for framing the interrelation between technological and social change and, second, to apply these tools to assess the social and political implications of Mondex electronic cash so far.

Drawing from Actor-Network Theory the concept of a *technological environment* is developed. A technology is understood not as a set of isolated artifacts, but as a process emerging from, and impacting on, an often very extensive set of interconnected social and technological actors. An environment is the specific configuration of all those actors that are necessary for a technology to gain and maintain a particular social functionality. The role of new technologies in social dynamics is to be found in the way they contribute

to changing the relationships among, and thus the characteristics of, those heterogeneous actors. This study shows how ANT can be used to map very large and distributed environments that include local and global actors. It also shows how the notion of the environment can support a critical analysis of a new technology by focussing on how actors initiate and adapt to change during the phase in which the new environment takes shape.

This approach enables us to understand better why Mondex failed to achieve its initial objective: to establish itself as an alternative to physical cash. More importantly, it facilitates going beyond a simplistic analysis of success or failure of a particular technological program and capturing the gradual process of environmental change to which such a major technological project contributes even if it does not stabilize in its first incarnation. Mondex, one of the most extensive smartcard projects ever undertaken by the financial industry, has already contributed to adapting banks and smartcards to one another to a degree that smartcards are now beginning to be widely used as a new delivery platform for variety of financial services, although not (yet?) for electronic cash. As far as electronic cash is concerned, Mondex has helped to push a number of actors, particularly regulators, to accept, or at least indicate likely acceptance of, new roles that could facilitate the future creation of an environment in which private, global currency schemes for electronic cash could indeed stabilize. Mondex, then, can be seen as a small but important step in the long-term stabilization of a comprehensive global financial system.

Table of contents

Table of Figures

1. Introduction

It is often argued that our societies are currently undergoing a phase of profound transformation connected in many of its aspects to the general but uneven spread of information technology. Such an assertion resonates well with our experience of the steady stream of new technological artifacts being incorporated into many facets of our daily life, as well as the new practices they engender.

This claim, however, introduces a host of vexing, controversial questions about the direction and quality of this transformation and the role new technologies play in its dynamics. This thesis takes the Canadian introduction of Mondex, a smartcard-based electronic cash system, as the focal point for an investigation of contemporary technology-centered social change. Mondex, under development in the UK since 1990, was first presented to the Canadian public in February 1997 as a limited field test in Guelph, ON. The aim was to establish an alternative to, and replacement of, physical cash. However, four years later, in 2001, this goal has clearly not been reached and if there is a future for electronic cash it will be as something other than a replacement of coins and bills.

Mondex, it seems, is a failed technology. This thesis rejects such a simplistic and misleading understanding of technological change framed as a dichotomy of success and failure. As an alternative, the thesis brings to the fore the multi-dimensional process of mutual adaptation between (new) technological artifacts and the social practices and institutions connected to them.

Money is an almost ideal object for an investigation into the relationship between the social and the technological because money is as overtly social as it is material. It is shaped as deeply by social as by technological dynamics. Money is a medium essentially empty of content, it has no meaning of its own and historically has taken on a wide variety of forms

(Davies 1994; Weatherford 1997). It is, like a thermometer or a scale, arbitrary and specific at the same time, which makes it a good indicator of change. Changes in the circulation of money are indicative of broader changes in the society through which it circulates, and also serve as a motor for further transformation. Mondex offers a rich case study as it represents, particularly in Canada but also globally, one of the most sustained and ambitious efforts to establish a new type of money.

However, before untangling the dynamics that have been constituting the fate of Mondex, it will be necessary to outline a theoretical framework which can guide us to focus on the interdependence of the social and the technological. Often our understanding of the relationship between social and technological change is based on a more or less explicit choice between technological and social determinism. Assuming that current social transformations are indeed connected to the spread of information technology, the question becomes too often: does technology spread actively by itself, following an inherent trajectory, or is technology a passive tool in the hands of dominant social actors? Posing the question as a dichotomy of this kind creates a theoretical dilemma that is entirely unnecessary. We do not have to take sides. Technology is, at its core, social and society is irreducibly material. Rather than trying to artificially separate what naturally belongs together, our analytical framework should focus on their interaction and mutual constitution.

For a similar purpose, Marshall McLuhan introduced the notion of the *environment* in his investigation of electronic media (McLuhan 1964; McLuhan & McLuhan 1988). For him, the environment of a technology comprises the totality of people and artifacts that either contribute to the existence of the technology or are dependent on this technology for their own existence. This idea is fruitful and, despite its age, still surprisingly innovative in at least three ways. First, it facilitates the conceptualization of technology not as isolated artifacts, but as growing out of a heterogeneous

setting that is necessary for its existence and constitutive of its characteristics. Second, this notion views this setting as comprising both humans and artifacts, thus shifting the focus on the interdependence of the two, rather than on their separation. Third, by conceptualizing technology as growing out of its own environment as well as impacting on it, this notion sidesteps the linearity of cause and effect that plagues the debate over technological determinism. Instead, the simultaneity of feedback effects brings interrelation and mutual adaptation to the center of attention. There is no longer a need to allocate *a priori* activity (cause) and passivity (effect) to either humans or artifacts.

This thesis rests on the premise that shifting our attention from technological artifact to technological environment will enable us to not only understand better the dynamics of the development of a new technology, but also bring into focus the broader social changes that are shaped by, and give shape to, the new technology. Thus, the main questions that this thesis addresses concern changes within the technological environment:

The first question focusses on the dynamics within the environment: What is the relationship between technological innovation and social change in the development of Mondex? The second question concerns aspects of the shape of the emerging environment: What are the political and social implications of the transformation associated with the development of new technologies of money? The third question concerns the relationship between the environment of electronic cash and the larger environment of electronic money: How do the transformations around Mondex relate to broader socio-technological change?

Change in an environment is, almost by definition, broad and inclusive. This is especially true for a technology like cash that touches so many aspects of our lives. Without a focus, the environment of money encompasses everything, and consequently, nothing. The perspective of this study is

shaped by two dimensions: by the course of development of the electronic cash itself and by my personal interest in social transformations. In the time span this study covers, 1997-2001, the activities around establishing electronic cash far outweighed those related to its use. Hence, this is a study of the attempted creation of a technology. This is not the same as to say that this study focusses on the social construction of the technology. Even though electronic cash was hardly ever actually used as a payment instrument, the study will show that it already had an impact on its own environment. Consequently, one argument of this study is that the construction and impact of a technology are not two distinct phases but occur at the same time.

My personal interest in social transformation concerns what one could broadly call the *civil sector*, that is the space of citizens, rather than of economic agents. Primarily political and social concerns motivate this study. Consequently, it does not address questions of how to manage technological change from a corporate perspective, even though business considerations play an important role in understanding the dynamics of electronic cash. I treat them only insofar as they are necessary to understand the overall socio-technological development, which is less detailed than, say, a business-case study would require.[1] Also, this study does not aim at improving the technology by better understanding how it might fit into existing socio-technological settings. Even though managers and business plans set some of the directions for the development, this study does not adopt their point of view and makes no direct recommendations. What this study does address are the environmental changes that their actions trigger, intended or unintended, and the way these feed back on the people and institutions of the Mondex environment, both at the center and at the periphery.

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[1] For business case studies of Mondex, see Ives & Earl (1997); Westland (1997)

By (re)introducing the concept of a technological environment, I hope to contribute to providing tools that help assess the ramifications of a new technology – the interconnected changes in the environment as a whole – a bit sooner, perhaps, even while this environment is still transforming, rather than after the fact, when all its elements are already in place.

This is a virtually unreachable goal. Søren Kierkegaard (1813-1855), arguing against what we might now call "totalizing grand narratives", warned that "life can only be understood backwards, but it must be lived forwards." His radical doubts regarding our ability to understand what we do as we do it must be taken seriously. There is no escape from surprise.

I hope that this study can help – through its framework and a case study that may set an example for other social studies of emerging technologies – to shift our analytical tools so that they can assess more fully and more quickly the unanticipated events as they occur. Developing a framework to capture the ramifications of socio-technological and demonstrating its usefulness in an analysis of the broader social implications of the Mondex case are the twin objectives of this studies.

The thesis is structured as follows. After this introduction comes Chapter 2, *Conceptual considerations*, which develops the theoretical framework for the study of technological environments. The main emphasis lies on presenting a vocabulary that can bring into focus the mutual constitution of the social and the technological and as well as the simultaneity of processes interlinked through feedback rather than through cause-effect chains. I will draw heavily from recent theories in the field of Science and Technology Studies (STS), in particular the Social Construction of Technology (SCOT) and Actor-Network Theory (ANT) as strategies to access technological environments.

Chapter 3, *Money: environmental approach and history*, comprises two sections. The first reviews different approaches to money developed in

sociology and, more cursorily, in anthropology and geography. This helps to locate an environmental conception of money within these fields. The second section of this chapter develops a historical perspective for the current transformations involving electronic cash by retelling some aspects of the history of money in the West. This is done through sketches of the four distinct environments that various artifacts of money have been a part of: commodity money, money on account, state credit money, and, finally, virtual money.

Chapter 4, *Technologies of electronic cash*, introduces, in non-technical terms, the technological basis of electronic cash. This section follows a conventional engineering-oriented model of describing a new technological system as a set of stable and unambiguous artifacts without any context.

Chapter 5, *Methodological considerations*, reviews the tools that can guide the generation of data and discusses the strategies used to conduct the case study. Observation, interviews and document analysis generated most of the data. Spokespeople, humans whose point-of-view is framed by a technological artifact, were asked to speak on behalf of non-human actors.

Chapter 6, *The emergence of the Mondex environment*, begins by considering the blind spots of the conventional, technology-centered way of describing electronic cash. It locates where the work of transforming one environment, cash, into another, electronic cash, takes place. The main part of this chapter is devoted to analyzing these transformations during the development of Mondex, the fate of the various actors involved and the ways they rubbed against each other. Rather than using chronology as the structuring principle, the case study traces through the environment several times, each time analyzing a different process of translation and the actors most affected by it.

Chapter 7 concludes this study by interpreting the environment mapped in the previous chapter. I will analyze why Mondex in its original conception failed, but also point out that in other regards the development of Mondex has been quite successful. After 10 years of development, smartcards are now much more firmly integrated into the financial industry as a delivery platform for services, although not (yet?) for electronic cash. I will further argue that the development of Mondex has contributed to changing some of the actors, particularly regulators, which now seem much more inclined to accept privately issued currencies that they were prior to the development of electronic cash. The thesis will conclude with some reflections on the role of technology in social change and of ANT as a way to access technological environments.

The study is characterized by a number of limitations that could give opportunity for further research. The development of electronic cash is far from finished. As it is becoming clear that the replacement of physical cash is not a viable strategy, new approaches, concentrating on networked computers and mobile carriers, are being explored. The research of this thesis could be extended to these new developments. On a conceptual level, the application of the vocabulary of ANT made the concept of technological environments workable for rich empirical research. However, lots remains to be done to further expand and render in detail this concept and to show its validity for a range of research questions.

Acknowledgments

Despite the fact that I am the thesis' sole author and bear the responsibility for its form and content, I did, of course, not w rite it in isolation. On the contrary, it has been positively influenced by a great number of people. My committee, particularly Andrew Clement, have given me the freedom and support I needed to go through a very open-en ded and reiterative research process. Their confidence was at times greater than mine. Mondex Canada has been a generous research partner. Particularly Joanne DeLaurentiis, the

CEO, has been very helpful, not only by agreeing to be interviewed herself, but also by encouraging her staff to do the same. In addition, she introduced me to staff at Mondex International and MAOSCO in London, UK. Without her endorsement, this thesis would lack the voice of the artifact and those closest to it. I also have to thank all my other interview partners without whom the case-study would lack one of its most appealing features: diversity. Following the actors, ANT's main strategic advice, is only possible if the actors consent to, and participate in, being followed. I have been very lucky in this regard.

This thesis also profited from a summer internship at Xerox PARC, made possible by Lucy Suchman. Discussions with her research group helped me to get a sense of the field of social studies of technology, even though some creative uncertainty still remains. My understanding of the philosophical aspects of ANT was advanced in discussions with Graham Harmon. The way he connected Heidegger and McLuhan, presented at a talk at the McLuhan Program, University of Toronto, and elaborated in many subsequent exchanges, advanced my understanding of ANT's ontology considerably.

This research could not have been conducted without the Internet. Many of the more specialized or regional information sources were exclusively accessible on-line. Two meta-resources were particularly important. First, the Electronic Frontier Canada's media-archive which collected articles from a variety of Canadian newspapers concerning Mondex. The stability of this archive was major help in dealing with the often ephemeral nature of on-line publications. Leo Van Hove, a part-time Assistant Professor of Economics at the Vrije Universiteit Brussel (Free University of Brussels), has been compiling what must be the most extensive resource site on electronic purses world wide. Without this site, and the personal email exchanges, the nagging doubt of any Internet researcher – to miss an important document – would more likely have been justified. If the case study can claim completeness, it is to a large extent due to this excellent resource and the

competent person who maintains it. Many others, too numerous to be listed here, have contributed to the research by answering my emails and providing me with information and clarification that would otherwise not have been available. Some of the most significant email exchanges are cited in the bibliography, section 8.2.

The final shape of the thesis has been greatly affected by Michael John Edwards, editor, poet and friend, who read the entire thesis in its various stages. His literary precision is responsible for preventing my natural tendency to mangle my writing, as well as the fact that English is not my first language, from interfering too much with the clarity of the argument.

I owe great thanks to Ana Viseu, who not only discussed the thesis with me, but contributed more than anyone else to making the time spent on it rich and rewarding.

2 Conceptual Considerations

So many new information-processing devices have become prominent in our environment in a remarkably short period of time that they have come to symbolize the social transformations they are a part of. This is not surprising. These new artifacts – from personal computers to bank machines, to cellular phones – seem to pop up over night, thus marking a distinct difference between a before and an after. I still remember receiving my first e-mail, in early 1994. Social transformations, on the other hand, tend to be slow, convoluted, long-term processes. However, these artifacts, while seemingly brand new and easy to grasp, have deep connections to the society in which they appear. Neither their appearance nor their fate are accidental, though the dynamics that shape them are often amorphous and difficult to understand.

In a phase of dynamic transition it is difficult to chart a course from the past into the future. This is not to say that the current development does not exhibit similarities to past developments, but contradictory trends abound and it is far from obvious which can usefully guide our analysis. While there seems to be little overarching *structure*, we can, however, observe many attempts at *structuring*: active processes to establish and maintain sets of reliable relationships in spite of contingency. Some of them are successful, others are not.

These attempts have certain things in common. Overall they are *heterogeneous*. They are undertaken in parallel by different social groups

involving resources of all kinds. There is only limited coordination among them. These attempted structurings are *local*, they can cover only limited regions within an open environment whose overall dynamics lie beyond their reach. They are *contested* because the different attempts to establish and/or maintain stable relationships do not aim necessarily at the same outcome. Rather, their attempted outcomes are often mutually exclusive or detrimental to each other. And they are intrinsically of *limited duration*: all that is done can eventually be undone, without ever returning to its previous state. As a consequence, social and technological development as a whole is *open-ended* and *unpredictable*, though not arbitrary or unintelligible.

Conceptually, such a situation poses two related problems. First, how can we avoid imposing established categories on a situation that is most characteristically marked by processes that establish new relationships among previously independent entities, perhaps even entirely new categories? Second, how can we take seriously those new devices which reside prominently in our experience of the present? How can we acknowledge their importance, often felt intuitively, without falling into the trap opened by this intuition? This trap is set by our common sense, which suggests that we isolate social and technological developments from one another and make sense of each independently, using a different vocabulary for each. Doing so implies a need to assign – implicitly or explicitly – agency to either of the two, thus forcing a choice between variants of technological or social determinism.

This trap, which frequently snares analysis, should be avoided. We can do so by changing the perspective, turning from technologies to technological environments. Perhaps the most sustained recent attempt to rephrase the problem of the relationship between the social and the technological constitutes the field of Science and Technology Studies (STS). Rather than looking at the interaction of subjects and objects across a gap that separates them like a net separates two tennis players, the focus has been turned in

such a way that it becomes visible how subjects and objects constitute one another and how categorical distinctions are made, rather than found. In the following, I review some of the strands of STS as strategies to explore technological environments. STS, as the name indicates, comprises two related areas of interest: science and technology. I will concentrate on the latter, only selectively referring to social studies of science if it helps to support my argument about role of technology in social dynamics. This chapter is, therefore, not a comprehensive review of the field, but a selective appropriation of some of its core ideas. Among the different strands that make up STS, the Social Construction of Technology (SCOT) and Actor-Network Theory offer the most interesting tools with which to explore and map technological environments.

First is an examination of how socio-technologies – settings consisting of social actors and technological artifacts – have come into perspective over the course of the last 30 years. Second is a review of SCOT, which proposes distinct concepts that work out the social shaping of technologies, thus bringing into perspective the connection between the object and its social environment. However, as I argue, SCOT has a number of shortcomings that are important to consider in order to better understand what is really at stake when we speak about technological environments. Actor-Network Theory, the third section of this chapter, introduces subtle but consequential conceptual changes without which environments remain difficult to explore. In the final section, I discuss some of ANT's limitations and propose ways not so much to overcome them, but to understand them and neutralize their influence.

2.1 Bringing socio-technologies into view

Socio-technologies have been at the center of attention of various approaches that make up Science and Technology Studies (STS), a discipline that sits uneasily in the broader movement of Social Constructivism (Pinch

1998).[2] A central tenet of this otherwise very heterogeneous endeavour is that social reality is contingent and must be explained by historical, social and material factors exclusively. No reference may be made to ahistorical factors (human nature, biology), to laws of history (class conflict, progress), or to laws of technological or scientific development (inherent trajectory, paradigm).

The starting point for what later became STS was the sociology of knowledge, first sketched by the German sociologist Karl Mannheim in the late 1920s and taken up in the Anglo-American context by Berger & Luckmann (1966). Their work is now seen as one of the starting points of Social Constructivism (Pinch 1998). Berger & Luckmann's focus was on the "analysis of the interrelations between institutional process and legitimating symbolic universes" (Berger & Luckmann 1966, p.170). However, in keeping with a certain reservation of Mannheim to follow through his own program,[3] they exempted some areas of human knowledge from social analysis, most importantly, "mathematics and at least parts of the natural sciences" (Berger & Luckmann 1966, p.8). The knowledge produced in these areas, they thought, had nothing to do with the society in which it was produced, but referred to a space that lay outside of the influence of social factors.

It was precisely for this category of knowledge that David Bloor (1976) and the "Edinburgh School" formulated a *strong programme* for the sociology of scientific knowledge (SSK). This program claimed that all human knowledge, including the content of scientific ideas, theories and experiments, was accessible to social analysis. Consequently, (scientific) knowledge was no

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[2] Latour (1999) has argued at great length that he is not a *social* constructivist. Latour, however, has not argued against constructivism, but against privileging the social in the construction.

[3] In order to avoid the trappings of a fully-fledged Marxist class analysis or the unfettered relativism which plagued later postmodernists, Mannheim "placed his major hope in what he called 'the 'socially unattached intelligensia', a sort of interstitial stratum which he believed to be relatively free of class interest." (Berger & Luckmann 1966, p.9)

longer understood as objective, thus asocial, truth but as a relational effect: "knowledge...is whatever people [collectively] take to be knowledge" (Bloor 1976, p.5). This strong programme evolved along four interrelated principles for the analysis of the relationships that make up knowledge (ibid., p.7):

- *Causality*. The focus is on the causes, social and others, which bring about a certain belief or state of knowledge. A belief cannot be explained by its intrinsic qualities.
- *Impartiality*. Both side of the dichotomies of truth or falsity, rationality or irrationality, success or failure need explanation. Truth is not self-evident.
- *Symmetry*. The same methods are to be used to explain what is regarded as true or false beliefs.
- *Reflexivity*. The program must be applicable to its own discipline.

At the time, this *strong programme* marked a significant new direction of inquiry. It combined the sociology of knowledge and the sociology of science. While the former exempted science from its analysis, the latter ignored knowledge and limited itself to the analysis of the social institutions of science as well as scientific errors. Such errors, and only the errors, were understood as the effect of undue social influence.[4] What SSK brought into focus was the core of the scientific enterprise, the scientific fact. Applying the *strong programme* to the scientific fact meant that now all aspects of the scientific enterprise were understood as implicated in heterogeneous relationships. Scientific facts were not merely neutral reports of an objective truth that is 'out there' waiting to be discovered, but are something that has many dimensions, including social ones.[5]

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[4] In a textbook published at the height of the (Mertonian) sociology of science, the discipline's scope is described as analyzing science's "essentially social character, its socio-historical development, its pattern of organization, the social images of science, social influences on the process of discovery, and the social responsibility of science." (Barber & Hirsch 1962, p.1)

[5] The strong programme has been criticized for being too strong. Bloor is one of the few sociologists of science "who gladly accepts the epithet 'relativist'" (Hacking 1999). Many others stress the distinction between relativism and constructivism (see Latour 1999a).

Simultaneously, in a parallel but independent movement, historians of technology began to shift their attention away from the development of technological artifacts as a chain of improvements – progressing either linearly or through revolutions – and their subsequent social impact (Mumford 1935; Braudel 1967). Thomas Hughes, for example, developed the notion of a *technological system* in which social, political and economic factors shape the development of very large engineering projects and the associated technological artifacts (Hughes 1983). Hughes focussed mainly on economic and technological factors in his analysis of the development of the electrical power grid in Western societies. Central to Hughes' project was the understanding that technological innovation was shaped by economic as well as technical reasoning. Edison, for example, understood very well that he needed to create a market for his innovations in order to win the competition against the existing gas infrastructures which provided the main source of artificial lighting at the time. The two aspects – technological and economic potentials – Hughes argued, cannot be separated, must to be understood as mutually constitutive. John Law introduced the phrase "heterogeneous engineering" to denote the heterogeneous types of resources which have to coordinated in any act of innovation or discovery (Law 1992). The middle ground was beginning to come into view.

In the mid 1980s, the two movements began to influence one another directly and at their intersection the social study of technology emerged (Bijker, Hughes & Pinch 1987; Callon, Law & Rip 1986a; Mackenzie & Wajcman 1985). The overall goal of this approach was "the development of an empirically sensitive theoretical understanding of the process through which sociotechnologies are shaped and stabilized" (Bijker & Law 1992, p.13). The combination of theoretical sophistication and empirical richness has been characteristic of STS, setting it off from primarily theoretical inquiries, such as the philosophy of technology (Brey 1997), or from

conceptually simplistic accounts of the development of technology as a series of inventions and their subsequent impact (Toffler 1980; Gilder 1989).

One of the reasons for including empirically rich case studies in the theorization was a healthy suspicion against general models and linear theories, a trait inherited from critical theory and post-structuralism. Wiebe Bijker, for example, stressed the "contingent character" (Bijker 1994, p.12) of scientific and technological development: there are no inherent trajectories or structuring paradigms.[6] The purpose of his *The Social Construction of Fluorescent Lighting, or How an Artifact Was Invented in Its Diffusion Stage* was to demonstrate that an orderly linear model of technology development – basic research precedes applied research, technological development leads to the development of a product which is then manufactured, diffused and eventually put to use by the end user – does not hold up under empirical scrutiny (Bijker 1992; 1994).

The return to the micro-studies of the 1970s which rejected the possibility of integrative theory-making altogether, however, was also not an option. Being equally dissatisfied with macro- as well as with micro-studies, Bijker & Law saw the fundamental problem as:

> We are involved, here, in what amounts to a trade-off – a trade-off between following the messy story wherever it leads us on the one hand, and trying to extract, develop or impose more general models of the course, that is if any description is a simplification – something we all have to come to terms with when we start to write – then a relatively well structured model represents a further echelon of simplification. (Bijker & Law 1992, p.7)

On the one hand, a detailed description of an empirical situation with its unique historical, social and technological dimensions offers a great sense of realism and proximity to the setting of study. However, the value of such a

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[6] Of course, the rise and fall of techno-scientific paradigms can be observed, but "even if we can identify a paradigm, this does not mean that we have thereby identified what it is that drives the way in which it is articulated" (Bijker & Law 1992, p.8).

detailed account is difficult to determine, since the setting that can be analyzed in such a manner is necessarily very limited. Furthermore, extrapolating from the conclusions reached in a micro-study is problematic. Its comparability to other settings, with equally unique historical, social and technological dimensions, often remains unclear. On the other hand, big integrative models offer a great deal of elegance and explanatory value, but they run into the danger of being so simplified that they obscure more than they reveal. By focusing on very broad and general features of complex situations they tend to reify what they seek to explain. Structures become essences and the heterogeneous, contested processes disappear into the more or less well-oiled machine of some sort of functionalism.

To address this dilemma it is not sufficient simply to integrate empirical vignettes into a larger theoretical construct to illustrate this or that point, since examples can be found for anything and this still does not address the link between theory and empirical material. The problem is made worse in settings that are new, unstable and open-ended in their development, since established theories are not at hand and case studies float around even more isolated when their settings change quickly. This, however, is precisely the problem we encounter when studying contemporary socio-technological controversies: the categories change, the territory moves and the analytical criteria are as fluid and dynamic as the field to which they are applied.

One of the common goals of various approaches within STS has been to try not to impose *a priori* hierarchical order on this material. A hierarchy – in which one set of elements is found to be more important than other sets – can, at best, be developed as a conclusion of the study, rather than assumed at its outset. Structure – relatively stable relationships among entities – is to be understood as one of the possible outcomes of ultimately contingent processes of structuring and it must be analyzed through accounting for the heterogeneous activities that make up this process. This sensitivity to the processes that make up categories and distinctions, the focus on

relationships that are in the open-ended and contingent process of stabilizing, rather than those that have already stabilized, is what makes STS approaches so well suited for an analysis innovative technological systems, such as electronic cash.

2.2 The Social Construction of Technology

Wiebe Bijker, SCOT's foremost theorist, frames the problem as "we must figure out a way to take the common evolution of society and technology as our unit of analysis" (Bijker 1994, p.10). Questions that arise out of such a perspective are "How do artifacts become instruments of power? And, conversely, how do power relations materialize in artifacts?" (ibid., p.4).[7]

The central requirement for addressing these questions, Bijker argued, is *explanatory symmetry*, a principle directly inspired by Bloor's strong programme. Whereas Bloor called for impartiality in regard to a statement being true or false, Bijker extended this impartiality towards an artifact being a success or failure. Both are outcomes of contingent events which need to be explained as a social process. Furthermore, they are the outcome of the same activity – the same kind of engineering, production and marketing knowledge goes into a successful as into a failed technological artifact. This means also that the same kind of analytical strategy should be employed in each case. Qualities of an artifact are seen as emergent, rather than inherent phenomena. Thus, attributes such as "working", "easy-to-use" or "efficient" are the results, rather than the causes, of an artifact being pervasively used.

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[7] Trevor Pinch distinguished between a soft and a radical approach to the social construction of technology. Its soft form, he wrote, "is simply equated with science and technology having social components. The science and technology we get has in some sense been shaped by such social components, whether they be political interests, consumer groups, marketing, gender stereotypes or whatever." The radical version, on the other hand, "is concerned to show how social processes influence the very content of technology - what it means for a technology to be deemed as working, for example. [....This] view is opposed to any conception of technological determinism which posits technology developing under its own immanent logic" (Pinch 1998). Bijker and his colleagues advocate a radical approach.

The artifact itself has no or few inherent qualities, particularly none that are normative. In the words of Bijker:

> A central adage for this research is that one should never take the meaning of a technological artifact or technological system as residing in the technology itself. (Bijker 1994, p.6)

However, this does not mean that artifacts are neutral or value-free. Far from that. It means that their values are emergent from social dynamics that are analyzed with the help of four concepts: *relevant social group, technological frame, interpretative flexibility* and *closure.*

A social group consists of individuals and institutions which have the same strategic interest towards an artifact. A group becomes relevant when it can actually directly or indirectly influence the shaping of the artifact. Relevant social groups are the main source of the dynamic of development. They are "the carrier of that process" (ibid., p.48). Their individual interests and strategies need to be accounted for in order to understand the emergence of the final product. This end result rarely reflects solely the view of one single group. Rather, the final shape of the artifact is generally the not entirely anticipated result of the interrelations of all relevant groups.

In the case study of fluorescent light, Bijker (1992, pp.78-79) identified six social groups that were directly involved in shaping the new light bulb. The first group consisted of the dominant manufacturers, General Electric and Westinghouse, joined into a cartel which enjoyed a near monopoly in the light bulb business. The second group consisted of the electricity-producing utilities. They were closely aligned with the first group, since they promoted exclusively the products of the cartel. In return, the cartel promoted the use of electricity. The third group were the fixture manufactures. They produced the sockets, reflectors and other "peripherals". The fourth group was the only independent producer of light bulbs, who wanted to get into a new market. An important, although indirectly influential, group were consumers, and finally the US government – more precisely two groups within the

government: the Antitrust Division of the Department of Justice, which filed an antitrust suit in 1942, and the War Department, which wanted the trial to be delayed because they feared it could interfere with the war-time economy. All these different groups had different agenda which they sought to promote by putting forward a particular type of light bulb. The cartel wanted to create a new market for light bulbs, whereas the utilities wanted to sell more electricity and opposed, therefore, a super-efficient new bulb that the cartel had initially developed: under the utilities' pressure, the lamp was changed from the high-efficiency into the high-intensity lamp, the manufacturers of fixtures were provided with a set of standardized specifications and the independent producer was able to expand its market share. The cooperation among across industries was secured, just as the government wanted.

What constitutes a set of social actors as a single group is that they have a more or less consistent reading of the artifact: their common *technological frame*.

> Technological frames provide the goals, the ideas, and the tools needed for action. They guide thinking and interaction. A technological frame offers both the central problems and the related strategies for solving them. (Bijker 1994, p.191)

The technological frame is a flexible, emerging category. It is built, adapted and maintained by the members of a social group through internal coordination. As long as the actors share one technological frame, no matter how much this frame changes over time, the actors can be said to belong to a single social group.

> A technological frame structures the interactions among the actors of a relevant social group. Thus it is not an individual's characteristic, not a characteristic of systems of institutions; technological frames are located between the actors, not in or above actors. A technological frame is built when interaction 'around' an artifact begins. Existing practice does guide future practice, though without logical determination....A technological frame comprises all elements that influence the interactions within a relevant social group and lead to the attribution of meaning to

technical artifacts – and thus to constituting technology. (ibid., p.123)

The elements of this frame – the shared understanding of the problem and the solution – vary from case to case. It can comprise elements such as *goals* – what do we want to reach by influencing this technology?; *problem-solving strategies* – how can we reach the goal given the our understanding of the problem?; *requirements to be met by problem solutions* – what would a better technology look like?; *design methods and criteria* – how should the artifact be built?; *user's practice* – what are users going to be doing with it?; *exemplary artifacts* – what artifacts can be referred to as positive or negative examples? and *accountability*: who can influence the further development of the technology?

Even within the most homogenous group, differences can be found; they can be social, cultural or interpretative. However, as long as the actors of this group *act* according the strategy implicitly or explicitly proposed by their technological frame, it can be said that this frame is shared. In this sense, SCOT has a certain action bias not untypical for STS. It is not much concerned with an actor's interpretation of the reality. The central manifestation of a social group is action itself: what acts as one group is one group – until it falls apart, that is, different members begin to pursue conflicting goals, as evidenced by their non-cooperative actions.

The dynamic of socio-technological development arises from the action of social groups in pursuit of their goals through the development and employment of technological artifacts. However, the artifacts around which social groups are formed are as much motivation for action as they are constraints for it. Shaping and being shaped, action and structure are inseparably intertwined.

> The technological frame of a social group is shaped while an artifact, functioning as exemplar, further develops and stabilizes within that social group – the social impact side of the coin. The technological frame in turn also determines (albeit to different

degrees, depending on the degree of inclusion different actors have in that frame) the design process within that social group — the social shaping side of the coin. This forms the concept 'technological frame' as a hinge between the social impact and the social shaping perspectives on technology. (Bijker 1992, p.93)

The development of an artifact is shaped by the interaction of different social groups, whose actions are structured by their respective technological frames. Each group tries to enforce a different understanding of the problem and a different solution the artifact should bring. As long as the controversial process of development continues, several different readings can exist parallel to one another. The artifact, thus, still has an *interpretative flexibility*. Simply put, there is no agreement on what an artifact is or what it should become: is it efficient or a waste of time and money? Is it the next big thing or a pipe dream? Is it the solution or the problem? Nobody knows for certain, yet.

Interpretative flexibility means that an artifact has varying qualities for different groups because it addresses different problems. Each group proposes a different path for future development. However, it does not mean that different groups simply have different opinions about the artifact. The concept brings into focus the idea that different views shape the development of the artifact. This is a concept intended to explain changes in a technology.

The possibility of demonstrating the interpretive flexibility of an artifact by deconstruction implies that there is an immediate entrance point for a sociological explanation of the development of technical artifacts. If no interpretive flexibility could be demonstrated, all properties of an artifact could be argued to be immanent after all. Then there would be no social dimension to design. ....But demonstrating the interpretive flexibility of an artifact sets the agenda for a social analysis of the design of technology as formulated in the 'working as result' requirement for a framework. (Bijker 1994, p.76)

Interpretative flexibility, then, marks a phase in the development of an artifact in which different groups make different claims about its

characteristics (Bijker & Law 1992). As Bijker showed in his study of the development of bicycles, the fact that early bicycles, the ones with a high front wheel, were difficult and risky to ride, was seen as much a positive as a negative quality. For those who would now be called "early adopters", adventurous young men who wanted to demonstrate their bravado by riding a bike that required considerable skills and courage, it was an important feature that it could not be used by just anyone.

Interpretative flexibility exists as long as different social groups promote different artifacts. "Relevant social groups do not simply see different aspects of one artifact. The meanings given by different social groups actually *constitute* the artifact" (Bijker 1994, p.77). The essence of the artifact emerges out of the social interaction around the artifact.

The three concepts introduced so far – relevant social group, technological frame and interpretative flexibility – are deconstructive. They offer the tools needed to break open what appears as a closed self-evident artifact. They help to discern the factors that shape the development of an artifact and the agendas pursued in its design. These concepts help to trace the controversies and the different choices that are made at different points in time. However, deconstruction is only one side of the coin.

Everyday experience tells us that the world is populated by artifacts that exhibit a remarkable degree of stability. The basic design of a bicycle and our understanding of its characteristics have not changed substantially over the last 100 years.

The missing link between the artifact in its flexible phase, full of controversy and open paths of development, and the fixed, finished, off-the-shelf phase of the artifact is provided by the concept of *closure*. While there are no inherent trajectories in technologies, their flexibility itself is usually limited.

Put simply, controversies do not last forever. The flexibility tends to diminish over time, as the artifact becomes more and more developed.

> Closure, in the analysis of technology, means that the interpretive flexibility diminishes. Consensus among the different relevant social groups about the dominant meaning of an artifact merges and the 'pluralism of artifacts' decreases. (Bijker 1994, p.86)

If this is not the case, then the artifact disappears again. Controversies that cannot be settled become settled because the actors leave the impasse and turn to something else. Law & Callon (1992) detailed the failure of the development of a British fighter jet. The interpretative flexibility of the object increased to a point where the project had to be abandoned because there was no consensus possible about how to proceed.

Consensus might be a problematic term because the process of ending a socio-technological controversy is likely to contain acts of dominance as well as acts of mutual agreement. The process of closure, when the shape and meaning of the artifacts is stabilizing, is often the most contested one.

Bijker wrote that "typically a closure process results in one relevant social group's meaning becoming dominant" (Bijker 1994, p.283). However, it seems that this process of closure can vary from artifact to artifact, sometimes involving the dominance of one group, sometimes the convergence of several. More generally, closure is achieved by compromises among some of the relevant social groups in order to make them powerful enough to effectively marginalize the other social groups. Compromises, or more neutrally, mutual adaptation of groups and their technological frames contains inclusion and exclusion. By taking into consideration some groups and interests at the price of others, power relations materialize in an artifact. In this sense, the process of closure determines which of the various options becomes reality. Social power differentials are constituted and stabilized by embedding them into the artifact. It is through the ability to privilege one

technological frame and render others obsolete that social power manifests itself.

There are a number of shortcomings to SCOT, such as the concentration on relevant groups. What happens to the non-relevant groups? Are they really not relevant only because they could not influence the shape of the artifact? Underlying this political shortcoming is a deeper and, for the present purposes, more relevant problem. Namely, the difficulty SCOT has following through its own principle of symmetry, to account for the social shaping as well as the social impact of technologies.

In the case studies, technological artifacts appear to be primarily mirroring social relationships. Artifacts embody these relationships. Their shape is a direct result of the struggle of different relevant social groups to embed their agenda into the artifacts. Once the artifacts are shaped, both the relationships and the agendas remain fixed in the artifact's materiality. The artifact, then, is understood as relatively passive, as a kind of receptacle of social shaping by powerful social actors. The difficulty of combining the social shaping and the social impact perspectives is pragmatically solved by differentiating the two temporally. In the design/production phase which, as Bijker (1994) has shown, can include all kinds of feedback loops, the artifact is shaped by social actors; in the phase of mass use, the artifact impacts on society.[8] Once the artifact is shaped, the way it is used, the activities into which it is inserted, hardly change the artifact or its meaning.

On a theoretical level the principle of symmetry has several dimensions. Not only in regard to working or non-working, but also "the conceptual framework should not make an *a priori* distinction among, for example, the social, the technical, the scientific, and the political" (Bijker 1994, p.13). For this, the notion of a *seamless web* has been developed. Seamless web

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[8] On this temporal differentiation between social construction and social impact, see Hughes (1994).

indicates that there are no clear-cut and rigid differentiations between entities, but that entities are mixed together in a way that interrelations constitute their differences.

> This resists the notion that the division between the social and the technical is either stable or matter-of-fact. To say this is not, of course, to deny that it is possible to point at, and distinguish between, machines and those who operate them. Rather it is suggested that this distinction should be seen as an accomplishment, rather than something that can be taken for granted. Accordingly it is argued that analysis should start with a seamless web of elements and look to see how that seamless web is broken up under different kinds of circumstances to create different *kinds* of objects. (Bijker & Law 1992, p.201)

Such a program is difficult to put into practice because it runs counter to a deep-seated sense of difference between humans and objects. Indeed, it seems inhuman to argue that the differences between the two are less important than their mutual constitution. Thus, it appears to be common sense to start with humans on one side and artifacts on the other and then see how they interact. And despite a different theoretical model – mutual constitution of the social and the technological – Bijker's case studies are characterized by a (temporally) relatively uneven distribution of constitutive power between the social and the technological. Powerful social groups shape the artifact, which then impacts on the less powerful groups.

A reason for this discrepancy between theory and case studies lies in the particular, counter-intuitive ontology that the seamless web argument needs to rest upon in order to be carried out. The notion that objects and subjects are fundamentally different and are to be treated separately is too deeply engrained in our vocabularies to easily replaces by a seamless web approach. SCOT has not sufficiently worked this out. However without paying special attention to ontological considerations regarding the relationship between humans and artifacts it is very difficult to put into practice a theory that can offer an alternative to the classic modern dichotomy of the subject and the object. This dichotomy underpins not only common sense, but also the

natural sciences (dealing only with objects) as well as the social sciences (dealing only with subjects, though they are sometimes objectified). SCOT, then, formulates an important program, but its conceptual tools that are not radical enough to fully support the shift from technological artifact to technological environments.

ANT, on the other hand, has put center stage the examination of the ontology that underpins its vocabulary for exploring socio-technologies.

2.3 Actor-Network Theory

Actor-Network Theory is a misnomer. It is not a theory. A theory is a systematic set of general principles with explanatory value within a certain subject matter. Darwinism, for example, is a theory in this sense. It proposes a general principle – survival of the fittest – to explain a particular subject matter – natural evolution. ANT, on the contrary, is quite specific about having neither general explanatory principles nor a precise subject matter. As Latour points out, "it is as much an ontology or a metaphysics, as a sociology" (Latour 1997). At the core of ANT lies a radical philosophical stance: Society, Latour claims, is "essentially, ontologically flat" (1996b, p.xi). This is a strong statement and deserves some unpacking. Ontology, the theory of being, is foundational to any attempt to think about the world.

> Any way of understanding the world, or some part of it, must make assumptions (which may be implicit or explicit) about what kinds of things do or can exist in that domain, and what might be their conditions of existence, relations of dependency and so on. Such an inventory of kinds of being and their relationships is an ontology. (Oxford Concise Dictionary of Sociology 1994)

Ontology, in this classic sense, is concerned with essential differences among entities and with grouping entities into categories according to these differences. Ontological differences are a priorical in nature. They are thought of as an unchangeable characteristic of existence itself, rather than a variable of existing in context. Ontological reasoning underpins the division of reality into categories for which different analytical strategies can be employed. In

short, things of different ontological categories are not compatible with one another since their very essence is different. Their difference precedes everything else.

Sociology, for example, has as its subject matter the institutions human beings create.[9] Thus we have a sociology of the family, of the organization, of religion, of ideas and knowledge, of power and so on. Social sciences have not as their subject matter the sociality of steel, the meaning of tables, or the characteristics of computer chips. Underlying such a definition of a subject matter is the assumption that there is an intrinsic, irreducible difference between subjects (human beings) and objects (a technological artifact or a scientific fact) and based on this difference, we do not need to understand one in order to understand the other. This particular ontology was established at the very outset of the modern scientific enterprise in the 17th century when the spheres of nature and science were defined as mutually exclusive (Latour 1993, pp.15-35). After three hundred years, what was once a highly contested political dispute (Shapin & Schaffer 1985) seems common sense, ingrained in our lay sensibilities as well as our scientific language and attuned to our everyday experience.

By stating that society is essentially flat Latour argues that there are no ontological differences at all. There are, to play with words, essentially no essences.[10] If all entities have the same essence, then essence becomes useless as a differentiating factor. In ANT, ontology is put up front to empty it out (Latour 1996d). ANT is an argument against essences. "What Sartre said of humans – that their existence precedes their essence – has to be said of all actants: of the air spring[11] as well of society, of matter as well as of

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[9] Institution is here understood broadly as any behavioral pattern of importance in the life of a community or society.

[10] This anti-essentialism is characteristic of most 20th century philosophy.

[11] The air spring refers to Schapin & Schaffer (1985) *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life.*

consciousness" (Latour 1993, p.86). This logic creates a certain paradox. Claiming that we must not have *a priori* assumptions about the ontology of entities is, of course, an a priorical assumption about their ontology. Namely, that ontological categories do not exist at all. This is the metaphysical aspect of ANT. It is, of course, an assumption about the essence of things to say that we should not make an assumption about their essence.

At first glance, ANT appears to have radicalized Bloor's principle of symmetry to the extreme. By denying the value of ontological differentiations, everything can and must be dealt with through a single framework. Bloor refuses an *a priori* differentiation between true and false beliefs, SCOT expands this to all characteristics of artifacts – working vs. non-working, success vs. failure, simple vs. complicated – and ANT expands it even further: most fundamentally, and controversially, to a symmetry between humans and non-humans.

This radicalization of Bloor's symmetry, however, is not a simple extension. If Bloor's principle is understood as the social turn in which truth and falsehood are made up of the same social material, then ANT is *One More Turn After the Social Turn...* (Latour 1992b). Indeed, Latour calls Bloor's principle of symmetry "completely asymmetric" (ibid.) because one thing – non-humans – is explained by the other – humans –, rather than both used to explain both. Latour extends symmetry to both Nature and Society, which he sees as equally made up of one another.[12]

But, if ANT is not a theory, why all this talk about ontology, a truly theoretical concern? ANT, at the end of the 20th century, builds on, or against, a long history of philosophy of science. Rather than making sweeping claims itself, ANT's argument is mostly oriented to drawing out and eliminating unaccounted assumptions about the nature of humans and

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[12] Latour, contrary to Bloor, refuses the label "relativist" because all his constructions contain also non-human components that are not reducible to (relativising) social factors.

nonhumans in our common sense. This is similar to meta-information that can be used to deal with information overload, effectively adding more information (filters) to get rid of unwanted information. ANT, then, can be understood as a theory filter – made up of theory. Theory against theory. Its aim is to filter out the conventional ontologies, replace them with its own ontology and thus construct an "empty methodological frame" (Latour 1997) which enables the analyst to trace connections between the seemingly heterogeneous elements that are enmeshed with one another composing environments.

> ANT places the burden of theory on the *recording* not on the specific shape that is recorded....Instead of constantly predicting how an actor should behave, and which associations are allowed a priori, ANT makes no assumption at all, and in order to remain uncommitted needs to set its instrument by insisting on infinite pliability and absolute freedom. In itself ANT is *not* a theory of action, no more than cartography is a theory on the shape of coasts lines and deep sea ridges; it just qualifies what the observer should suppose in order for the coast lines to be recorded in their fine fractal patterns. (Latour 1997)

ANT is an infralanguage used to dive below the apparent differences between Nature and Society, or Artifacts and Humans. It investigates heterogeneous activities that go on beneath the surface which produce these differences and, simultaneously, tie these entities to one another. ANT, then, does not advocate the return to a simple empiricism, because such a thing does not exist. The very categories of such a naïve approach, for example humans on one side, artifacts on another and facts on a third, are loaded with ontological assumptions that ANT wants to clear out (Latour 1999a). Fernand Dossé calls this *the principle of underdetermination* which stems from the "the concern...with avoiding a preconception of the actors, the controversies, and the most diverse configurations, as to follow them better" (Dossé 1999, p.97).

However, as the problems of putting to practice SCOT's concepts have shown, these preconceptions are built right into the standard vocabulary (of the sciences) and shape in subtle but pervasive ways the stories that can be

told with it. In order not to be pulled back to the surface of common sense by the modern ontology, ANT has developed a set of conceptual tools to create a recording device to follow the messy story of socio-technological relationships.

2.3.1 The vocabulary of ANT

The vocabulary of ANT is not rigidly defined, but in general characterized by deliberate shifts that make it possible to incorporate the underlying ontological program: from social actor to actor – or actant; from social relations to actor-network, from interaction to translation. These, as Callon & Latour explain, "are hybrid terms that blur the distinction between the really social and human-centered terms and the really natural and object-centered repertoires" (Callon & Latour 1992, p.347).

Actor

Actors are simply "entities that *do* things" (Latour 1992a, p.241). The concept of an actor does not imply any kind of characteristics of the entity, other than its ability to effect something, somewhere. An actor can be a human being – a hacker trying to break into a computer; or it can be a technological artifact – a computer running through routines of checking passwords; or natural objects – electrons squeezed through transistors on a computer chip.

The ability to be an actor is not intrinsic in the entity itself. An isolated entity cannot be an actor because it cannot act upon something. Acting – that which turns an entity into an actor – is a relational quality. The ability to act does not reside in the entity, but is located in the relationship between entities. An actor "can literally be anything provided it is granted to be the source of an action" (Latour 1997). An entity becomes an actor when other actors grant it a certain competence to do something.

Freely expanding on the famous study of the door-opener (Latour 1992a), this can be illustrated as follows. The competence to open a door can be granted to different actors, humans or non-humans. In the door which goes to my office at the University of Toronto, the competence to open the door is granted to humans (me and the people I share the office with). If one of us wants to enter the office, we have to open the door manually. This is simple enough since the door has a special handle to do this. This handle, though, is different on the inside than it is on the outside. It is constructed so that every person who is inside can get outside by simply turning it. On the outside, however, there is a lock built into the handle which restricts who can to open the door to those carrying a matching key. In short, a small set of human and non-human actors (handles, a lock and matching keys) are in place to modulate the flow of people through the door in ways that are congruent with our ideas of office culture, privacy, property, security, fire safety and so on.

However, if the user can be expected to have his/her hands full, or particular courtesy should be displayed, the competence to open the door can be taken away from the person wishing to pass through the door and granted to another human being: an employee standing at the entrance of a glamorous hotel, for example. This has the advantage that the door is always safely opened and closed afterwards (which I sometimes forget to do when leaving my office). However, it has the disadvantage that it takes considerably more resources to keep that position staffed by a human, rather than by a handle and a lock. If the problem of (not) closing the door has to be addressed, then another non-human actor, maybe one as simple as a spring and two nails, can be endowed with this competence.

If neither the competence to open nor to close the door can be granted to a human exclusively, then a somewhat more sophisticated actor needs to be put in place. A device combining electrical and mechanical elements which detects an approaching actor (a human being, a robot, or a dog), opens the

door and closes it after a predetermined time. Across the different settings, the action is always the same: opening and closing a door. But depending on the circumstances, the situation in which the door is implicated, the human and non-human resources available, the competence to open and close the door is granted to different actors: an all purpose human being – me (and my office key); a specialist – the colourfully uniformed employee of a hotel; a simple device – a spring; or a complex device – an automatic door opener consisting of electronic sensors, wiring, mechanical parts and a technician capable of repairing if as necessary.

The complex electro-mechanical device is an aggregated actor, or in ANT terminology, a *black box*. The term black box is borrowed from cybernetic theory. A black box is any setting that, no matter how complex it is or how contested its history has been, is now so stable and reliable that it can be treated as a fact of which only the input and output count (Latour 1987, p.3). A black box always acts as an single entity. Creating a black box is an achievement. Before it turned into a readily functioning black box, the automatic door opener was under development. Multiple different solutions were tested, relationships between the elements were fragile and, perhaps, even contested. But now that it is properly installed, the little mechanism hidden in the wall works reliably, opening and closing doors according to instructions. Contributing to its reliability is that fact that if it fails a technician is available to repair it. In general, the more an artifact seems autonomous, the more closely defined are its relationships to humans because "the more automatic and the blacker the box is, the more it has to be accompanied by people" (Latour 1987, p.137).

Anything that acts as an entity can be treated as an entity, as a single actor. Such aggregated actors can have any size, they can be a local door opening device or a multi-national corporation. An actor is always specific to a network and what is an aggregated actor in one network can be multiple competing actors in another network. If I want to understand the door

opener, I can safely treat the institution where it is installed as one single actor which, for example, issues a new safety policy according to which laboratory doors need to be equipped in a certain manner. However, if I want to understand the safety policy, I have to consider a different network, that which produces the policy. In this context, the corporation might turn into a set of competing actors such as management, finances, employees, pending law suits, new government regulations and many more. All these actors together influence what exactly the safety policy will be.

In short, what an actor "is" is determined by other actors, and their interrelation ties them into a network.

network

A network is simply a set of relationships. As the term actor does not imply any particular characteristics of the entity which is acting, so does the term network not imply any particular type of relationship among the entities which make it up. A network in the ANT sense, is *not* ordered or planned like a technical network, for example, the telephone network which is characterized by a purposeful design with a more or less centralized administration directing the plugging of cables from one machine to another. There are fundamental differences between a technical network and an actor-network. The former is designed by engineers, the latter is emergent from the interaction of heterogeneous actors. The former has a single overarching purpose, the later has, potentially, as many purposes as there are actors.

An actor-network is therefore never as clearly structured as a technical network. It is always more ambiguous, more partial and more dynamic. To highlight the non-structured aspect of the network concept, terms such as *filament*, or Deleuze's and Guattari's *rhizome* have been proposed as alternatives (Latour 1997).[13] Both terms stress the wiry, threaded

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[13] Michael Lynch has pointed out that a more fitting, though less elegant, name for ANT might be "actant-rhizome ontology" (quoted in Latour 1999b).

dimensions of connections, rather than their purposeful and ordered aspects. This is not to say that an actor-network cannot be orderly and highly structured. But it says that this is the special case of a black box, or an aggregated actor. It implies that the orderly and structured features need to be explained as the result of a specific network-building process, rather than assumed as an inherent characteristic of the network itself. As Michel Callon and John Law put it, network is merely "a metaphor of relationality" (Callon & Law 1997, p.170 n9).

Networks produce effects, for example, the construction and maintenance of an artifact. Nothing exists in total isolation, in the void. Everything is dependent on a set of relationships which create an environment in which it can prosper and take on a specific identity. There are no actors without networks and no networks without actors. Both have to be performed and be performing in order to exist. This is the activity that takes place in a technological environment.

While Latour (1993) claims that STS has discovered this "middle kingdom", others were exploring parts of this terrain a long time ago. I want to draw attention to two scholars whose ideas seem to point into a similar direction as the network concept of ANT. I have already mentioned McLuhan's notion of the *environment*, but Norbert Elias' concept of *figuration* also bears remarkable similarities. Contrasting the actor-network concept with these two other ideas has not only the advantage of tracing the middle ground using a different vocabulary, but also serves to highlight the points at which ANT goes beyond any of its precursors, thus, what constitutes its real innovation.

Norbert Elias (1897-1990), a cosmopolitan sociologist of German descent, explains his central idea with characteristic elegance.

> What is meant by the concept of figuration can be conveniently explained by reference to social dances. They are, in fact, the simplest example that could be chosen. One should think of a

mazurka, a minuet, a polonaise, a tango or rock 'n' roll....One can certainly speak of a dance in general, but no one will imagine a dance as a structure outside the individual, or a mere abstraction. The same dance figurations can certainly be danced by different people, but without a plurality of reciprocally oriented and interdependent individuals, there is no dance. Like every other social figuration, a dance is relatively independent of specific individuals, but not of individuals as such. It would be absurd to say that dances are mental constructions abstracted from the observations of individuals considered separately. (Elias 1969, p.131)

The concept of figuration, derived from *configuration*, a concept in Gestalt psychology, conveys several ideas that also apply to the actor-network concept. First, actors are interdependent, their actions can only be understood by taking into account their relationships with other actors. Second, figurations have a certain dynamic of their own which arises from but transcends the individual actors that make it up. The figurations and the actors are determining one another. There is no dichotomy between action and structure: both are co-present all the time. There can be no dance without dancers and no dancers without dance. This is also of central importance in the concept of an actor-network.

The point is worth making explicitly because it breaks down an abstract distinction common in social analysis between (determined) actor and (determining) structure. Neighbors do indeed shape new actors as they enter into transactions with them, but they are in turn reshaped by their new circumstances. (Law & Callon 1992, p.26)

Third, figurations, like actor-networks, are dynamic and their development is open-ended. They can change their character, swing transforms into rock 'n' roll, they can become more rigid and enshrined in institutions like the rock 'n' roll hall of fame, or they can disappear. The dancers leave the stage and go home.

There is, however, at least one crucial difference between the concept of a figuration and that of an actor-network. A figuration, as the dance example indicates, is made up of human actors exclusively. Elias, while writing about things such *The Rise of the Fork* (Elias 1939), never saw artifacts as

something other than passive tools. The fork was an indication of, not an actor in, the cultural transformations at the end of the Middle Ages. An actor-network, on the contrary, comprises heterogeneous elements: human and non-human, individuals as well as institutions. An actor-network is built of actors of all shapes and sizes.

McLuhan's concept of the environment is also derived from Gestalt psychology, which introduces the distinction between figure and ground. The figure/ground relationship describes a way in which perception is structured. The figure and the ground together constitute the totality of reality.[14] However, it is the figure on which perception is focused. The figure is what appears structured, as the foreground, and ground appears as unstructured and background. The (back)ground, however, only appears to be unstructured. It is in fact highly structured by the figure which arises from it. Figure and ground are mutually constitutive. "The ground of any technology or artifact is both the situation that gives rise to it as well as the environment (medium) of services and disservices that it brings into play" (McLuhan & McLuhan 1988, p.5). A couple of pages further, the McLuhans state that "the dynamic interaction of a figure [is] a part of its ground, each thing creates its own space; that is, it reshapes the ground even as it is shaped by the ground" (McLuhan & McLuhan 1988, p.41).

McLuhan thought of environment, or ground, not as a passive container, but as a set of processes that shape the relation between all the things which together make it up. Much of his work was devoted to exploring but, sadly, not to explaining the environment created by various artifacts. In *Understanding Media* (McLuhan 1964), for example, he investigates environments of TV, radio, print, cars, clothing, money and many others. His disjointed style comes from the recognition that the processes in the

environment are all at once, they are simultaneous rather than linear, and they involve heterogeneous elements. Tracing their relationships, he jumps from element to element in what appears to be a mosaic of independent observations.

Here lies the strength and the weakness of McLuhan's environment concept. It allows us to speak of heterogeneities, simultaneities and mutual influences. It does not imply an *a priori* notion of what the environment is made up of. In this sense, environment and actor-network are closely related. In a network, all actors are active at the same time, they do not stand in line patiently waiting to be ordered in a tidy sequence of cause and effect. Actor and network are coexisting and coextensive. A network is made up of actors, and entities can be actors only if they are implicated in a network of relationships.

> The actor-network is reducible neither to an actor alone nor to a network. Like a network it is composed of a series of heterogeneous elements, animate and inanimate, that have been linked to one another for a certain period of time....An actor-network is simultaneously an actor whose activity is networking heterogeneous elements and a network that is able to redefine and transform what it is made of. (Callon 1987, p.93)

The common ground is quite extensive. Both McLuhan and ANT speak of mutual constitution of humans and objects. In the case of McLuhan, the subjects, through the balance of their senses, are reworked by the technologies. Both speak of the relationship between the object (figure, or network effect) and the condition which creates and sustains it (environment/ground, or actor-network). Both focus on simultaneity and instant feedback rather than on cause and effect. Both reject the idea of independent variables. Even time and space are understood not as absolute but as produced in specific contexts. Latour call this the "spatio-temporal

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[14] Both McLuhan and Latour are quite explicitly indebted to Martin Heidegger who made a similar distinction between things that one can grasp and things that are just there. He differentiated between *beings* and *being*, between *Zuhandenheit* and *Vorhandenheit*

framework" (1996c, p.239) created by each network. Both are quite explicit about their rejection of the Euclidean idea of an independent time/space grid. John Law even wrote that "we may imagine ANT as a machine for waging war on Euclideanism" (Law 1999, p.7).[15]

But the similarities end here, and particularly on the empirical level, the concept of the environment and of an actor-network have led to very different accounts. While McLuhan included in his definition of the environment both the situation that gives rise to the figure as well as the impact of the technology on its environment, he was clearly more interested in the impact side. Unsurprisingly, he has been called a techno-determinist (e.g. Williams 1975, pp.126-29), though this is unjustified (Levinson 1999). ANT, on the other hand, has been more interested in the situation that gives rise to an artifact, hence ANT is regarded as a part of social constructivism, an assessment that is equally unjustified (Latour 1999a).

Stylistically, McLuhan and ANT could hardly be further apart. McLuhan's concepts are opaque and he has never been interested in making his assumptions transparent. Consequently, he made few attempts to flesh out the concept of the environment. "I explore, I don't explain," was his maxim (McLuhan & Zingrone 1995). Insights derived from McLuhan's approach, thus, remain impressionistic and his underlying theory is difficult to formalize despite his own attempts to do so (McLuhan & McLuhan 1988). ANT, on the other hand, has devoted considerable energy to spelling out its own (ontological) assumptions, thus making them accessible to scientific critique.

Through the network concept, ANT addresses many of the concerns vital to Elias and McLuhan but, through a much higher degree of reflexivity, avoids their limitations. Like Elias, ANT stresses the interdependence of the actors as a central feature of their existence (Callon 1999). Similar to Elias' dance

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[15] I have explored elsewhere the affinities between McLuhan and ANT in more detail (see, Stalder 1998b).

example, it makes no sense to look at an actor in isolation. Unlike Elias, ANT does not limit to human beings what the figuration / actor-network is made up of. Like McLuhan, ANT stresses simultaneity, feedback loops rather than cause-effect relationships, and heterogeneity. Unlike McLuhan, ANT develops a notion of how the different actors in a network are related to one another. What exactly happens among the different actors – their acts of redefinition and transformation in the network-building process – is a central concern of ANT.

Translation

"Translation places the interdefinition of actors...at the heart of the analysis" (Callon 1992, p.82). In the process of building up a network, actors need to align with one another. This process is open-ended and its results are uncertain. Failure is frequent (Callon 1986a, Latour 1996a, Law & Callon 1992, Vidgen & McMaster 1996). But shaping and maintaining networks is what actors do. In this process, they assign other entities the competence to act in certain ways, and restrict them from acting in others. They turn them into actors of "their" network. The network defines the actor's identity, role or set of competences.

However, new actors do not fall from the sky, but are always already implicated in existing networks which grant them with certain competences. They already have an identity. Consequently, the new arises from a (re)combination of the old. Old and new go hand in hand. This does not imply a zero-sum game of endless recycling. New things are created, every day. Innovation does indeed take place. But it does not take place in the void. To integrate an actor into a new network, the identity of the already otherwise defined actor needs to be changed, sometimes slightly, sometimes dramatically. This can happen as an extension of or addition to existing identities, or in direct competition with them. In either case, something existing has to change in order to create something new.

Returning to the example of the door opener, the point about interdefinition can be illustrated quickly. The standard door with a manual handle requires a specific kind of user: the-user-who-stops-to-open-the-door. Certain competences and characteristics are attributed to him or her. The automatic door which senses the approaching user and opens and closes the door in a predefined interval requires another user: the-user-who-does-not-stop-to-open-door. Different competences and characteristics are now required. To make the door work, the user now is required to pass through the door in the predefined period of time. This translation appears minor to most users, so insignificant that they might not even notice it since they want to pass through doors quickly anyway. However, for other users who might not able to pass through doors quickly, they might be in a wheel chair or carrying a bulky load, such a translation might entail a significant change, it might even be impossible. If that is the case, they might request changes in the door-opening mechanism to prevent being caught between automatically closing doors. They want the door-that-opens-and-closes-automatically to be change into a door-that-opens-and-closes-automatically-equipped-with-sensors. We use such doors everyday in our elevators.

What is important here is that translation among actors is a process full of feedback loops. Contrary to a translation of a text, where the new is merely derived from the original, the translation process in an actor-network is bi-directional. For A to translate B into B', it is often necessary to change into A'. Translation is a process of negotiation between all parties involved.

One can think of this as stage drama. The automatic doors says to the the-user-who-stops-to-open-the-door: "I will open and close the door for you if you accept your new role as the-user-who-does-not-stop-to-open-door." The user, who was so far the-user-who-stops-to-open-the-door, replies to the door: "I will do so, but only if you guarantee that you will not trap me if I'm slow." And the door replies: "All right, I'll get some sensors and be careful."

A door, of course, does not speak. It is mute, deaf and cannot be careful. However, there are people whose intentionality is framed by the door. We can think of them as the spokespersons for the door, because they take on its point-of-view. The company that manufactures the door-opening mechanism, for example, speaks for the door. This company will do whatever it takes to make the door prosper, that is, to fit it into as many places as possible, with as few changes as necessary.

Because they are held in place by various, pre-existing networks, actors are unwieldy. Change does not come easily or always predictably. Actors have to be fitted into a new network. There are any number of strategies that can be employed to convince an actor to take on a new role (Callon 1986b). Adapting to a new network can be made attractive for the actor because it enables what he, she or it has always been doing to be done better, whatever better means from the actor's point of view. Sometimes, all the other actors in the network have been changing to such a degree, that the remaining actor needs to adapt simply to stay the same.[16] The French proverb "Plus ça change, plus c'est la même chose" captures this change for the sake of continuity. Brute force can also affect change. Making actors change whether they want to or not. The alternatives to adapting might be so unattractive that the actors have virtually no choice. In our door example, the company might simply threaten to fire anyone who is not willing to adopt the new way of passing through the door. Or the employees could sue the company for installing a safety hazard, thus forcing changes in the door design.

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[16] Joseph Weizenbaum argued that computers had, overall, not a transformative but a conservative social effect. He wrote: "Many of the problems of growth and complexity that pressed insistently and irresistibly during the postwar decades could have served as incentives for political innovation....Yet, the computer did arrive 'just in time.' But in time for what? In time to save -and to save very nearly intact, indeed, to entrench and stabilize - social and political structures that otherwise might have been either radically renovated or allowed to totter under the demands that were sure to be made on them. The computer, then, was used to conserve America's social and political institutions. It buttressed them and immunized them, at least temporarily, against enormous pressure for change" (Weizenbaum 1976, p.31). Beniger (1994) made a similar argument.

Translations are, at first, attempts, and they are *goal-directed*. Through a translation an actor wants to achieve something. But what? In a crude Darwinian analogy, one could say that actors want to exist, and reliable existence is achieved by enrolling other actors to help them to exist with as little change as possible. This is not always successful. Actors do disappear. Stability is always threatened. No single actor can control the entire network, and consequently, every actor is subject to influences that are outside that actor's control. Even the most powerful actor has to change if the resources change, even the blackest box can be forced open. Furthermore, since every actor is implicated in multiple networks, it is quite impossible for the actor to participate in all the translations without being subject to change itself. Not only this, if change in one network forces the actor to adapt, then this adaptation can force changes in other networks to which the actor is connected.

There are, however, considerable conceptual problems with terms such as "goal-directed". A goal requires an intention, and intention is something that is problematic to attribute to non-humans. In his study of Aramis, a failed French project for a new subway system, Latour (1996a) addresses this problem through a trick that inspired my little dialogue between the door and the user. Rather than trying to avoid the problem, Latour exaggerates it greatly and endows his artifacts with speech. The coupling of a subway train now literally debates with the microchip in what would be a conductor's cabin, if only there were a conductor. And how much wittier is the chip than my wooden sort of door.

However, chatty artifacts are a charming artifice and cannot really satisfy. Does a computer chip want to exist? No, of course not, the chip has no soul, no will! But yes, in a way, it does. Not the chip itself, but there are a number of intentional social actors that need the computer chip to maintain their own identity. Who? The engineers, the CEO, the shareholder of chip-

manufacturers all need the chip to be what they want it to be. Intel Corp., with its thousands of employees and billions in stock market capitalization, is dependent on the chips it builds. The chip, then, becomes the actor that enables each of them to continue doing what they already do. But they are not the only ones who need the chip as an actor, indeed, everyone who uses computers relies on the chip's action in their daily life. They all, in some way or other, contribute to the chip's continued existence and action, even if they only change the batteries from time to time.

This seems like another trick. If behind every non-human artifact stands an army of social actors, then why not go directly to those actors and ask what they want, instead of looking at the chip itself? Bluntly put, the answer is that without the chip, there would be no army of social actors standing there. These actors have aligned themselves to create and use the chip and now the chip is a critical element for keeping that alignment alive. Without computer chips, there would be no Intel Corp. and no computer gamers. This does not say that without Intel (or other manufacturers) there would be chips. After all, chips do not produce themselves, except, perhaps, on the fringes of the universe. But what it says is that without taking into consideration the particularity of the chip, we cannot understand the specific shape and strategies of Intel or the obsession of the gamers. The chip, then, is an actor, an entity that does something. It acts on other actors' behalf, however, it does not act as they would. After all, it's a computer chip and not an assembly of shareholders. And that is precisely what makes it so attractive to the shareholders. It can do things for them that they themselves couldn't do. But this comes with a price. They, in turn, have to do what the chip itself cannot do. The chip and the shareholders (and engineers, etc.) have to adapt to one another. As long as this adaptation works, they can dance together. Not a mazurka or a polonaise, but the juggernaut polka of socio-technological change.

We have come full circle now, actors are entities that do things. Since there are no unbridgeable ontological differences among those actors, they can enter into the most promiscuous relationships with one another. In these relationships, they translate other actors in order to build networks through which they can change or maintain their identity. As Michel Callon concludes, "translation is the mechanism by which social and natural [or technological] worlds progressively take form" (1986b, p.224).

2.3.2 The dynamics of an actor-network

Actor-networks do not exist. They are performed. Actor-networks are created and held together by recurring action. If the action stops, then the actor-network ceases to exist, as much as a river vanishes if it dries up. Hence ANT is made up of terms that focus on process, rather than on structure: actors, entities defined by nothing other than what they do, and translation, the transformation or transubstantiation of competence to act.

Michel Callon (1986b) differentiates between four different *moments* in the process of building up and stabilizing an actor-network. The first such moment is the *problematization*. At the beginning of each new actor-network lies a problem to which the attempted actor-network can be presented as the solution. To "create" a problem, the different actors who are supposed to share this problem need to be defined in relation to one another and to the problem itself. Once the actors are defined, a solution can be presented to all their woes. This solution is the new actor-network, often presented as a simple artifact and a few associated procedures. Michel Callon calls such a proposal an "obligatory passage point" (ibid., p.205) because the new actor-network configuration is presented as the necessary condition to solve the problem. Problematization – the interdefinition of actors and ways to solve their common problems – is often relatively easy to accomplish because the actors are defined without being consulted. In a sense, the problematization defines the strategy of the initial actor(s).

The second moment of translation is to test if the different actors accept the identity which has been assigned to them during the problematization. First is strategy – where to go? Through the bottle neck of the obligatory passage point! It then turns into tactics – how to get there? A series of negotiations begins, some of them in the board room, trying to align different institutional actors, others in the laboratory, trying to create a technological actor that is able to carry out reliably the action for which it has been assigned the competence in the problematization, when the blue print was drawn. In this phase, which Callon calls *interessement*, the problem of how to interest actors in accepting their roles is addressed. As already mentioned, an actor rarely springs up *de nihilo*. Finding ways to align an actor which is held in place by multiple, already existing networks might entail loosening some of the existing connections, thereby translating the actor more easily. Cutting off old ties and building up new ones often goes hand in hand.

The third moment is the one of actual *enrollment*. Now matter how convincing the tests and negotiations have been, the crucial moment is when the network actually begins to rely on the participation of all actors involved. Now shows the actual strength of the alliances previously built up. In technology development, this phase often corresponds to field tests in which the alliances are put under the stress of a "real life situation". "Bugs" – unexpected behaviour of artifacts and people – are addressed and the actors are finely aligned with one another. Do the actors really act as predicted? Do they accept their new roles and identities?

In line with Bijker's concept of closure, one could define a fourth moment in the development of an actor-network: *stabilization*. After a period of tests and fine-tuning, an actor-network needs to achieve stabilization to survive. In a stabilized network translation is completed and interaction among actors works smoothly, the friction is eliminated to a large degree and the actors have accepted their respective identities. The network now functions so

reliably that it no longer is the focus of controversies. It can be safely ignored as it turns into a black box and recedes into the background. The figure turns into ground. When an actor-networks stabilizes, all the relationships that make it up stabilize too. As Bijker & Law put it:

> Technology is stabilized if and only if the heterogeneous relations in which it is implicated, and of which it forms a part, are themselves stabilized. (Bijker & Law 1992, p.10)

With stabilization actor-networks tend to become more and more rigid, as all its actors rely on it to maintain their own identity.[17] The more actors there are involved in defining one another's identity, and the more the translations though which this interdefinition takes place are carried out by actors of diverse materiality, the more stable the network becomes. The network building process becomes *irreversible* (Callon 1991). This does not mean that it cannot change anymore. It means that the actors have become dependent on the network for their own existence, they can no longer go back to their previous identities. What was once only one of several possibilities becomes the new status quo. Of many potential futures, a single one is being realized as the present.

Of course, in an empirical situation, to which we will turn soon, these moments do not follow each other neatly. What Jean-Luc Godard said of films, that they have a beginning, a middle and an end but not necessarily in this sequence, applies equally to actor-networks. In order to fit the solution, the problem can be redefined, if necessary several times, as Bijker (1992, 1994) has shown for the fluorescent light bulb. As long as there is flexibility, the development can go in any direction. Stability can increase or decrease, actors can be reliable allies or treacherous deserters.

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[17] This is why it is often simpler to build, say, an organization from scratch than to change an existing one.

ANT, then, can be understood as a set of concepts – actor, black box, network, translations etc. – for mapping complex socio-technologies, or technological environments. It has also proposed the idea that four moments – problematization, interessement, enrollment and stabilization – are of particular importance for the development of such complex entities.

2.4 The limits of a mapping device: beyond ANT

I have characterized ANT as an *ontological manifesto* that informs a vocabulary facilitating the exploration socio-technologies thus making technological environments accessible for empirical research. Through these tools ANT aims at creating an empty methodological frame, a clean slate on which relationships among heterogeneous actors can be traced. To create and maintain an artifact, these actors must be aligned with one another through a process of mutual interdefinition. If successful, these entities give stability to one another, if unsuccessful, their relationship breaks apart and the artifact disappears. Each actor within this network is actively engaged in (re)producing the conditions that sustain the network. Their actions create a certain effect which can be a fact, an artifact or an event. The interplay of all the actors and their interdefinition create the conditions of the object's emergence and maintenance as well as the impact of its existence.

Unsurprisingly, not everyone agrees that we are in need of a new ontology nor that the vocabulary of ANT is fully successful in framing the interrelation between humans and artifacts. The critique of ANT can be divided roughly into two camps. One is an *external* critique which questions the validity of the premises of ANT itself, and the other is an *internal* critique which points to problems arising while working with the ANT ontology. I will not deal with the external critique because it leads deep into the philosophy of science, particularly the natural sciences, into the territory of the *science wars* and, consequently, beyond the scope of this study (Latour 1999a, Ross 1996, Sokal 1998).

The internal critique, however, is directly relevant because if we accept ANT's ontology as a premise for the investigation of emerging socio-technological relationships, its epistemology generates a number of difficulties. According to a sensible assessment by Walsham (1997), four major shortcomings plague the usefulness of ANT for analyzing actual socio-technological settings. ANT:

- is limited in its analysis of social structures
- has a problem limiting the description of its object
- has an amoral stance
- has a problem of a generalized symmetry

In the following, I will examine each of these shortcomings. The first two can addressed within ANT, the last two are characteristic features of ANT and relate to its particular status as a *infralanguage*, or, mapping device.

First, is ANT *limited in its analysis of social structures*? With its focus on the network-building process, ANT stresses the local and the contingent, paying less attention to considerations of constraints and structures. Latour (1991) argues there is no need to develop a separate vocabulary, one that deals with action and another that deals with structure, because (macro) structures are made up of (micro) actions. What appears to be a powerful structure is nothing other than a large number of well-aligned actors. There is nothing intrinsically different between actors of different sizes. The only aspect that is different is that large actors can coordinate extensive resources, that is, many other actors acting together. What makes an actor large, then, is the ability to coordinate a great number of actors to act reliably across time and space. The power of the president of the United States of America lies not in the person who holds the office, but in the person's ability to send, for example, troops into a foreign country to act on his behalf. If the actors in the chain which transforms the presidential order into a bomb dropping thousands of kilometers away refused to do their required work, then the president could sign orders all day long and nothing would happen. Such

chains of action need to be reenacted with every order, with every policy issued. Otherwise, the order remains on paper only (Latour 1986). Well-established chains of command, to use the military term, can be reenacted very effectively, since all actors rely on the functioning network to keep their identity. It is much more risky for the general to refuse a presidential order than to pass it on, even if he thinks it is wrong. The order passes downwards, the responsibility seems, conveniently, to pass upwards.[18]

Actor and network stabilize one another, and what can be observed as structure – recurrent patterns of relationships – appears. This idea of a mutual constitution of actor and structure is commonplace in mainstream sociology. Anthony Giddens, for example, developed the notion of "structuration" to frame this interdependence. Giddens, however, remains somewhat vague as to what makes the stability of structure, which he explains as an effect of "routinization" and the "recursive nature of social life" (Giddens 1984).[19]

The problem is that, in practice, ANT's concentration on local actions within the chain of action makes it difficult to trace very long chains, for reasons of practicability. While ANT is good at opening up complexities, it is less able to keep the complexities manageable. It is therefore not surprising that ANT often produces studies of relatively small cases. Thus, its applicability to larger settings seems limited.

A way to reduce the complexities of large settings while keeping the ability to trace the formation of relationships and the interdefinition of actors across material boundaries lies in reconceptualizing the notion of the *black box*. A black box, as we know, is any network that is reenacted in such a reliable

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[18] This double movement is the standard excuse of bureaucrats who argue that they are not responsible for the effects of their actions (see Arendt 1964).

[19] Giddens cannot be more than vague on this point because he places all the burden of creating stability and recursiveness of behaviour on human shoulders, which cannot carry such a weight alone. Hence "the nature of social life" is evoked as a supporting mechanism.

fashion that we can take it for granted, that is, that we need not know its inner workings to understand its behaviour. Its functional logic can be deduced from its recurrent patterns of action. Most of the things we use everyday are treated as black boxes. I do not know how my computer works, but I know that when I hit ctrl-w, the open window disappears. It is the same with cars: I do not need to know how the engine works, but I know that if I turn the key and press the gas pedal, the car is likely to start rolling. A black box is an aggregated actor, it is a network seen as a point. The advantage of reducing a network to a point, of aggregating many actors into one actor, is that this allows us to connect actors of very different sizes to one another, thus jumping from what has been traditionally called the macro-level to the micro-level, without introducing conceptual discrepancies and, equally important, without drowning in a flood of data. Raising the notion of the black box to higher prominence than is usually done allows us to increase the heterogeneity within the network, to connect not only actors of very different materiality, but also of very different size to one another. The difficult question is: when can we see a network as a point and when is an actor aggregated?

The answer depends on the network under consideration. If I analyze suburbanization, then the car can be treated a reliable entity, even though it breaks down. From time to time, from the point of view of the interrelation of people, cars and places, this does not matter. On the other hand, if I want to understand the changes in the curriculum of car mechanics, then the car has to be treated as a flexible actor-network in which the appearance of a new actor, for example computer chips in the late 1980s, is of major importance. It is not the car itself that is either a black box or a flexible actor-network. It has to be treated as one or the other in relation to the network the analyst chooses to investigate, which is always only one out of a large number of networks in which the car, or any other actor, is involved. In some of those networks, the car has been a reliable entity for the last 50 years or more, in others it is under constant construction.

Aggregated actors are at the same time actor and structure. They are actors in the sense that they are active elements within the actor-network. They are structure in the sense that they bring to the network a set of internal constraints and a specific time-space continuity. The constraints and continuity arise from their need and ability to keep aligned all the different actors which they aggregate. The ability to make many actors act as one, to be a large aggregated actor, comes at the price of being restricted by the mutual interdefinition of all those actors. Change, then, becomes more difficult but also more far-reaching. The notion of aggregated actors, with their internal constraints and their influence over the network-building process, allows for a simultaneous consideration of the dynamics of actor relations and their structural constraints.

The notion of an aggregated actor could also be useful to deal with the second problem, which Walsham (1997, p.476) calls a "rather mundane issue" and, at the same time, a "major problem": *how to limit the description?* Every actor is held in place by networks of other actors and, to make things even more complicated, these networks have no boundaries. [20] ANT studies can be seen often as somewhat unsatisfactory because they have difficulties credibly claiming their own completeness. This has led to calls for more specificity and more empirical detail in studies (Monteiro & Hanseth 1996). It has also led to appeal to journals to generally expand the length of publishable papers (Walsham 1997). Latour reacted to this problem by expanding a case study to book length without really reaching a satisfactory level of explanation, even though in this case one could argue that the level of detail was too high (Latour 1996a). Unfortunately, the solution for this problem lies not simply somewhere in the middle, in the right number of details. The problem is less quantitative than qualitative.

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[20] Networks have no outside, or Latour (1997) put, "networks have no shadows." Networks do not develop against the backdrop of some unifying framework.

The difficulty of limiting the description arises from an insufficient definition of the relationship between the analyst and the network. Question: is the network an actor's or an analyst's category? Likely answer: both! It is an actor's category in the sense that each actor is indeed implicated in networking processes which are independent of the analyst. We do not need sociologists to constitute society. On the other hand, actors are involved in multiple networks simultaneously and there is no clear distinction among them. In order to single out one for description, it is necessary to develop a specific question to be asked in relation to the actor under consideration. It is impossible to study all the actor-networks that make up a car. There are too many. But it is possible to study, say, the actor-network that makes understandable the car's role in the process of suburbanization. The multiplicity of networks has been reduced to the single network that defines the relationship of cars and suburbs. But there is nothing in the numerous actor-networks of the car that suggest that this network is particularly important. There is no priority among the various actor-networks. It is the analyst who brings a heuristic interest to the mesh that is made up of intersecting networks and to the unwieldy number of relations that each actor is implicated in. In this sense, analyzing actor-network relationships is like carving out of a chaotic, continuous nature a discrete scientific fact that can stand on its own. Analysis is a significant amount of work that transforms what it works on (Latour 1999a). While we do not need social scientists to constitute society in general, it seems unlikely that particular forms of social organization such as "free markets" would have emerged without theorists postulating free markets as natural (Callon 1998).[21]

In this sense, an actor-network analysis does not need to account for everything, but only for what is relevant to the specific network that is being traced in an attempt satisfy the analyst's interests. How much detail is

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[21] In the social sciences, this idea is quite unproblematic. See also Giddens' notion of the 'double hermeneutic' character of knowledge in this area. "Social knowledge spirals in and out

needed for the answer is related to the question. Question and answer are, as always, interdependent. While the network has, arguably, infinite detail, not all of this detail is necessary for the analysis of the network in regard to the specific question.

But what kind of answers does ANT really provide? ANT is said to have "a certain void on the level of content" (Dossé 1999, p.97), or an "amoral stance", the third major problem listed by Walsham (1997). Its apparent inability to support value judgments threatens to turn it, as Langdon Winner (1993, p.397) put it, into "a blazé, depoliticized scholasticism." Latour (1991) argued that before we can diagnose the (a)morality of an object or setting, we must describe its network. And once we have described a network, then its interpretation does somehow emerge.

> The *description* of socio-technical networks is often opposed to their *explanation*, which is supposed to come afterwards....If we display a socio-technical network - defining trajectories by actants association and substitution. Defining actants by all the trajectories in which they enter, by following translations and, finally, by varying the observer's point of view - we have no need to look for any additional causes. The explanation emerges once the description is saturated....There is no need to go searching for mysterious or global causes outside networks. If something is missing, it is because something is missing. Period. (Latour 1991, pp.129-30)

This is not very satisfactory, not even for Latour himself, who has modified his position on this over the years, acknowledging the difficulty more openly.

> ANT is a powerful tool to destroy spheres and domains, to regain the sense of heterogeneity and to bring interobjectivity back into the centre of attention. Yet, it is an extremely bad tool for differentiating associations. It gives a black and white picture not a colored and contrasted one. It is thus necessary, after having traced the actor-networks, to specify the types of trajectories that are obtained through highly different mediations. This is a different task and the one that will make ANT scholars busy for a number of years to come. (Latour 1997)

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of the universe of social life, reconstructing both itself and that universe as an integral part of that process" (Giddens 1990, p.15-16).

Unfortunately, this does not bring us much further either, but it points at least to the problem: the difference between description on one hand and explanation or interpretation on the other. The problem originates from the unusual position that ANT occupies somewhere between a theory (interpretation) and a methodology (description). While Walsham (1997) argues that it is both, more accurately one could say that it is neither of the two. A theory is based on an hypothesis about which entities make up a subject matter and their relationships to one another. ANT's entire premise is precisely the opposite; to avoid any *a priori* hypothesis about entities and their relationships in order to trace them across boundaries established by a modern ontology and enshrined in academic disciplines. It is, as already mentioned, an anti-theory. This is a mixed blessing. On the positive side of the balance stands the ability to bring into focus the creation of hybrid worlds populated by heterogeneous entities, each giving shape to and being shaped by this world. On the negative side the difficulty of interpreting and assessing the worlds it describes.[22] It is also not a methodology in the proper sense, since it does not specify how the tracing is to be done.

One way to make sense of this limitation is to assess more precisely the aims and the scope of ANT. ANT, rather than being an explanatory theory, is better understood as a mapping device. ANT is a particular way to make visible and map technological environments, rather than a theory about them. The difference is similar to the difference between geology and map-making. Maps trace lines, altitudes, coasts, rivers etc., but do not contain a theory of their evolution. Mapping is a necessary part of geology, but it is, or at least should be, independent from theoretical swings in the discipline. It would be absurd to accuse a map of being devoid of theory and explanation. Indeed, it is the map's very virtue not to advance an argument about what it

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[22] This is not too different from the critique that McLuhan was confronted with. His breathless tracing of ground patterns has often been interpreted as their endorsement.

maps, but to simply register shapes within the region covered as accurately as necessary.

It is deliberate that I say as *accurately as necessary*, rather than as accurately as possible. The analogy to map making can also help to address, from another angle, the problematic aspect of how to limit the description of an actor-network. Each map has a scale. Depending on where I want to go, I need a map of a particular scale. A map covering the whole of Canada uses a different scale than a map of Toronto. It would be misleading to say that the Toronto map is better than the Canada map because the former shows things that are hidden in the latter, or to argue that the ideal map should have the scale of Toronto map but the scope of Canada's. We would soon end up with Borges' Chinese map that delighted Baudrillard (1983) so much: a representation so detailed that it swallows what it represents. Rather, the Toronto and the Canada map have similar amounts of information, but answer very different questions. If I want to find my way around within Toronto, a street map is what I need. If I want to drive across the country, a road map is what I need. Which one is adequate can only be decided in relation to my goal. The point of the analogy is that in order to decide what and how to map, or which actor-network to trace, it is necessary to develop a question in relation to which the adequacy of detail can be assessed.

The analogy to cartographic maps, however, breaks down exactly on the issue of scales. Maps have a uniform scale and are thus only able to register what is within their particular scale. Certain things are too big, others too small to be represented on the map. A map of Toronto is as little able to include the province of Ontario as the map of Canada can include the streets of downtown Toronto. An actor-network, on the contrary, does not have a uniform scale. It can be made up of actors of very different sizes and materials. What binds them together is not some general communality, such as scale or category, but the specificity of the network in which they are entangled.

Perhaps the most vexing problem is the last shortcoming in Walsham's list: the generalized symmetry. The problem is that of agency, or more precisely, that of *the relationship between human agency and machine agency*. ANT distributes agency among a chain of actors comprising humans as well as non-humans. The result of this move, as Dick Pels puts it, is that "people and things are semiotically equalized" (Pels 1995, p.138). ANT's aim has been to reconceptualize agency not as a quality inherent in social actors, but as a relational effect produced by configurations of heterogeneous actors. Arguing against a seemingly overwhelming tradition which distributes agency in a paradoxical way – in the natural sciences, nature is all active and society is passive, in the social sciences it is vice-versa – the emphasis of ANT has been to break down these barriers and insist on the distributed action of social and material entities, and that the very separation between the two must be regarded as an achievement, rather than a given.

While this was a very strong statement initially, once we have come to understand the notion of a materially distributed agency, it becomes quite commonsensical. The assumptions that ANT makes about how actors act are minimal, like most other assumptions beyond its radical ontology. Let's review Latour's example of a gun's action (Latour 1999a). We can think of an actor having an unknown, perhaps even unknowable, number of *sub-programs* for action: getting from A to B, or from B to C and so on. In the case of the gun, one of the sub-programs of action is literally getting a bullet from A to B. This program, however, is only a potential, there are many others. The gun could also be used to hammer in a nail. Each subprogram might be, but does not need to be realized. Moreover, which of the subprograms is being realized in a given moment is not determined by the gun itself. The sub-program – a potential for action – is incomplete in the sense that it requires additional actors to be activated. A gun cannot aim and trigger itself. But a sub-program is also not simply passive, waiting to be picked up. It actively defines both ends of the chain of action in which it

needs to be placed in order to be carried out. Placed between two people, the gun turns one into a shooter and the other into a potential target. Now one of the sub-programs that has been built into the gun, shooting a person, can be activated.[23] Having defined someone (or something) to shoot, and someone (or something) to be shot at the gun can carry out its sub-program. By accepting the role defined by the gun, the holder of the gun has added his own sub-program to the gun's sub-program, s/he has combined the gun's potential agency with his/her own potential agency. Out of the combination of several potentials for action, an actual event emerges. Someone pulls the trigger, someone is shot.

In order to appropriate some of the gun's various sub-programs more fully, the user of the gun has to adapt to the gun in specific ways. For example, s/he might need to learn how to shoot, maintain it, possibly organize lobby groups that secure his/her legal status as gun-owner, and so on. The better the gun, the gun owner and the society - of which both the gun-owner and the gun are constitutive actors – are attuned with one another, the more precisely can the gun carry out the program of the user, which by now, can no longer be separated from that of the gun. Both become a new unit, a hybrid of human and non-human elements: the gun-carrying-human within a society that attributes a certain legal status to this entity. It is in this configuration that the effects of the gun are ultimately determined: the gun is now either a hunting rifle, a decorative piece on the wall, an illegal possession, a murder weapon, or a substitute hammer, while the person is now either a hunter, a collector, an offender, a killer or an improvising carpenter.

Actors define one another. For the user to be able to take advantage of the gun's potential, s/he has to accept the gun's definition of the user, s/he needs to incorporate certain aspects of the specific sub-program that s/he

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[23] These other actors do not need to be humans. Missiles can be guided by automatic systems aiming at military facilities.

wishes to activate and thus adapt to the gun while, in the same process, the user adds his/her sub-program to the gun, thus defining it. Mutually adapted to one another, they become a new unit able to act in ways that can neither be reduced to the gun nor to the user. This is similar to the way Norbert Elias' dances cannot be reduced to two dancers considered in isolation. Humans and artifacts act together, their actions, furthermore, are not simply added to one another, but they are mutually constitutive. This is how far the definition of an actor as an entity that does something, anything, can lead us. We have reached, once again, the limitations of what ANT can do.

The last two problems of ANT – amoral stance and generalized symmetry –are less related to the conceptual tools put forward than to a "category error" that frequently creeps into our understanding of ANT. This error is to think of ANT as a theory. This is not what it is, even though it carries 'theory" in its title: the misnomer mentioned earlier. Like all conceptual constructs, ANT has a limited scope, though unlike a theory, the scope is not limited by its subject matter or a real hypothesis. ANT provides neither, but its scope is limited otherwise. It is a mapping device, an empty methodological frame, a clean slate. ANT, then, offers nothing more, but also nothing less, than innovative tools to describe, or map, complex terrain more accurately than has been done before. It avoids imposing the fault lines created by the modernist ontology onto what it maps. Rather than assuming what to find, ANT has put all its effort into avoiding assuming anything. ANT is most powerful in tracing relationships among entities that have previously been thought of as unrelated. Tracing these relationships, ANT can highlight their mutual constitution, thus offering a new perspective on their dynamic. The development of the actors cannot be understood without taking these previously unseen relationships into consideration. This, and only this, is what ANT excels in. This is substantial, and I would argue groundbreaking, but it is not everything.

If we accept this limited scope of ANT, the final two problems are transferred on the other side of the framework that ANT has built.

ANT can trace complex socio-technological relationships and the mutual interdefinition of social and technological actors. ANT brings into view technological environments. However, it cannot, and specifically does not want to, interpret the landscape it has mapped. This needs to be done in relation to something outside of ANT. This *something* is researcher's interest for which to answer s/he has mapped the technological environment in the first place. Here is were morality or social concerns are reintroduced or where particular differences between human and machine actions are reestablished.

The three research questions that guide this thesis and that inform the interpretation of the technological environment of Mondex mapped with ANT successively reintroduce social and political concerns in order to make sense of the activities mapped. This will be done in the conclusion of the thesis. The first question concerns the dynamics within the environment: What is the relationship between technological and social actors in the development of Mondex? By mapping how the social shapes the technological and how the technological frames the social we can answer the question why Mondex failed in its original goal to replace cash while, at the same time, some of its technological actors have been rather successful in creating an environment through which to stabilize themselves.

The second question focusses on aspects of the shape of the emerging environment: What are the political and social implications of the transformation associated with the still ongoing development of new technologies of money? By looking at those actors that have already changed, we can gain an understanding of the direction of the still ongoing development. This can help us to see in what aspects Mondex, and other

electronic cash systems, have already transformed the environment they are trying to become a part of.

The final question brings to the fore the relationship between the environment of electronic cash and the larger environment of electronic money: How do these transformations around Mondex relate to broader socio-technological change? Relating the development of Mondex to broader history of the development of virtual money, which will be sketched in the next chapter, will help to assess the historical dimension of the environmental change to which Mondex is contributing.

The two great inventions of the human mind are writing and money – the
common language of intelligence and the common language of self-interest.
Mirabeau (1749-1791)

3. Money: environmental approach and history

Money, paraphrasing the famous definition of John K. Galbraith (1975), is
simply what everybody accepts as money. What is accepted as money,
however, is not an arbitrary convention. The material object to be used as
money must to be able to support two "concrete" functions: it must be useful
as a medium of exchange, and as a store of value. These two functions
require one another. If money cannot be exchanged, it becomes reduced to
its commodity value, for example the amount of gold it contains. If money
cannot sustain its value over time, because of physical decay or hyper-
inflation, it ceases to be accepted as a medium of exchange because it
depreciates in the hands of its holder. In other words, whatever artifact is
taken to be money, its material and social qualities contribute to rendering
its functions within the economic system stable and predictable. In addition,
modern money usually also serves such "abstract" functions as a unit of
account, a means of payment, and a common measure of value (Davies
1994, p.27).

3.1 Money as an environment

Based on this classic definition as a medium of exchange and common
measure of value, money has often been regarded as something objective, or
objectifying, thus deeply impersonal. As the mediator between strangers who

have no knowledge about, or personal interest in, one another, Georg Simmel and Karl Marx, the classic authors on the social nature of money, saw it as a destroyer of communal bonds and traditional life styles. For both of them it was a force in, and a symbol of, the increasing rationality and impersonality of modern life and its alienating social relationships (Dodd 1994). For Marx the increasing role of money in the capitalist economy was a sign of the increasing alienation which was to be overcome in an ultimately moneyless socialist future.[24] For Simmel the impact of money was more ambiguous. On the one hand, it was an instrument of cold impersonality, on the other hand, "money, because of its impersonal character and its unconditioned flexibility, has a strong affinity with the individual achievement as such and has a specific power to accentuate it" (Simmel 1907, p.341). Money, for Simmel, was both destructive and creative. It corroded the distinctions that marked the social order from which it emerged and new social distinctions were created by its use. Through the increasing use of money *independent communities became dependent* and *dependent individuals became independent.*

For both Simmel and Marx, though, money was particularly characterized by an explicit lack of content. As Simmel put it, "money has a very positive quality which is designated by the negative concept of lack of character [, it is] detached from all specific contents" (ibid., p. 216). Similarly, Marx wrote that "money as medium of circulation becomes coin, mere vanishing moment, mere symbol of the value it exchanges....As the most superficial (in the sense of driven out onto the surface) and the most abstract form of the entire production process [money circulation] is in itself quite without content" (from *Grundrisse*, quoted in Spivak 1987, p.32).

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[24] Consequently, one of the first acts of the Bolsheviks following the Russian revolution was to abolish money. This was, though, also one of the first policies to be revoked in the face of disastrous consequences. For a recent example of a neo-Marxist analysis of money as an agent of alienation, see Neary & Taylor (1998).

Today, money is still generally viewed as something that derives all its qualitative characteristics from its quantitative aspects. All that is important about money is expressed in a figure: how much? Money is understood as relating to nothing but itself, as "signifying nothing" (Rotman 1987). Or, as Gertrude Stein put it, "whether you like it or whether you do not money is money and that is all there is about it" (quoted in Zelizer 1994, p.2). Money, cold, impersonal, detached from social realities, turned the world into a "huge arithmetical problem" (Simmel 1907).

Sociologists, unsurprisingly, have conceptualized money as a social product embedded in complex social practices. Viviana Zelizer called it a "powerful ideology of our time that money is a single, interchangeable, and absolutely impersonal instrument" (Zelizer 1994, p.1) and drew attention to the ways in which "people are constantly creating different kinds of money" (ibid.). As she pointed out, people personalize and modify money as they cope with the different demands for money. People differentiate through "earmarking" among different monies, for example, household money versus vacation money. This helps to distinguish different uses and priorities, for example, vacation money is surplus from household money. The same money can mean different things to different people in different circumstances. Different social meanings are commonly attached to money, thus giving it a content that Simmel and Marx saw as missing. However, these meanings are, even for Zelizer, secondary, that is, they are more or less arbitrary and idiosyncratic additions to the underlying unchangeable quantitative qualities of money (Zelizer 1998).

Other sociologists – most importantly, Talcott Parsons, Anthony Giddens and Jürgen Habermas – have analyzed money less through the interpretations of its users than as a medium of exchange that connects different social groups to one another (Dodd 1994). Parsons (1971) understood money as a specific *language* for social communication which facilitates exchange among the differentiated elements within a social system. He wrote, "financial

transactions, therefore, constitute a certain type of 'conversation'" (Parsons 1968, p.465). Most important about money was its function in the coordination of society at large across its constituent self-centered, self-regulating sub-systems. Money, for Parsons, was a rational meta-language which made it possible to connect sub-systems which otherwise would have difficulties "talking" to one another. Parsons' approach, functionalism, has been criticized heavily for its bias towards equilibrium and stasis as well as for its problematic use of metaphors. Overly complex in their formulation, the analytical meaning of the various metaphors was in constant danger of disappearing in a confusing "sea of analogies" (Dodd 1994, p.161).[25]

Anthony Giddens also conceptualized money as one of the means by which a large and differentiated society could function as an interdependent unit. Money, he argued, facilitates *time-space distanciation*, that is the extension of continuous social relationships beyond what is present in time or space. For Giddens, money is a "symbolic token", that is, a "medi[um] of interchange which can be 'passed around' without regard to the specific characteristics of individuals or groups that handle [it] at any particular juncture" (Giddens 1990, p.22). Put simply, a dollar bill is a dollar bill is a dollar bill, no matter who holds it. However, for Giddens, money is not a language that flows through society like blood flows through a biological system, one of Parsons' favourite metaphors. "Money does not relate to time (or, more accurately, time-space) as a flow, but precisely as a means of bracketing time-space by bracketing instantaneity and deferral, presence and absence" (Giddens 1990, p.25). Central to this bracketing of time-space – central to the development of modern societies – is the development of abstract trust. Trust, as Giddens understands it, is confidence in the reliability of something in the context of its possible contingency. Without trust in the reliability of what is absent, money would not work. Money is always a bet on what is absent. It is accepted because everyone believes

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[25] Giddens (1984) made a similar point when discussing the problems of transporting biological metaphors into the social sciences the way Parsons did it.

that he or she will be able to reuse it, in another locale or in the future. Money, like "all disembedding mechanisms...depend[s] on trust....Trust is vested, not in individuals, but in abstract capacities" (Giddens 1990, p.26). For money to work, we do not need to trust the specific merchant to accept it, but we trust in the ability of money to be accepted, independent of the characteristics of the people involved in the transaction.

Habermas also rejected Parsons' notion of money as a language, though for other reasons than Giddens. For Habermas language is not simply a communication medium, it has inherent properties, such as rationality, which cannot be attributed to money. Money, on the contrary, carries a logic that contradicts the rationalizing power of speech. For Habermas money expresses exchange patterns typical for what he called *Systemwelt* (systemworld), which is dominated by instrumental rationality, that is by reasoning focussed on goal attainment (Habermas 1987). On the other hand, his *Lebenswelt* (lifeworld) is characterized by communicative rationality, that is by non-strategic communication aimed at consensus and truth. The increasing pervasiveness of money in modernity, then, is a sign for what Habermas calls "internal colonization".

> Internal colonization of the lifeworld refers to a process by which institutions and imperatives associated with the system expand and break into, or colonize, institutions and imperatives associated with the lifeworld. This process is mediated by money and power, and profoundly conflicts with the form of reasoning on which the lifeworld is based. Internal colonization distorts lifeworld consciousness because instrumental rationality suffocates the lifeworld, where communicative rationality should predominate. (Dodd 1994, p.71)

This is not the place to spell out the considerable differences behind the various concepts of money I have but named but to note that across these differences there is common ground.[26] Money, in one form or another, is seen as symbolizing and advancing a rationality that is typical for modern

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[26] See Dodd (1994) for a more detailed treatment of the sociological perspectives of money.

societies. Money incorporates what is thought of, positively or negatively, as the spirit of modernity: rationality, objectivity and impersonality.

Recent anthropological studies of money, however, have rejected "the widespread social scientific portrayals of general purpose money as having intrinsic qualities that make it a destructive and homogenizing force wherever it appears, an acid that dissolves everything from social relationships to categories of exchange" (Akin & Robbins 1999, pp. 2-3). For example, cross-cultural studies of various forms of money investigated how different cultures produce different forms of money and "how an existing world view gives rise to particular ways of representing money" (Bloch & Parry 1989, p.19). Money, then, does not impact on a society by advancing a specific rationality but arises from the totality of social relationships that make up a given culture. As different as the societies from which money emerges are, so are the forms and social meanings of money. The underlying assumptions of such views were stated by anthropologist Jack Weatherford. He wrote:

> Money never exists in a cultural or social vacuum. It is not a mere lifeless object but a social institution. To function completely as money, a material can not exist simply as an object; it requires a particular social and cultural system. (1997, p.24)

Important to note is the close relationship between money and the social institutions through which it circulates. Depending on the changes in these institutions, the artifacts that are used as money change too. In a state of emergency, almost any scarce and desired thing can serve as money. In 1715, for example, the authorities in North Carolina declared as many as 17 commodities, including maize and wheat, to be legal tender (Davies 1994, p.38).

Ignoring nuances, one can sort the approaches to money into two camps. Sociological treatments of money have taken a social impact view: money is an agent of modernization, it has certain unchanging characteristics which

impact in more or less predictable ways on the society in which it comes to be used: positively, as a language of an internally differentiated system (Parsons), necessarily, as a disembedding symbolic token (Giddens), or negatively, as an agent of internal colonialization (Habermas). On the other hand, anthropological approaches have developed more of a social constructivist understanding (Akin & Robbins 1999; Bloch & Parry 1989; Weatherford 1997). Here the emphasis has been on the various cultural and social institutions that shape an understanding of money and the practice of its use. Rather than seeing it as an abstract unvarying concept, it has been understood as a set of artifacts and practices that deeply reflect the culture from which it emerges.

Similarly as an environmental approach to technology facilitate to avoid slipping into social and technological determinism, so can an environmental approach to money avoid the pitfalls to the above sketched more conventional ways of thinking about money.

Important references for such an environmental conceptualization of money can be drawn from the development of economic geography over the last decade (Harvey 1989; Hepworth 1989; Martin 1999). An assumption shared by many authors in this field is that despite its abstract functionality, money is inherently spatial and social. The monetary system relies on specific institutional arrangements which are, though global, changing and flexible, always situated and local. Authors in this field have been analyzing money as a material or institutional process of circulation, rather than as an abstract functional concept (see, for example, Sassen 1991). Most studies, however, have focussed on the financial industry, particularly the global financial markets, and their changing patterns of organization (for an overview of the current state of the field, see Martin 1999).

An approach that can be made useful for an analysis of (electronic) cash was proposed by Leyshon & Thrift (1997). Money, they wrote,

is constituted in a number of different networks of human practices, and used and thought of in different ways in these networks....In practice this means conceiving money as a series of transactional networks...which depend for their upkeep on often distinctive concepts, texts and instruments. (Leyshon & Thrift 1997, p.189)

Three clusters of actors make up the phenomenon of money (Crump 1981) understood in this way: a sets of instruments (e.g. coins, bills); a particular set of financial institutions and practices; and a broadly conceived set of interpretations of what money is and what it does. It is the specific historical configuration of these three clusters that shapes what money is at any given time. What is important about money, then, are the multiple actors which are defined by maintaining its material and functional continuity. Monetary objects – coins, bills, electronic impulses – are but the visible "tip of the iceberg" of the environment from which they emerge and on which they impact. Monetary objects' easy visibility makes them, as Fernand Braudel (1967) wrote, a "wonderful indicator" of the more difficult to grasp condition of their environment.

3.2 An environmental history of money

Armed with such an integrative view, one can roughly discern in the history of the West four distinct environments, each indicated by specific monetary objects: *commodity money, money on account, state credit money* and, currently prevalent, *virtual money*.[27] These environments were cumulative, rather than strictly consecutive and they were overlapping, dynamic, and internally highly differentiated. Nevertheless, each was characterized by distinctive patterns in the relationship between the material form in which the bulk of monetary value circulated through society and the various social

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[27] This is not the standard view. Conventionally, only three epochs have been differentiated. Monetary historian Glyn Davies, for example, wrote: "Technological improvements in the media of exchange have been made for more than a millennium. Mostly they have been of a minor nature, but exceptionally, there have been two major changes. The first at the end of the Middle Ages, when the printing of money began to supplement the minting of coins, and the second in our own time when electronic money transfer was invented" (Davies 1994, p.646). The terminology of the monetary objects is derived from Leyshon & Thrift (1994).

and technical arrangements that organized this circulation. The first three environments will only be sketched briefly to indicate both the dynamics of money as well as the scope of these environmental changes. The fourth environment, virtual money, sets the stage on, or perhaps better within, which the development of electronic cash unfolds.

3.2.1 Commodity money

Commodity money indicated the dominance of the first environment we are considering, prevalent from about 1200 to about 1500.[28] The monetary artifacts were coins minted from precious metals, mainly gold and silver, but also, particularly in Northern Europe, copper. The difference between the nominal and intrinsic value of money in this period was derived from the authority of a local aristocrat or other dignitary who had received the right to operate a mint as a form of personal privilege. Such privileges, rights and the resulting obligations formed a dense web of personalized dependencies typical of the medieval system of feudalism. During that time, money reemerged onto the European scene, from which it had, apart from a short-lived revival in the 9th century, almost vanished since the fall of Rome. At the beginning of this epoch the majority of the population lived in self-sufficient agricultural communities and was involved in only limited local trade, which was predominantly barter. Most peasants paid their tributes in kind (produce or forced work).[29] By the end of the epoch, even most peasants were required to pay their duties in money, which they obtained from ever expanding markets. During most of the epoch the increasing importance of money in everyday life and the newly developing social

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[28] As a possible date to denote the emergence of this environment one might choose 1202, the year in which Leonardo Fibonacci published his *Liber Abaci*, the mathematics book that introduced Arabic numerals first to Italy, then to the rest of Europe, providing one of the fundamental tools for the growth of the monetary economy (Weatherford 1997, p.83). Or, one might choose 1252, when the first gold coin was minted in Europe (Florence and Genoa) since Roman times (Kindleberger 1984, p.9)

[29] Despite the predominately local character of early medieval life, coins had an uncanny ability to travel. In 965, Ibrahim Ben Ya'qub, a Jewish traveler from Tortosa in northern Spain, found central Asian coins in the market of Mainz, Germany (Buchanan 1997, p.53).

distinction based on its possession clashed with the prevailing Christian value system, which viewed money with great suspicion. After all, it was the Devil who had tempted Christ in the wilderness with the wealth of the world and Christ himself had expelled the money handlers from the temple in Jerusalem. Dealing with money in general, and money lending in particular, was condemned and often restricted to Jews who, as non-Christians, were seen as already condemned to eternal hell (Le Goff 1988). However, despite such tensions, the newly emerging merchant classes expanded and gained self-confidence. This laid the foundation for the development of a new culture in which bankers and rich merchants played a major public role: the Renaissance (Burke 1987).

The resurgence of trade and the limited supply of gold and silver, provided mainly by Eastern European mines, soon reached the limits of commodity money. On top of the deepening coin-based market economy, new forms of value transfer developed beginning in the 14th century: the "bills of exchange." These allowed a merchant to receive money in, say, London to buy wool and pay it back in Florence after he had sold the wool to important textile proto-industry. Bills of exchange served not only as a convenient way to conduct long-distance trade, they also offered a loophole to escape the church's condemnation of any form of interest as usury.[30] Technically, these bills of exchange were not lending money, but contracts, often, but not always, involving foreign currency exchange, and this made it impossible for all but the most sophisticated merchants to determine the exact amount of interest involved (Davies 1994, p. 219). To handle and make use of these new complex tools international banking and merchant houses emerged, first in Northern Italy, then, unevenly, throughout Europe. Novel ways of financing not only made long-distance trade possible, but they also facilitated it by splitting the risks involved among many "shareholders". This was particularly important for sea voyages, which were the most expensive and

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[30] Lending money with interest was viewed as "selling time". But time belonged to God alone, and it was a grave sin to claim for man what belonged to God.

risky but also the most lucrative of all investments. Bills of exchange, long-distance trading and banking fueled one another's development; each of the three grew through its association with the others.

3.2.2 Money of account

By the mid 1500s, European culture was deeply monetarized. The church's condemnation of money had lost much of its sting. The church itself was deeply implicated in the money economy (church taxes paid in money, donations, sale of letters of indulgence[31]). The mints were being centralized (still within relatively small territories), banks and merchants had developed sophisticated instruments (bills of exchange, bank credit, double-entry book keeping[32]) to manage the flow of money, and trade was ever expanding. These new instruments, through which the bulk of the monetary value began to circulate, constitute a new form of money: *money of account*. Money became a unit of account. Rather than traveling, money stayed in the bank and was represented by receipts and bills. Such a system was based on a relatively high degree of trust among the parties, a trust usually based on family ties. Most of the big bank and merchant houses of the time were built around one or more families, and they lasted as long the family members were able to keep the business thriving, which was usually not more than a few generations.

Although the intra-European trade was deepening too, it was the extra-European trade which provided the basis of explosive growth. Most importantly, the new world discoveries – trade-missions "supported by royal sponsorship and joint-stock finance" (Davies 1994, p. 175) – led to a huge

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[31] One of the reasons for the popular appeal of the German Reformation was outrage over the increasingly direct connection the Catholic church drew between donation of money and salvation. One of the most (in)famous slogans to promote the sale of letters of indulgence in Germany claimed: "Wenn das Geld im Kasten klingt, die Seele aus dem Feuer springt!" (When the money drops into the box, the soul jumps out of the fire).

[32] 1494, the first book on double entry book-keeping was published in Italy. Its message spread rapidly. The commercially most relevant parts of the books were republished in 1504 as *The Perfect School of Merchants*. (Davies 1994, p.224)

influx of gold and silver. One of the consequences was a rise in prices throughout Europe.[33] Money penetrated deeper and deeper into the fabric of everyday life as trade and production accelerated. The means of circulation became increasingly inadequate for the scope and complexity of the emerging economy. "The mines could not produce enough precious metals, bad money drove out good over the years, and the evils of hoarding[34] were always lurking. The solution would be to create something better than commodity currency....the answer was to invent symbolic money" (Braudel 1979, pp. 112-13).

In 1456 Johann Gutenberg published the first printed book: the bible.[35] During the 1500s, the technologies of printing and paper-making steadily advanced and the technology of minting changed from hand-striking techniques to mechanized methods of manufacture in order to increase output and fight counterfeiting.

> The transformation of coin-making from the slow laborious hand hammering methods...into a more mechanized form, able to produce a faster, cheaper and more uniform output, much more difficult to counterfeit, was not the result of a sudden, single intervention, but emerged from a long process of trial and error, made all the longer and more difficult by the furious opposition of the established moneyers. It took many years of patient effort to produce horse-powered machines to roll the metal, to cut out the circular blanks, to stamp the engravings firmer and more quickly than it was possible by hand, and, perhaps more important than all else at the time, to be able to introduce various forms of grainings around the circumference of the coins and make engravings around the edges, both of these latter devices enabling the facile coin clipper finally to be outwitted. (Davies 1994, p.241)

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[33] During the "Price Revolution" (1540-1640) prices in Europe rose approximately six-fold (Williams 1997, p.167).

[34] Hoarding in this context means artificially tightening the money supply by stockpiling coins in times when the circulation seemed insecure.

[35] Soon afterwards, Gutenberg lost control over his business to his banker, Johann Fust, who successfully sued Gutenberg for not repaying the loan he had taken out to develop the printing press. Thus, the first book to contain a date (14.8.1457) and the name of the publisher listed Fust and his son-in-law, Peter Schoeffer, not Gutenberg. (Davies 1994, p.178)

Technically, this process was state-of-the-art. It required advanced high-precision machines and highly skilled labour. Only a few engineers were able to build and operate such machines and they took their knowledge with them from one mint to another, corresponding to changing political and financial currents in the capitals of commerce (Paris, Amsterdam, London). As a side effect, printing and minting became technically more similar.

However, it was not until the late 1600s that printing and money were fused and the first paper money was issued in the West.[36] Among the pioneers was the Bank of Amsterdam (founded 1606), which issued paper receipts for deposited coins. Soon, these paper receipts circulated instead of the deposited coins. The value of the paper money was backed by the bank which, in the beginning, issued paper money strictly as receipts for actual deposits. The receipts of the Bank of Amsterdam enjoyed an excellent reputation. This reputation came from the fact that it was one of the few Dutch banks that did not have to close down during the recent war (with Louis XIV), when depositors suddenly began to withdraw their bank deposits. Unlike other banks the Bank of Amsterdam had not issued more paper money than it had deposits.

The first fully-fledged paper money, however, was issued in Sweden in 1656 to replace the heavy Swedish copper currency.[37] In 1667 the issuing bank underwent a serious crisis when it was discovered that it had issued more paper money that it had copper to back it up. The bank was subsequently taken over by the Crown and turned into the Rijksbank, the oldest Central bank in Europe.[38] Scandal and bankruptcies of unprecendented scale

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[36] Technologically, it was a step backwards, since the early bank notes contained significant handwritten and hand-stamped elements, adding credibility and status to the printed notes.

[37] To make use of its rich copper mines and to keep the precious metal in the country, Sweden issued commodity copper money. However, since copper was much less valuable than gold, the coins needed to be huge and heavy. In 1658, the 8 daler copper coin issued by King Carl Gustav weighted 14 kg.

[38] The Nobel prize in economics was inaugurated in 1968 to commemorate the tercentennial of the bank.

continued to be closely connected to paper money. In 1716, in France, the Scotsman John Law set up the Banque Générale (soon after nationalized into the Banque Royale) and began to issue paper money. By 1720 the bank has lost the backing of the king of France and was ruined through what amounts to one of the first pyramid schemes of modern finance: the so-called Mississippi bubble. Promising to harness the riches of the French colonies in the New World, Law used the capital of new investors to pay out fictitious profits to the old investors. Like all such schemes, it required ever more new investors to pay out the old ones and, eventually, the entire pyramid collapsed in a run on the bank (Davies 1994, pp.553-55). While there were risks involved in paper money, there were also clear incentives to favour it over commodity money. As Adam Smith observed:

> Bank money...as it represented money exactly according to the standard of the mint, was always the same real value, and intrinsically worth more than the current money. (quoted in Rotman 1987, p.25)

In other words, trust shifted from the institutions of the "old economy" (the products of the local mint, the money exchanger) to the institutions of the "new economy" (the trans-local financial institutions).

In North America, one of the first issues of paper money was in 1690 by the Massachusetts Bay Colony to finance a war with Canada. Military expenditures promoted early issues in other colonies too, but soon the money was also used for civil projects, such as municipal building works or repaying public debts (Williams 1997, p.183).

The Dutch, Swedish and North American examples highlight some of the dynamics that spurred the issuing of paper money despite a number of spectacular bank failures. The complexity of the economy was encumbered by the limitations of commodity money. Merchants were actively seeking new ways to conduct business more easily and more effectively. Previously exotic instruments, such as bills of exchange, became ever more widely used and

prepared the ground for the acceptance of paper as money. Early paper money was still money of account, in the sense that it represented, more or less directly, receipts held by a specific bank which the bearer of the bill could redeem upon presenting the note. "Early issues of paper money in the West were all essentially speculative. With no established procedure to draw on, there was little alternative but to learn from experience, costly though that could be....Moreover, whereas early types of paper credit, such as bills of exchange, were used predominately by merchants and financial agents, the seventeenth and eighteenth century saw the spread of paper money as a form of circulation currency used throughout society" (Williams 1997, p. 191).

This accelerated under the influence of expanding governments' ever growing demand for money. Governments' budgetary needs were growing, not the least because of the professionalization of administration and warfare. Both came to be conducted by salaried professionals instead of by the privilege-financed nobility.

With the increasing importance of the institutions of the nation-state in the circulation of money, a new monetary environment began to emerge from the 18th century onwards: *state credit money*.

3.2.3 State credit money

The most important trading place of 18th century Europe, London, lead the way. In 1694, to finance an ongoing war with France, the Bank of England was established. It brought along "the crucial change in government debt from royal personal obligation to a higher status of national debt" (Davies 1994, p.237). What makes this change so significant is that it highlights a shift in the fabric of the society: institutions began to become more important that individuals. Louis XIV, against whom the English were fighting at the time, was among the last generation of European kings who could credibly claim: L'état c'est moi (I am the state). Increasingly, the state was

becoming a state bureaucracy. Furthermore, the state was beginning to take over the role as the central authority in the circulation of money. With this new institutional framework, governments were able to increase their borrowing because it was increasingly unlikely that they would default on loans. Over the next 200 years, with considerable national differences, modern money emerged. Money became state credit. The state became the guarantor of ever increasing public debt. Central banks were regulating mostly national banks, and stock exchanges were institutionalized to facilitate the accumulation and allocation of capital within and across national boundaries. Governments, for the first (and, perhaps, only) time, were beginning to get a tight grip on the circulation of money.

The emerging middle class developed new theories of money. Money came to be seen as the lifeblood of an economy which was understood as an entity of national scale. The rule books of the merchants – which distilled personal experiences into guidelines of how to run a business – were superseded by abstract and impersonal theories which had the society as a whole as their frame of reference. The rise of the nation state and the increasing importance of money was reflected in, and advanced by, the doctrine of "mercantilism". This theory, which shaped European economic policy during the 17th and much of the 18th century, advocated the export of manufactured goods in exchange for precious metals and money. Terms like "balance of trade" began to appear in the early 1600s. "The new micro-economic concept of balancing the books of an individual company was now being transferred to the macro-economics of the state" (Davies 1994, p.227).

On all levels money became more and more abstract. Technologically, it was produced with ever increasing uniformity in centralized, state-controlled mints and (central) banks. Various ways of denominating money were unified into a pervasive decimal system, first introduced during the French Revolution. In Canada, for example, the process of decimalization of the

currency began in 1854 and was finalized in 1871 when the last province, Prince Edward Island, adopted the new standard (Powell 1999, pp.7-9).[39] The variety of monetary artifacts decreased. In the context of the nation state, they became more and more homogenous. In the context of colonialism the same coins and bills were accepted in increasingly large territories. In the 19th century, the British pound was the leading currency around the globe, in the 20th century, the US dollar took over the dominant position. Institutionally, money became more and more enshrined in highly abstract specialized and formalized institutions, organized by a small elite of professionals.

A new outlook on money emerged. Christian values became more and more a matter of private conviction. Protestantism, according to the famous argument of Max Weber's *Protestant Ethic and the Spirit of Capitalism* (1930) established a new Christian morality by elevating resourcefulness to the status of a religious virtue. The accumulation of wealth, though not its consumption, was to be regarded as a moral imperative of the Protestant ethic. [40] In the context of Protestant morality, particularly within the various strands of Calvinism, money, if earned properly and not conspicuously consumed, became an objective measure of a person's state of grace.

However, in the 19th century this religious ethic of restraint was gradually eroded by the burgeoning commodity economy. Money, more than anything else, became a tool for worldly consumption, a new attitude for which Thorsten Veblen, in *Theory of the Leisure Class* (1899), coined the term "conspicuous consumption".

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[39] In Canada, it took another 100 years to transfer other measuring systems (temperature, distance, weight) to a decimal system.

[40] Max Weber introduced the term "innerweltliche Askese" (inner worldly ascesis) to highlight the novel combination of the pursuit of goals within the material world and an austere spiritual discipline. Traditionally, ascesis was sought in a withdrawal from the material world.

While the monetary system became more complex and abstract, all forms of money still remained anchored in the material world.[41] The centralization and nationalization process which differentiated *state credit money* from *money of account* and from *commodity money* can also be seen in the arrangements through which this anchor with the material world was maintained. If worst came to worst, commodity money contained its own material value. If the central authority broke down, each coin kept at least its commodity value. Money of account was drawn against specific deposits which contained either bullion or some other form of commodity. The breakdown of the issuing authority affected only money issued by this authority, but there were many different issuers, as the lucky holders of Bank of Amsterdam receipts found out in the late 17th century. With the ascendancy of central banking, the issuing of currency was centralized into one institution in each country backed up by the nation state.

In 1815 the gold standard became legally recognized in Britain, after it had for a long time been in existence informally. This measure allowed the state, through the central bank, to assume the role of the ultimate guarantor of the currency. Coins and bills became legal tender, that is, "money designated by the government as acceptable payment of all debts, public and private" (Kindleberger 1984, p.469). Other countries soon followed: in 1871 the newly unified Germany switched to the gold standard, as did Russia, Austria and Scandinavia. In 1878 France abandoned the double silver/gold standard (bimetallism) in favour of gold. Glyn Davies calls the dominance of the gold-standard in the late 19th century an example of the "sailing ship effect" (Davies 1994, p.354). Just as the best sailing boats were built well after the steamship had already become commonplace (~1870), so did the supreme

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[41] "Money, like the calendar and the system of measurement, is a cultural construct that may have arbitrary aspects, but to function properly, it needs stability and predictability. A society can base its calendar on the sun, on the moon, or even on a combination of both, but the calendar must have an anchor somewhere in the real world. The important issue is that the calendar functions as part of a system that is stable and that all people understand. Similarly, as long as money is stable, it can be based in shells and beads, gold and silver, or plastic or electrons, but it needs to be practical and predictable" (Weatherford 1997, p.267).

development of commodity money, with its concept of intrinsic value, take place long after notes, cheques and other forms of "fiat" money had become essential elements of everyday life.

Throughout most of the first half of the 19th century, the monetary system of the US was chaotic, with a large number of state and local currencies competing against one another. In many ways, this reflected the highly decentralized character of the development of the US largely due to a widespread distrust of central authority which many of the (political) immigrants had fled. The Civil War (1861-1864) changed that.

> The war required a rapid transfer of resources from diffused and decentralized civilian expenditure to concentrated and centrally controlled military expenditure, by means of some combination of taxing, borrowing and printing money. (Davies 1994, p. 485)

While the South relied on simply printing huge amounts of money to finance its war (causing a corresponding hyper-inflation), the North began to create a modern monetary system. In 1862, the *Legal Tender Act* granted the Federal government the authority to print legal tender, soon to be known as "Greenbacks" for the color used for the printing on their reverse side. This laid the groundwork for the development of the Federal Reserve system (officially established in 1913), a kind of decentralized central bank, which facilitated the creation of a national currency while maintaining a highly decentralized, state-regulated banking system.

By the mid 1870s, the system of state credit money had reached a first peak. Most of the European national economies were based on state-issued currencies controlled by government-authorized central banks. These currencies were all based on a common gold standard, though there was significant popular resistance against it in the US, where it was said that the population was crucified on a "cross of gold". In many ways, the gold standard was the first truly global financial system. It affected directly the everyday life of a large part of the world's population. Gold mines were

operating around the world and gold was traded internationally, and the new monetary artifacts were in everybody's hands, though in very unequal measure.

The relative openness of the system (gold could flow into and out of a country with minor restrictions) and the near universal consensus not to interfere with the basic principles for the sake of (national) short-term gain corresponded to a nearly universal faith of the colonial powers in laisser-faire systems of various shades.[42] This universalism, though limited in practice, reflected the generally optimistic world view of the dominant bourgeois culture. The state guaranteed long-term stability based on universal principles of rationality and progress. Of course, this optimistic vision was neither shared by everyone nor was it free of ideology. The bourgeois optimism was brought to a violent end by the First World War. 14 years after the actual date change, the 19th century as a historical period ended (Hobsbawn 1994).

Rising expenses during the First World War forced most governments to abandon the gold standard. Under the conditions of war, the free flow of gold came to an end. England, for example, effectively abandoned the gold standard in August 1914, although the respective laws were not changed for many years. After the war, England tried to reestablish the gold standard but was not able to do so due to the lack of international cooperation. A time of monetary and political instability began. Money, which by now was paper money for most people in Europe and North America, became increasingly volatile. The stress introduced by this volatility made many people feel that they were subject to forces well beyond their individual influence. Shortly after the war, the German economy collapsed under the weight of punitive

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[42] Analyzing the Canadian policy under the gold standard, Powell wrote: "With the gold standard in place, monetary policy was largely "on automatic pilot." Paper money was freely convertible into gold without restriction, and there were no controls on the export or import of gold. This implied that there was virtually no scope for the authorities to manage the exchange rate or conduct an independent monetary policy" (Powell 1999, p.14).

reparation payments ordered in the Versailles treaty, and the Mark underwent a spectacular hyper-inflation. In less than two years (1921-23) the price of a postage stamp rose from 20 Pfennig to 500 billion Marks. German newspapers reported the outbreak of a new illness called "zero strokes" or "cipher strokes" caused by the difficulties of calculating such large figures (Weatherford 1997, p.202). On November 20, 1923, the Mark stood at 4.2 *trillion* against the US dollar, the German government introduced a new currency, the Rentenmark, which was based on land. The US government lent Germany US$ 200 million to return to the gold standard and the Reichsmark was introduced in 1924. However, by then the entire middle-class had lost their savings and the basis of the Nazis' rise to power was consolidated.

The economic depression which followed the stock market crash of 1929 made it all but impossible to return to the prewar stability of the gold standard. In 1931 England officially abandoned its attempts to do so. London was no longer the dominant financial center of the world. The glorious British empire was fading into the sunset.

Under the shock of the depression and the Second World War a new institutional framework was set up at the Bretton Woods conference (1944). Its goal was to reintroduce stability into the international financial system. The International Monetary Fund and the World Bank were created, to promote, among other things, monetary co-operation and discourage competitive currency devaluation. Such policies gave national governments, most notably the US and England, instruments to manage the interdependent national economies and achieve specific policy goals, such as the recovery and political integration of Germany and Japan. For the industrial world, these policies brought long-term economic growth and stability. National currencies were more or less stable. The US dollar, which had taken over the role of the British pound as the world's leading currency,

was put on a gold basis. Most European currencies were pegged against the US dollar and thus indirectly also put on a gold standard.[43]

The Bretton Woods system constituted a second peak of the system of state credit money. In contrast to the 19th century, governments took on a much bigger role in controlling the economy. The depression and the Second World War had turned the government, particularly in the US, from a more or less passive arbiter into a powerful economic actor channeling increasing amounts of money through expanding government programs. The financial system and all the forms of money it created were centered around the nation-state. The financial markets were mostly national, so were their institutions, which were dominated by the central bank. What went beyond the nation state was international, that is, transfer from one national system into another. Compared to the 19th century gold standard, the financial system created at Bretton Woods was more *international* but less *global*. There were no elements envisioned in the system that were outside or beyond the reach of national governments. However, this very power of the state, expressed most sharply in the almost global presence of the US army and the two-block system of the cold war, laid the seeds of corrosion of the state currency system. Soon after the Second World War, a new type of money began to emerge, resulting in the currently dominant type of money: virtual money.

3.3 The rise of virtual money

In the environment of virtual money, the bulk of monetary value was represented by electronic impulses in the computerized accounting systems of a relatively few, highly interdependent, globally operating financial institutions. They emerged from national institutions over the course of about 30 years via expansions and mergers, propelled by new technologies and government (de)regulation.

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[43] Beyond the industrial world, the achievements of this new institutional framework were less glorious. Developing countries were integrated more and more into the growing world economy, though under conditions that were generally not to their favour.

Felix Stalder [83]

By the late 1950s, parts of the financial establishments of Eastern Europe, the Arabic countries, Italy and Great Britain all faced the same problem: they needed to find ways to mobilize capital outside of the then tight governmental controls. Different independent developments had brought them to this conclusion. In the context of the rapidly deteriorating East-West relations in the late 1940s and early 1950s the communist governments – obliged to hold US$ to conduct trade with western countries – began to fear for the security of their American assets. The rise of McCarthyism seemed to make more likely the possibility of seizure of those assets for political reasons.[44] Advised by British bankers, they transferred their US$ to a Soviet-owned bank in Paris, the Banque Commercial pour l' Europe du Nord.[45] Eurodollars,[46] among the earliest types of virtual money, were created.

With rising political tensions in the Middle East, the Arabic countries began to develop similar concerns, especially in the wake of the Suez War in 1956. Egypt began to shift its US$ assets out of the USA. In Italy a rigid lending-rate structure motivated aggressive banks to seek markets outside the lira to offer their customers better credit. In 1957 the Bank of England – as a reaction to the British balance of payments crisis resulting from a massive outflow of capital – prohibited banks from doing Sterling financing of third country trade, that was basically all trade not involving a British importer or exporter. Subsequently, British bankers started to use US dollars as prime currency for financing international trade.

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[44] The seizure of foreign assets is a rarely used but nevertheless possible weapon in a political conflict. In April 1982, during the Falkland crisis, Margaret Thatcher's government seized Argentinean assets in Britain.

[45] This policy tied well into Soviet plans to increase trade relations with Western Europe as a means of possibly destabilizing the transatlantic partnership.

[46] The so-called cable code, the name under which the Soviet-owned bank communicated in the financial networks was EUROBANK, hence its US $ became the Eurodollars. Subsequently all currencies held outside the country of their denomination became Eurocurrencies independent of their actual 'physical' location. US$ deposited in Tokyo are also called Eurodollars. The geographical reference in the name is purely a convention.

With all elements in place – supply (politically uncontrolled but trusted US dollars), demand (industry seeking to circumvent national restrictions in order to finance expanding volume), and a mediator (the European banking system led by the British) – a new environment began to take shape that supported an accelerating growth of virtual money: in 1964 about US$ 14 billion were tied into the eurocurrency market, in 1985 the market comprised about US$ 1.7 trillion: an average growth rate of more than 57% per year. The first Eurobond was written in 1963, slowly rising to 310 in 1980 and exploding to more than 1300 in the mid 1980s (Hepworth, 1989 p.164). Such tremendous growth would have been impossible had it not been feeding on and accelerating broader economic and technological developments.

After World War II, as the USA began to pour massive amounts of money into foreign countries as part of their efforts to rebuild Europe (Marshall Plan) and as payment for their overseas troops. More and more US dollars left the USA, not all of them returning in the form of contracts to US firms. In the shadow of the political expansion of the USA large US companies started to transform themselves into multinationals, powering the political-military hegemony with an economic dominance: the "Pax Americana" was established.

This industry/military driven expansion provided the initial input and incentive to develop a global financial infrastructure to enable and accelerate multinational production and international trade. An indicator of the growth of this financial infrastructure is the expansion of US banks. In 1960 only 8 banks had foreign branches, by 1978 more than 100 US banks had a combined total of 761 foreign branches (Hamelink, 1984 p.61).

The technological basis to support virtual money did not materialize over night. New applications had to be developed, implemented and trusted. Initially, the communications channels were cumbersome, seriously limiting

the scope of the workable applications. The telecommunications infrastructure was only beginning to expand to a global scale. In 1951 the first transatlantic telephone cable was laid. It could carry 36 conversations at one time. By 1976 the sixth cable was laid, carrying some 4000 conversations at one time. Not before 1988, the first fiber-optic cable was laid that could carry 40 000 conversations at once (Wriston 1992, p.42-44). Also in the late 1980s satellite communication was established, providing almost abundant communication channels. The financial industry was one of the first and most demanding users of the new technologies that fused telecommunication and computing. Between 1972 and 1985 the largest US banks increased the proportion of their operating expenses dedicated to telecommunications from 5 to 13 percent, and "finance became the sectoral leader of overall corporate information technology spending" (Schiller 1999, p.13). By the late 1980s, CitiCorp's Global Telecommunications network, the largest private system in the world, linked offices in ninety-four nations, transmitted 800 000 calls each month, and supported US$ 200 billion in daily foreign-exchange trades. In 1981 the 10 largest US investment banks spent 1980 US$ 2 billion on new technologies and by 1995 this figure had risen to about US$ 17 billion (Lowell & Farrell 1996, p.41).[47] These investments had consequences beyond the financial institutions themselves. As Dan Schiller noted:

> Financial network applications harbored further profound political-economic consequences. They allowed the exponential increases in the trading volumes of the securities market, foreign-exchange, and other speculative instruments, so that stateless capital flows acquired the ability to overwhelm the national monetary policy objectives of even the largest economies. (Schiller 1999, p.14)

During the course of the 1960s the international economy grew increasingly dynamic, imposing serious strain on the Bretton Woods system, anchored as it was in the convertibility of the US dollar into gold. In the late 1960s, a series of crises undermined the viability of the system and on August 15,

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[47] In 1998, Canada's six major banks invested $ 2.7-billion in information technology (Financial Post, 20.11.1999).

1971, Richard Nixon ended the convertibility of the US dollar, thereby eliminating the gold standard for the entire Western economy.[48]

A possible candidate for the date at which the environment of state currency was superseded by the one of virtual money is the year 1973. Two years after the end of the gold standard, the Bretton Woods system finally broke down and exchange rates began to float freely. In the same year, another important change occurred which, in the long run, gave the first one its real weight. The financial markets moved from telex and telephone to computer networks as prime means of communication. Reuters, the news agency that had started as a pigeon courier for financial information in 1849 (Read 1992), launched its monitor screen service, "the forerunner that led to a worldwide surge in financial trading" (Fallon 1994 p.31). Only six years later the network connected some 250 000 screens world-wide. Reuters established itself as not only one of the most important news agency for the financial markets,[49] but also as a provider of the tools to work the markets by connecting the dealers world-wide in a way that allowed them to conduct their business within the Reuters network.

During the early 1970s new network-based services changed the structure of the financial markets and created a technological infrastructure that could support the subsequent explosive growth in trading volume. For the currency markets, especially for Eurodollars, the most important was the opening of CHIPS (The Clearinghouse Interbank Payment System). Founded in 1970 by

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[48] No immediate dramatic events followed. Nevertheless David Harvey points at this time as the "sea change" marking the shift between modernity and postmodernity: "The breakdown of money as a secure means of representing value has itself created a crisis of representation in advanced capitalism. It has also been reinforced by, and added its considerable weight to, the problems of time-space compression....The rapidity with which the currency markets fluctuate across the world's spaces, the extraordinary power of money capital flow in what is now the global stock and financial market, and the volatility of what the purchasing power of money might represent, define, as it were, a high point of that highly problematic intersection of money, time, and space as interlocking elements of social power in the political economy of postmodernity." (Harvey 1989, p.298)

[49] Though it is, of course, by no means the only news source for these markets.

a group of the largest New York City commercial banks in order to effectively communicate among themselves, CHIPS expanded gradually in the 1970s and 1980s to include other commercial banks and financial institutions. The purposes of the CHIPS, and similar systems such as S.W.I.F.T. (Society of Worldwide Interbank Financial Telecommunications, founded also 1973) are twofold: they serve as the means of communication, passing authenticated messages back and forth over a secure network, and as clearinghouses guaranteeing the execution of the deals arranged over that network.

These technological and institutional changes were paralleled and, probably, accelerated by a political paradigm shift. The dominant post-war economic theory, Keynesianism, which advocated strong government intervention, was gradually replaced by monetarism. Most influential in the late 1970s and the early 1980s this theory advocated a much more restrained government policy aimed primarily at the control of the monetary supply. An unusual event of explicit joint regulatory and technological changes was instigated on October 27, 1986 when the London Stock Exchange was partially deregulated and switched to a new computer based-trading system (Davies 1994, p.433). "Big Bang" was an apt name for this event because it signaled that the virtual money system had overcome two barriers that could have impeded its further growth: technological limitations on handling the increasing volume and complexity of transactions efficiently, and national regulations limiting the number of opportunities which could be pursued. The institutional framework which maintained state credit money was eroding further and further.

3.3.1 Virtual money in everyday life: the rise of credit cards

Most people came in contact with money represented by electronic impulses not through the financial markets, but more mundanely through credit cards. A credit card, in the most general definition, is a standardized carrier of information which identifies an individual as the holder of a line of credit at a

trusted third party. The third party mediates between two parties that do not need to trust one another by paying the merchant and billing the customer.

In a society with little mobility, this would not have been a much needed service, since store owner could grant credit to customers s/he knew on a personal basis. But in the 1920s more and more people began, as a part of their everyday activities, to drive their new cars to places where they might not have any personal relationships and, on their travels, they might not always have the necessary money in hand to pay for gasoline or the then frequent repairs.[50] To solve this problem, and create customer loyalty, oil companies began issuing what can now be seen as a precursor of credit cards. These cards could be used to purchase the company's own products from any merchant who carried them. Soon, large chain stores were offering similar credit cards. These early cards, however, were more of a promotional effort since they allowed only the buying of the goods and services of the issuer. They were essentially an extension of the traditional credit account which stores provided to many customers.

In the wake of the success of this service, the issuers soon experienced what James Beniger (1986) called a "control crisis". Such a crisis is caused by the speeding up of existing processes (granting credit) to a point were they become impossible to be handled with traditional technology (paper receipts). The first technological innovation introduced was a metal plate, called "charge-a-plate", that was embossed with the name, address and account number of the customer. These plates, and corresponding imprinters, made it possible to capture customer information more quickly and more accurately.

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[50] Early automobiles were leading-edge technology, unstable and prone to breakdowns.

The first multipurpose credit card was created in 1950 by Diners Club. As the name indicates, the card was first used for restaurants, 27 expensive restaurants in N.Y.C., to be precise. In the beginning, the cards were simply cardboard pieces which the customer's name on one side and the list of member restaurants on the other. In 1955, Diners Club switched from paper to plastic format. In 1958 American Express, a company founded in 1850 with a well-established traveler's cheque business, began to issue its cards, also targeting the high-income executive (Grossman 1987). Banks were beginning to fear they were losing control over an emerging market to non-bank institutions and they began to issue their own cards. In 1958 Bank of America introduced its card. Banks were still limited to operating in one state, but since Bank of America operated in California it soon became the biggest and best known of all cards. Other banks, too small to create their own card, joined the BankAmerica Service Corporation, a national licensing organization founded in 1966, which changed its name to Visa eleven years later. Also in 1966, several other banks formed the Interbank Card Association, which changed its name to MasterCard in 1980.

From the beginning the control crisis in the credit card system was manifest in two problems. The first problem was to manage quickly and efficiently the vast amounts of payment receipts generated by the growing number of transactions. The flood of paper slips that had to be processed manually created major difficulties both for Diner's Club and American Express as they started their operations. Due to it, both were losing significant amounts of money (Grossman 1987, pp.263-265). Automation was needed to cope with this volume of paper. Optical Character Recognition (OCR) was developed and a standardized font, OCR 7B, was adopted for the account number. A standard form was designed to record the imprinted data in a consistent location. Machines that could rapidly scan the information on these forms were developed.

The second aspect of the control crisis was a high level of losses caused by fraud and users unable to repay their debt. Both problems, inherent in any credit system, were exacerbated by some of the ways the credit card issuers tried to overcome the chicken-and-egg problem they faced as they tried to establish their systems. They needed merchants to attract consumers and consumers to attract merchants. Due to this problem, a credit card system could not start out small – the few merchants would scare away the few users and vice-versa – so credit card systems required large investments right from the start.

The Bank of America, and others too, tried to solve the problem by aggressively mass mailing pre-approved cards to its customers. While this helped to address the chicken-and-egg problem by expanding the user base rapidly, fraud skyrocketed.[51] In 1960, the bank's losses amounted to 15 percent of the transaction volume (Evans & Schmalensee 1999, p.78). The problem was exacerbated by the cumbersome ways credit card transactions had to be settled in the context of a highly fragmented American financial industry. Even in the early days nearly 50% of all credit cards transactions involved two different banks, that of the customer and that of the merchant. This additional step of interbank clearing not only produced additional paper, but also slowed down the processing speed, thus making it more difficult to combat fraud (ibid., p.79).

No single bank was big enough to develop a scheme on its own which would overcome the chicken-and-egg problem, so more and more banks abandoned proprietary systems and joined the emerging consortia. The credit card business, like many other businesses, is subject to what economists call "network effects". The more nodes there are connected into a network, the more attractive the overall network becomes to each node. The classic example for the network effect is the fax machine. A single fax machine is

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[51] In part because credit cards were sent in distinctive brightly coloured envelopes (Richardson 1970, pp.83-84).

useless. Two fax machines are somewhat useful. The more fax machines are connected to one another, the more useful every single fax machine becomes, eventually one simply "needs" to have a fax machine.[52] "Typical network goods have little or no value in isolation: they derive their value solely from their 'connection' with other goods" (Van Hove 1999b, p.139).

Because of such externalities, it was desirable for banks to join forces with competing banks to offer the same credit card. Each additional user, even if s/he belonged to the competing institution, added to the value of the credit card of the bank's own users.[53] The increasing integration had the downside of increased interbank clearing and easy and frequently used opportunities for fraud. Again, technology provided the means to address this part of the *control crisis*. In 1970, the International Standards Organization (ISO) approved standards for a magnetic stripe on cards. These standards made it possible to create interoperable equipment that could read and process the electronic information on the stripe, automating the data entry. This improved greatly the systems' ability to handle increased transactions at greatly reduced costs. In the late 1960s, there was a strong belief that the "cashless" society, and paperless banking, would be a near future reality. Credit cards were seen as a first step in this direction. In 1970, an observer of the financial industry predicted:

> recent technological developments in the areas of microelectronics, electronic data processing, and information retrieval and communication systems will revolutionize the American monetary system. The technical advances that are currently being implemented by progressive bankers are on the verge of completely changing the traditional concepts of payment media and commercial banking....In

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[52] To be more precise, there are two types of network externalities, *direct* or *demand* and *indirect* or *supply* externalities (Van Hove 1999b). Fax machines are an example of direct externalities, since each machine becomes more useful with more machines to connect to. Credit cards are an example of indirect externalites. New users do not add directly to the utility of the cards of existing users. However, they might add utility indirectly by convincing more merchants to accept the card.

[53] The VISA network grew from 1 issuer in 1958, to six issuers in 1966, to 243 in 1970 and to 6 500 in 1998. The growth rate for MasterCard was similar.

the not-too-distant future, money usage as it is known today
largely will have disappeared. (Richardson 1970, p.1)

In 1973, the year when the financial market began to switch to computer-
based communication, VISA introduced its global electronic card
authorization system, and a year later its electronic clearing and settlement
system. Both systems were crucial to crack down on fraud, speed up the
internal processing of information and lay the foundation for the rapid
expansion of the entire network. While it did not eliminate fraud, it enabled
the expansion of the network by keeping fraud at sustainable levels.

Throughout the 1970s and 1980s, credit cards became more and more
popular. In 1970, 16% of the households in the US had credit cards, by the
end of the 1980s, this number has risen to more than 55%. The distribution
of credit cards, however, was widely unequal across income segments. At the
end of the 1980s, more than 90% of the households in the highest income
quintile had at least one credit card, while less than 20% of households in
the lowest income quintile had one (Evans & Schmalensee 1999, p.89). This
differentiation of payment systems along income lines mirrored and
contributed to a deepening of social divisions. The lower income households
were increasingly closed in what anthropologist Jack Weatherford called the
"Cash Ghetto". He wrote:

> By the end of the twentieth century, cash in all forms, including
> coins and paper bills, had declined in importance around the world.
> Even before money lost its gold backing, it was becoming less
> important for the financial elite and thereby for the general
> society. At the same time, however, cash found correspondingly
> greater usage among poor people. In the modern two class system,
> the poor pay with cash while middle-class consumers use plastic and
> checks. (Weatherford 1997, pp.211-12)

For people with bank accounts, however, the lines between virtual money
and physical cash were blurring. With the spread of Automated Teller
Machines (ATMs), the virtual money system created an ever greater number

of interfaces which could convert the virtual into the physical by dispensing cash, or convert the physical into the virtual, by accepting deposits of cash (or cheques) into bank accounts. The first ATM, then called "customer bank communication terminal" (CBCT), was installed in 1969 in Philadelphia. Initially, banks viewed ATMs mainly as a means to reduce costs by replacing branches with computer terminals. Another incentive to install these machines was that they enabled banks to operate at more points within their local area. Soon, however, competitive pressure forced banks to install more and more ATMs. By 1979 some 6 000 ATMs were installed throughout the US. Each of these machines was connected to a closed proprietary network which was operated by individual banks.[54] The biggest network was maintained by Citibank which, in 1979, connected more than 400 ATMs. These proprietary networks could be shared with other banks through franchise agreements, but the service was provided by the bank which owned the system. A dynamic similar to the development of credit cards ensued. The proprietary networks owned and operated by a single banks gave way to networks that were operated by specialized joint ventures among banks. The growth of the number of ATMs throughout the 1980s was paralleled by the increasing importance of these shared networks. Their share of ATMs grew from 16% in 1980 to 94% in 1990.

3.3.2 Debit cards: the Canadian experience

In the beginning, the development of credit cards and ATMs was similar in Canada and the US. The first ATM, or "bankette", as it was called, was installed by the Royal Bank in Toronto in 1972. At the end of 1978, 250 ATMs were installed across Canada (Bartel & Arbuckle 1987, p.7) and in 1980 the Royal Bank interconnected its nearly 400 ATMs into a national, proprietary network. Other large deposit-taking institutions developed similar national,

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[54] Unless otherwise noted, all figures in this paragraph are from Evans & Schmalensee (1999)

proprietary networks. However, the financial sector was structured very differently in Canada. In the US it had been shaped by state legislation aimed at restricting banks from operating in more than one state. The result was an extremely fragmented industry of several thousand, often very small banks. In Canada, on the other hand, the industry was dominated by less than ten large, national deposit-taking institutions. In 1984, half of them set up a not-for-profit joint venture, the Interac Association. Its first mandate was to develop the framework to interconnect the ATMs. This interconnection of previously closed networks began in 1986. Soon, the other major banks joined Interac. The network externalities of joining were very favourable and the costs to built up a competing network were prohibitive.

With the development of ATMs another artifact of the virtual money system was distributed to a very large number of people: the bank card. This card was modeled after the credit card. It had the same material, the same size and used the same magnetic stripe standards and technology to store information. However, its issuing dynamics were quite different. The bank card holds no line of credit, it simply allows users to access their own bank account. Consequently, the risks are substantially different than with a credit card. Bank cards are issued for every bank account and are used as a means of identification at the ATM, together with a personal identification number (PIN).

Based on the successful introduction of the bank card and the establishment of the shared network for ATMs, Interac began, in 1990, to develop an additional use of this base infrastructure: Interac Direct Payment (IDP). The IDP enabled individuals to use their bank card to pay in stores. Rather than having to go to an ATM first, withdraw cash and hand it over to the merchant, the new system transferred the exact sum of the purchase directly from the customer's to the merchant's account.

The dynamics of the development of this system were very different from the dynamics of the credit card system. Since it ran on the same infrastructure as the bank card, the same card that was already issued to all bank account holders could be used. Thus it was not necessary to sign up users. The bank card was simply redefined as a debit card. The technology of the card itself did not change at all. What changed was the environment that supported the card. It grew considerably. Instead of connecting only a few thousand ATMs, more than 80 000 merchants had been added to the network when it reached national coverage in 1994, two years after it was first tested on a regional scale. After some initial reservations, the debit network grew significantly both in number of payment interfaces (POS terminals and ATMs) as well as in the volume of transactions. It has become an international success story: in 1998, Canadian had the highest per capita use of debit cards and ATMs in the world (Sinclair 1998).

The growth was accelerated by various factors. First, the debit card network was simply an expansion of the existing ATM network, which itself could take advantage of the automated interbank clearing system which had been set up in the early 1980s to facilitate settling accounts among the large banks. Technically, it was a relatively smooth expansion of the existing infrastructure, to which new elements were simply added. Institutionally, the small number of participants made it easier to agree on an integrated shared infrastructure that could be centrally coordinated, through a specialized joint venture. This ability to coordinate the introduction centrally also made it easier to support with various national advertisement campaigns. Furthermore, there was no chicken-and-egg problem. Millions of cards were already issued and used at ATMs throughout the country. New was that these cards could be used at more places. There are, possibly, specific Canadian cultural values that contributed to the rapid acceptance of the debit card. As one observer wrote, in Canada "the fear of debt is very strong. In many cases it overrides the free use of the bank's money for up to 10 days for those who use credit cards and pay off their bills before the payment

deadline" (Whithington 1997). This opinion has been repeated many times (e.g. Baglole 1998; Mahood 1999) but it remains speculative. However, cross-cultural studies of electronic payment systems have shown that they are significantly shaped by cultural factors (Singh 1999).

Although cash and paper cheques remain the two most frequently used forms of money in the everyday life of most people, a vast interconnected network has been put in place since the 1960s. In the early 1990s this network allowed the holders of the appropriate identification to access their money remotely using a variety of instruments through millions of entry-points.[55] Over the course of more than thirty years, the experience of money has been shifting more and more from metal and paper to plastic and electronic impulses. The virtual money system was established as an reality of the daily life for everyone, including those who were excluded from it, and physical cash was effectively stigmatized for all but low value purchases (Weatherford 1997).

As the virtual money system expanded, some of its artifacts assumed importance beyond the financial sector. In North America, for example, the credit history began to play an important role in a growing number of settings that were not directly related to virtual money. Originally created as one of the many ways to reduce losses in the credit card system, the credit history, became, next to the driver's license and the social security number, one of the central means of identification and assessment of individuals, almost like the criminal record. As the virtual money system consolidated, the way it classified people grew in importance. Not belonging to it, as expressed in not having a credit history, or having a "bad" credit history, added new layers of discrimination against the already excluded. The credit history became a document routinely asked for, for example by landlords

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[55] In 1991, the most popular credit card, VISA, was accepted in more than 2.5 million locations.

screening future tenants. The credit history assumed such importance that the rights of the individual to access and, if necessary correct it, had to be defined by law.

No form of money ever disappears completely. Even commodity money is still being minted. No longer commonly accepted as payment, it turned into a collector's item. Cash and various forms of paper-based money continue to be used frequently, however, the range of situations in which they are commonly used as payment is shrinking. The virtual money system has taken center stage. The bulk of money has become electronic impulses circulating through the networked accounting systems of large financial institutions.

Historically, each new form of money was closely related to an enormous shift in the way money was used. New types of money represented, and accelerated, the transformation of the society that used them. The introduction of *commodity money* enabled the emergence of an economy beyond the barter and subsistence levels and thus contributed to the differentiation of society and culture: villages changed into towns. *Money on account* enabled not only the economy to grow, but also facilitated the connection of regional economies through long-distance trade. *State credit money* facilitated the integration of the growing economies and societies into nation states, administrated by very large bureaucracies, both in the public and private sector. Virtual money signals the emergence of a new environment. Both on an institutional and a personal level, a myriad of interfaces promises to deliver the new global culture of virtual money: "Anytime, Anywhere." In this culture of electronic ubiquity, physical objects, coins and bills, and the people using them, became to be seen by some as an anachronism, and, for the increasingly computerized financial industry, a costly one at that. In the early 1990s, the appetite of the financial industry to replace costly coins and bills with something more efficient and profitable, electronic cash, was growing.

4. Technologies of electronic cash

4.1 Definitions
4.2 Technologies of smartcards
4.3 Stored value cards, a brief overview of the field
4.4 Mondex: technological layout

The technical development of electronic cash, and the hopes of cutting down on expensive cash management by expanding the instruments of virtual money, gained significant momentum in the mid-1980s in the wake of the maturing of three independent technological developments: cryptography, the Internet and smartcards.

First, in the late 1970s and early 1980s, new encryption techniques were developed, publicized and tested which could be used for the secure and private transfer of electronic cash, most importantly, public key cryptography (Diffie & Hellmann 1976; Rivest, Samir, Adleman 1978). Until then, the same key was used to encrypt and to decrypt a message (symmetric encryption). Public-key cryptography solved one of the most vexing problems of cryptography, the so-called key management problem. At the heart of this problem was the question of how to share secure encryption keys over insecure communication channels.

In public key cryptography, rather than using only one key, each person holds a pair of keys, one called the public key and one called the private key. Each person's public key is published and easily available, while the private key is kept secret. The need for the sender and receiver to share secret information is eliminated; all transfers involve only public keys, and no private key is ever transmitted or shared. No longer is it necessary to trust the communications channel to be secure against eavesdropping or betrayal. The only requirement is that public keys are associated with their users in a trusted (authenticated) manner, for instance, in a trusted directory in a PKI (Public Key Infrastructure) system. Anyone can send a confidential message

by using the addressee's public key to encrypt a message so that it can only be decrypted with the associated private key, which is in the sole possession of the intended recipient. Because to different keys are used, this is also called asymmetric encryption. Furthermore, public-key cryptography can be used not only for privacy (encryption), but also for authentication (digital signatures): A sender encrypts a message with his or her private key which can only be decrypted with the associated, unique but freely available public key, thus proving that the holder of the secret key encrypted this message (RSA Laboratories 1996, pp. 17-18).

Second, the development of computer networking and the spread of computers into the general public inspired visionary researchers to work on the problem of secure and private payments for everyday use over insecure networks (Chaum 1983). This strand of research and development was greatly expanded in the early and mid-1990s when the Internet grew into a mass medium and development of new payment systems was viewed as a central element for developing electronic commerce (Lynch & Lundquist 1996, Negroponte 1995, Wayner 1997).

Third, smartcard technology had developed to the extent that its first mass implementation was undertaken: by France Telecom in 1984 (Fancer 1996). The smartcard provided what appeared to be a well-suited platform to develop an electronic cash scheme for the general public.[56]

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[56] The idea of a chip card dates back to 1968 when the first patent for the incorporation of a chip into an ID card was filed in Germany. A similar patent was filed in Japan in 1970. The two patents, however, focused mainly on the embedding of the chip, rather than its functionality. In 1974 a French journalist and inventor, Roland Moreno, filed a new patent which focused more on the functionality of the chip, a focus that began to be practical since the semiconductor industry was able for the first time to supply the necessary chips at a price that encouraged further experiments. In the same year Moreno funded the Societé Internationale pour innovation (Innovatron). However, it took another 10 years before the first mass application of this technology was released. Currently most chip card manufacturers are licensees of Innovatron.

These three developments contributed to the creation of reliable cryptographic protocols. They also fuelled the emergence of two possible platforms for electronic cash – Internet and chip cards – were almost completely independent from one another. Furthermore, each was developed outside of the financial industry and without reference to its long-standing interest in furthering the cashless society (Anderson 1966; Richardson 1970).[57] The emergence of these technological options, however, stimulated interest in electronic cash within the financial industry and propelled its development from theoretical papers circulating in the small circles of cryptographers and futuristic bankers to a more central position in the development of the new information infrastructure.

4.1 Definitions

Fueled by the resurgence of interest in electronic cash in the early 1990s, many attempts were made to define technically what should, and should not, be called electronic cash and the properties the to-be-developed system must realize (Camp, Sirbu, et al. 1995; Chaum, Fiat & Naor 1990; Okamoto & Ohta, 1991).

The Bank for International Settlements, for example, defined electronic money

> as 'stored-value' or 'prepaid' products in which a record of the funds or 'value' available to a consumer is stored on an electronic device in the consumer's possession. The electronic value is purchased by the consumer...and is reduced whenever the consumer uses the device to make purchases. In contrast to the many existing single-purpose prepaid card schemes (such as those offered by telephone companies), e-money products are intended to be used as a general, multipurpose means of payment. Moreover, the definition covers both prepaid cards (sometimes called "electronic purses")

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[57] While there is no direct relationship, there is an indirect link inasmuch as the financial industry was one of the first heavy users of computing equipment and security applications, thus playing an important role in development of the computer industry and of computer security in general. (Beniger 1986; Hamelink, 1994; Schiller 1999)

and prepaid software products that use computer networks such as the Internet (sometimes referred to as "digital cash"). (BIS 1996)

There was debate over whether the term *electronic cash* might be more appropriate than the term *electronic money*. On the one hand, the emphasis on cash highlighted that the emerging technologies were intended to be used in a manner similar to coins and bills for casual, low-value payments. On the other hand, the term electronic money had the advantage of being more generic. It was less prone to perhaps misleading analogies, since electronic money could have properties that were very different from physical cash. In practice, both terms have been used interchangeably (see, for example, Lynch & Lundquist 1996; Wayner 1997). I use electronic cash to denote specifically those products aimed at low-value purchases, whereas term electronic money refers to the entire variety of (possible) electronic payment instruments involving direct value transfer.

Like coins and bills electronic cash is value itself. Hence, the fundamental difference between electronic cash and other electronic payment tools is that "currency and other kinds of e-cash store and convey value in and of themselves rather than merely representing value residing elsewhere, such as a deposit account" (ter Matt 1997). Electronic cash aims to integrate cash into the virtual money system that has developed over the last 30 years by converting value stored in coins and bills into electronic impulses stored in a smartcard- or network-based system.

The BIS definition of electronic cash was the broadest one possible, including only two characteristics: it must be electronic value rather than electronic information referring to value, and it must be useable as a multipurpose means of payment. This excluded credit cards on the one side and single purpose systems such as prepaid phone cards on the other. The different electronic cash systems were all located in the space between these two end points. Conventionally, the technologies of electronic cash are divided into four basic categories dependent on authentication mechanisms and platform.

Felix Stalder   [102]

Authentication concerns one of the central problems for any electronic cash system. How can it be made certain that only legitimate transactions take place? The legitimacy of a transaction depends on a) that value cannot be forged or spent more than once (security), and b) that the entire transaction, once taken place, cannot be disputed. There have been two basic approaches to authentication: on-line and off-line.

• On-line transactions require interaction with a bank or other "trusted third party" (via modem or network). On-line systems prevent fraud by requiring merchants to contact the bank's computer with every sale. This is similar to the way merchants currently verify credit cards at the point of sale. The record held at the third party can also serve to verify that the transaction has really taken place if this is disputed.

• Off-line transactions are conducted without having to involve a "trusted third party". Off-line electronic cash systems prevent fraud through a combination of hardware (smartcards) and encryption software that should make it impossible for an unauthorized party to create electronic cash and insert it into circulation. Off-line systems also keep a (limited) record of the transaction locally which can serve to verify the transaction for dispute resolution. [58]

Credit cards, for example, create on-line transactions because using them involves one or more third party. Coins and bills, on the other hand, enable off-line transactions because no third party needs to be involved to authenticate, clear, or record the transaction.

The second important way to classify electronic cash proposals has been to differentiate between *network-based* and or *card-based* products (see, for example, Furche & Wrightson 1996). A network-based electronic cash system

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[58] The use of the terms on-line/off-line has nothing to do with the now popular use of the terms on-line in the context of the Internet. A transaction which does not require central clearing is off-line even when it is conducted on-line, over the Internet.

is designed to be used on computers that are part of a communication network (for example the Internet or an Intranet). The computer's hard drive can be used as the storage device for value, usually through some type of "electronic wallet", a client-side application that contains the value. Card-based electronic cash products, on the other hand, always involve some kind of "smartcard", a chip card that not only stores the value but also all the necessary programs to communicate with other chip-cards, if they are compatible. Such cards are commonly called *stored value cards* (SVC) or *electronic purses* (BIS 1996). In the following I will concentrate exclusively on smartcard-based technologies.

4.2 Technologies of smartcards

Smartcards are credit card sized plastic cards with a microprocessor. To activate the software stored on the chip, the card needs to interface with a card reader. Smartcards serve as portable devices for applications that require individual identification and a high degree of security. Technically, smartcards are defined by ISO (International Standards Organization) standards sets 7810 and 7816.[59] The former defines the physical properties of the card itself (dimensions, flexibility, temperature resistance, etc.), while the latter defines the chip and the electronic module (location on the card, location of the contacts, basic electronic characteristics of the chip, transmission protocol, data structure, etc).[60]

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[59] ISO comprises national standardization bodies (such as the Canadian Standards Association, CSA). The International Electrotechnical Commission (IEC) also works on standards in the field of electronics. In many cases the two standard sets have been combined and are often referred to as ISO/IEC standards. ISO/IEC have a Joint Technical Committee (JTC1) which looks after computer related standards. Within JTC1 there is a sub-committee 17 (SC17) which looks after Identification Cards. SC17 has six working groups (WG) below it. WG4 is involved in the standards for Contact Integrated Circuit (IC) cards whilst WG8 is working on contactless IC card standards (Banerjee 1997).

[60] For a comprehensive standards list, see Rankl & Effing (1996, pp. 397-409) and Banerjee (1997).

Figure 1: Schema of the physical elements of a smartcard
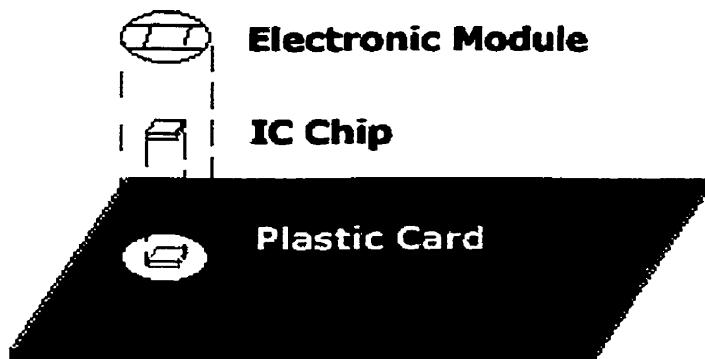
Source: CREC/KPMG (1998)

Four types of smartcards are commonly differentiated: the memory card, the microprocessor card, the "super" smartcard and the optical card (Bright 1988; McCrindle 1990). Memory cards are the most simple, their main attribute is storage capacity. They contain no processing or significant security capabilities. The main difference between a memory card and a magnetic stripe card is that the former can store larger amounts of information (several hundred kilobytes vs. max. 220 bytes) and are more robust. Such cards are usually optimized for a particular application, for example a prepaid telephone system such as Bell's QuickChange.

What is commonly referred to as a smartcard is the micro-processor card. The central element of this type is a full-fledged micro-processor, consisting of the CPU (central processing unit), the ROM (read only memory), the EEPROM (electrical erasable read only memory) and the RAM (random access memory). The ROM contains the chip's operating system (OS) and is etched during manufacture. The ROM's content is identical for all chips of the same production run and cannot be changed during the lifetime of the chip. The EEPROM is the chip's non-volatile memory, to and from which data and also program codes may be written and read under the control of the operating system. Information stored in the EEPROM can be changed dynamically. The

RAM is the chip's working memory, where the actual processing of data takes place. This is volatile and all the data stored here is lost when the chip's supply voltage is switched off (e.g. by pulling the card out of the terminal during a transaction). The typical architecture of a microprocessor is similar to that of a personal computer.

Figure 2: Typical architecture of a card microprocessor
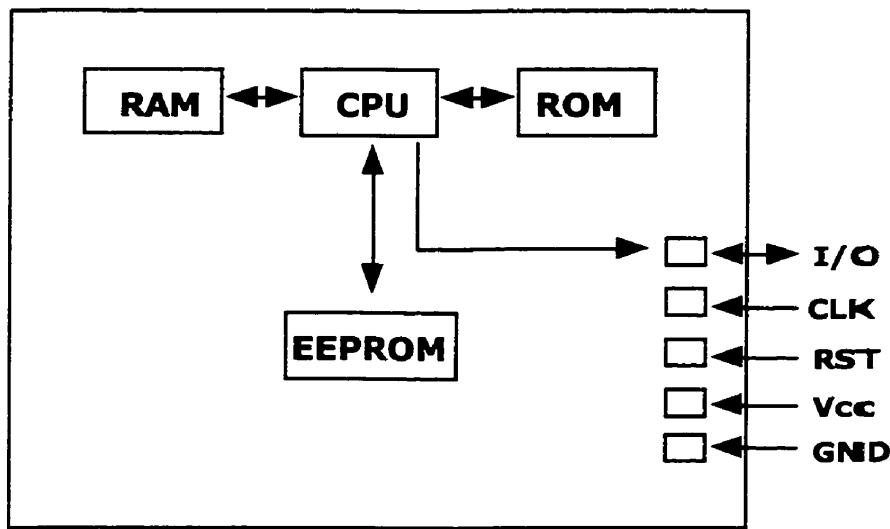
Source: Rankl & Effing 1996 p. 14[61]

A smartcard does not carry its own power supply. To activate the processor, the card needs to receive power from its environment, usually a reader into which it has been inserted. However, there are also *contactless smartcards*. These need only to be brought within the range of an electro-magnetic field (up to one meter radius) and operate in the low frequency (LF), high frequency (HF) or microwave (MW) spectrum (Zoreda & Oton 1994, p.52).[62]

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[61] The 5 boxes on the right side indicate the contacts through the connection between the card and the reader. I/O (Input/Output) is used for communication. CLK (Clock) carries the timing signals, RST (Reset) resets the card upon insertion. Vcc is the contact for the power supply (standard is 5V) and GND (ground) is used a reference voltage.

[62] Contactless cards that work on a longer range contain their own power supply (e.g. those used in road toll systems).

"Super" smartcards are micro-processor cards with a (very small) key-pad and display. Optical cards are not really smartcards by strict definition since they require no chip. They are used for storage only and rely on principles similar to CD-ROMs. In the following, I will use smartcard as synonymous with micro-processor card.

A smartcard consists of three materially distinct layers. The non-electronic layer includes the plastic card and the printing on the card defining the visual "user interface". The hardware elements are the chip and electronic module. The software layer consists of two functions: the operating system (OS) and the application(s). Depending on the type of smart card, the OS and the application can be written as single piece of software or they can be developed as two separate pieces of software, similar to the way the OS of a PC is separate from any specific application.

Even though the smartcard architecture is similar to that of a personal computer, the two types of computer are different in important ways. The operating system of a smartcard has no user interface, cannot access external data storage media and is completely static, that is, once etched onto a chip, it cannot be changed. It is etched into the chip itself. This is not only because of the limited resources on a smartcard, but also because they are optimized for very specific purposes. For smartcards, "the first priorities are secure program execution and protected access to data" (Rankl & Effing 1996, p.101).

The security of smartcards arises from two aspects. First, the hardware itself can be made tamper-resistant by optimizing the physical architecture of the chip and the logical architecture of the operating system. Second, the card can check the authenticity of devices with which it communicates. Due to its passive nature, a magnetic stripe card cannot perform any checks on the device with which it interacts. Smartcards, on the other hand, can be used to authenticate one another and do not necessarily need to be connected with a

back-end system. This, however, creates new security risks since, depending on the system, both cards can be "in the open", that is accessible to attacks in a hostile environment, e.g. hacking attempts carried out in a well-equipped laboratory (Anderson & Kuhn 1996). No system is ever entirely secure for a long time. If a successful method of attack is detected, countermeasures against it are incorporated into the next version of the technology, thus "resulting in the well-known cat-and-mouse game of measures and countermeasures, attack and defense" (Rankl & Effing 1996, p.268). The security of a smartcard is built on several levels (hardware, OS, application) and they are dependent on one another. If one is breached, then the entire system is compromised.

The dynamics shaping the development of smartcards have continued to be rather fluid, despite more than thirty years of development. The power of the chips has continued to increase, parallel to the increase of computing power in general. In the mid 1990s, most of the implemented smartcard systems used 8-bit processors, while later ones used 16-bit. 32-bit processors have already been developed but are not yet widely implemented. Each chip upgrade offers new opportunities to develop more, and more extensive, applications for the smartcard platform, as well as to incorporate more sophisticated security software that requires more processing power. At the same time, knowledge and equipment to (re)engineer smartcards is becoming more available and new ways to attack the integrity of the information stored on the cards are being developed (Anderson & Kuhn 1996; Schneier & Shostack 1999). The cat-and-mouse game continues.

4.3 Stored value cards, a brief overview of the field

In the second half of the 1990s in almost all of the highly developed countries, and some technologically less developed countries, some form of stored value cards was implemented. In some places as limited trials, in

others on a national scale.[63] European countries were leading in development and implementation. The first SVC ever implemented was the Danish Danmønt system launched in late 1993. The system was based on disposable cards that could not be reloaded. It was licensed by VISA and used in the 1996 trial during the Olympic games in Atlanta. Most of the early electronic cash schemes were national in scope and using proprietary technology incompatible, not only across borders but also within countries, for example, France, where more than one e-cash system existed.[64] There were significant differences among the countries, both in terms of the technologies used, and the state of implementation. However, acceptance of the schemes remained very low in all of them during the entire 1990s (Birch 1998; CPSS 1996, 1999; Böhle, Rader & Riehm 1999;   Van Hove 2000b).

The Proton system was the most widely implemented technology for stored value cards in the late 1990s. It was developed by a consortium of Belgian banks and launched in February 1995. It has been being used in Australia, Belgium, the Netherlands, Sweden and Switzerland, and licenses have been sold for 15 other countries, including Canada. More than 30 million Proton cards were issued in its first 5 years.

The Proton system is based on memory cards and incorporates more advanced security features than its Danish counterpart. The Proton system does not support transfers among consumers. All transactions are cleared through the central computers of the issuers. Hence, the system is fully accounted and transactions can be easily de-anonymized with a reference

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[63] As of late 1999, stored value systems have been tested/implemented in at least the following countries: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Finland, France, Germany, Ghana, Guatemala, Honduras, Iceland, Hong Kong, Italy, India, Ireland, Israel, Japan, Kenya, Kyrgyzstan, Luxembourg, Malaysia, Mexico, the Netherlands, New Zealand, Nigeria, Norway, Poland, Portugal, Puerto Rico, Russia, Slovakia, South Africa, South Korea, Spain, Singapore, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, United States, Uruguay, and Venezuela (Van Hove 2000a).

[64] Card Technology, December 13 - December 17, 1999, Summary <http://www.cardtech.faulknergray.com/stor.htm#31>

transaction, for example, when the card is loaded at an ATM. Because the system is fully accounted, it is possible to see if there are any sources of illegitimate insertion of money. While this makes the system highly secure, it also makes it highly privacy invasive, similar to credit and debit cards. In the Proton system complete accountability is necessary not only for security reasons, but also because each issuer creates its own value, which makes interbanking clearing necessary if the merchants wants to redeem value at one bank that has been issued by another bank. A similar, though incompatible system, *Geldkarte*, has been implemented in Germany since 1997. More than 40 million magnetic stripe debit cards with micro-chips for stored value have been issued.

At the end of the 1990s, the initial diversity of systems began to diminish. Many proprietary systems were abandoned. In June 1998, several major global financial institutions, including VISA and American Express, adopted the Proton standards. In July 1998 a new technical standard was announced in order to allow for interoperabilty of so far incompatible schemes: the Common Electronic Purse Specification (CEPS).[65] After its announcement, CEPS was adopted by VISA and various other issuers. Together they represented 90% of the installed base at the turn of the century.[66] CEPS aimed to enable full interoperability among the various schemes, so that value could be transferred among the cards of various issuers (Van Hove 1999a).

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[65] CEPS defined requirements for all components needed in a globally interoperable electronic purse programme, while maintaining full accountability and auditability. CEPS, which was made available in March of 1999, outlined overall system security, certification and migration. CEPS aimed to create an open, de facto, global electronic purse standard.

[66] CEPS has been, or will be, adopted by the ZKA (Zentraler Kreditausschuss, which represents the German banking industry and operates the Geldkarte scheme); SERMEPA (the technology subsidiary of Visa España, which operates the local Visa Cash program); SSB, the Italian electronic purse operator; Swedish banks supporting the Cash purse scheme; NETS, Singapore's national ATM and debit card processor and operator of the CashCard electronic purse scheme; the French Groupement des Cartes Bancaires, and Europay Austria, which operates the Quick scheme (Van Hove 1999a)

Effectively, CEPS consolidated the field of stored value cards into two camps. In one were several independent national and international schemes agreeing on a common standard to create interoperability among their fully accounted and centrally cleared systems. In the other was a single system with global aspirations: Mondex.

4.4 Mondex: technological layout

Mondex is a software application designed to create, store and transfer electronic cash using dedicated smartcards.[67] On the level of the smartcards, the entire Mondex system consists of four differently configured types of cards that are ordered into a "hierarchical purse class structure" (O'Mahony, Peirce, et al. 1997, p.185). These are all able, to varying degrees, to accept, store and distribute money. The hierarchy of the classes is defined by the capabilities built into the cards and the associated roles of the holders of each type of card in the Mondex system. The holder of the first type of card is called the "Originator". Its function is to create (and destroy) value. This is similar to the function of a mint in the circulation of coins and bills. In contrast to the mint, the Originator needs no physical raw material such as metal or paper. It creates value literally out of nothing, by writing it on its specially configured card. The card of the Originator is configured not only to create money without transfer, but also to hold very large amounts of value. It is only able to exchange value with cards of the second type, bank cards. Bank cards are also configured to hold large amounts of value, but they can exchange value with all other cards in the Mondex system. The third type of card is the merchant card. These are configured to hold large amounts of value and they can accept value from consumers, but they cannot, or only to a very limited degree, distribute money back to consumers or to other

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[67] All the specifications which describe Mondex communication protocols and security algorithms are confidential and proprietary. At the time of writing, they are not available in the public domain. This permits only a rudimentary description of the system. In the following, I will analyze the conceptual architecture of the system as it has been published by Mondex and/or in the technical literature (Furche & Wrightson 1996; O'Mahony, Peirce, et al. 1997; Rankl & Effing 1996). All of these elements are actors entangled in the network building process. Many of them have not yet stabilized and their definition causes considerable controversy, which I will examine in later chapters.

merchants. It is a design feature of the Mondex system that merchant cards can deposit their value only to an account held by a participating financial institution. Therefore, merchants cannot use their cards to make, for example, wholesale purchases from other merchants. The fourth type of card is the consumer card, which is configured to hold relatively small amounts of money (usually less than $1000). This card is in many ways the most versatile one. It can accept from and distribute to not only bank and merchant cards, but also other consumer cards. This configuration of cards shapes the flow of value within the Mondex system as shown in Figure 3.

Figure 3: Diagram of value flows in the Mondex system
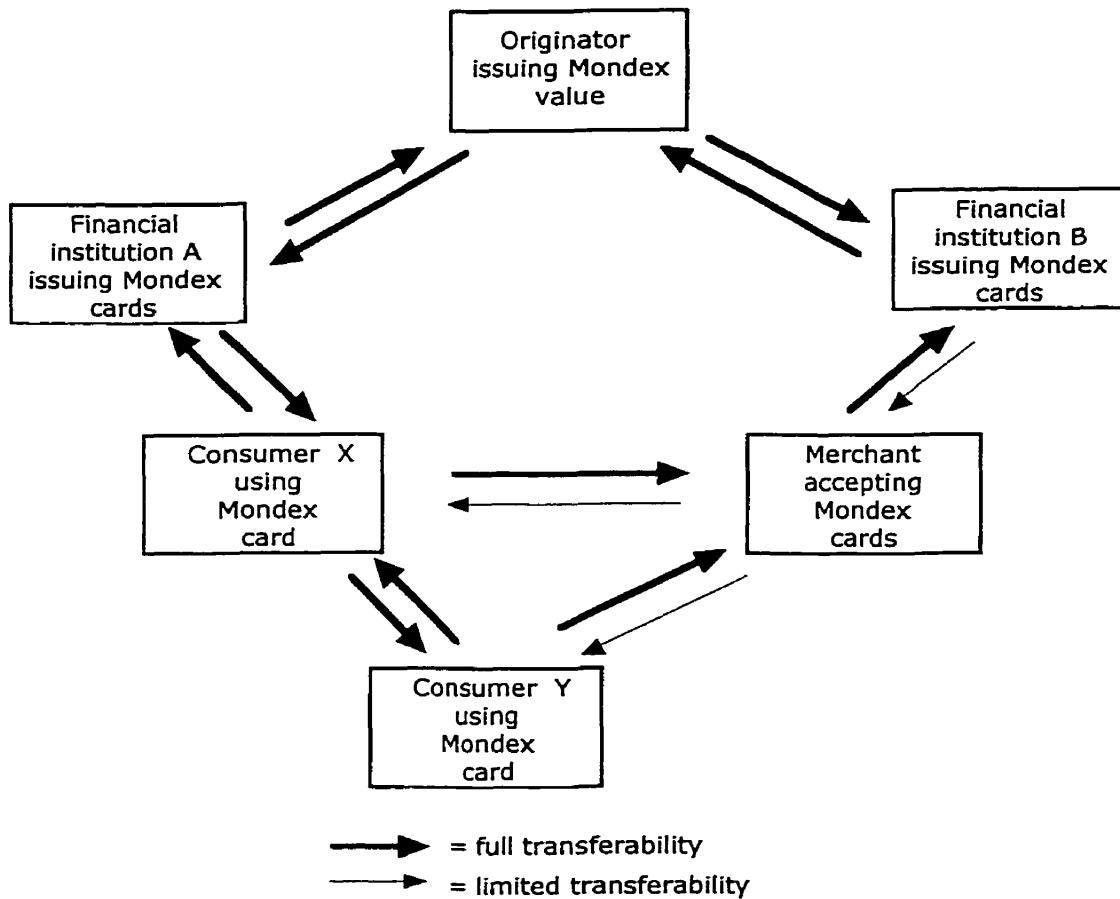
Source: adapted from Stuber (1996, p.15)[68]

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[68] Contrary to Stuber, I distinguish between full and limited transferability.

Full transferability means that the total of the stored value can be transferred, whereas limited transferability means that only fractions of the total value can be transferred.

The circulation of Mondex value begins with the Originator creating value. This value is then sold to financial institutions issuing Mondex cards. These, in turn, sell this value to consumers. Mondex is a stored value system, which means that before money can be spent it needs to be loaded into the Mondex card. If a transaction exceeds the amount of value stored on the card, it cannot be conducted. Consumers can transfer value to other consumer cards, to merchants or back to the bank. Merchants can give only limited amounts of money back to consumers, being required by the limitation built into their cards to deposit the bulk of the value back to the banks. The banks can then either sell value to other customers or sell it back to the Originator. Since there is only one Originator (per currency) there is no interbank clearing.

Mondex is a closed system in the sense that value can only be transferred from one Mondex card to another. Since Mondex allows transfer among cards that are not necessarily accounted for by the issuer, or another third party, Mondex is an off-line system. This off-line quality is unique to Mondex. All other major systems are on-line systems that require some form of central accounting of all money transferred among cards (Lynch & Lundquist 1996; Rankl & Effing 1996; Wayner 1997). However, while the transfers among consumers, and among consumers and merchants, seem to be unaccounted the system has some monitoring capabilities built into. Each card has a unique 16 digit identifier that is transmitted in every transaction. The consumer card holds a record of the last 10 transactions. The merchant's terminal holds a record of the last 300 transactions.

Furthermore, every time a consumer or merchant card comes into contact with a bank card a detailed record of the transaction is captured. Since contact with a bank card means either deposit to or withdrawal from a

deposit account, this record is, at least, as detailed as the one created when using an ATM for physical cash transactions. The division of the Mondex system into four card classes assures that the merchant cards and the consumer cards come in regular contact with the bank cards, and thereby the monitoring systems of the issuers. In addition, the consumer card has a built-in limitation which locks the card after an as yet undisclosed number of consecutive transactions without having been in contact with a bank card (Rankl & Effing 1996, pp.345-46). To unlock the card, it must to be brought in contact with a bank card (e.g. at an ATM).

To purchase a newspaper at a Mondex-equipped store, a typical example used in Mondex's promotional literature, the consumer inserts his or her card into the merchant terminal. The merchant then punches in the price – $1.20 – similar to the procedure of using a debit card, To approve the transfer of Mondex value, the consumer hits the "approve" button on the merchant terminal. Once the purchase is authorized by the customer, the value is transferred from his/her card to the merchant card stored in the terminal. The transfer takes 5-10 seconds to be completed, depending on the technological specifications of the equipment involved.

Figure 4a: A typical Mondex consumer card

Source: Mondex Canada

Figure 4b: A Mondex merchant terminal

Source: Hitachi[69]

Figure 4c: An electronic wallet for consumers
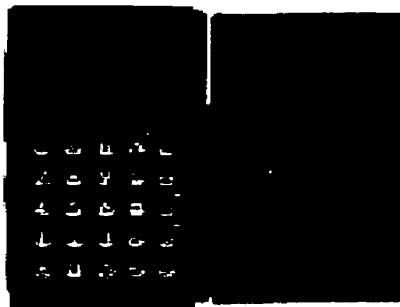
Source: Hitachi[70]

To transfer value both Mondex cards (the sending and the receiving one) have to be inserted in a hardware device: a smartcard reader. This reader can be stand-alone (electronic wallet, point of sale terminal) or connected to a communication network, either through the phone or a computer (Internet). The transaction between cards is schematized in Figure 5.

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[69] http://www.hitachi.co.jp/Div/nfs/devices/photo/vtt2.jpg [22.02.2001]

[70] http://www.hitachi.co.jp/Div/nfs/devices/photo/wallet.jpg [22.02.2001]

Figure 5: Flow of information during transaction

Figure 5: Flow of information during transaction
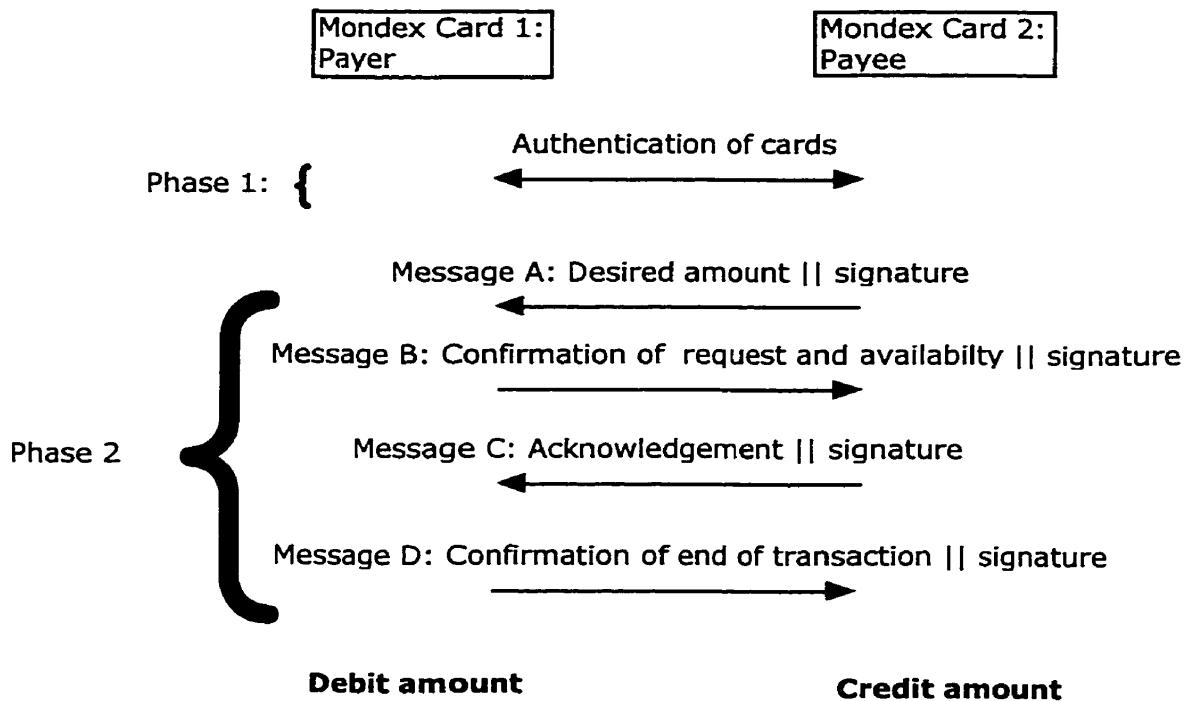
Source: adapted from Rankl & Effing 1996, p.346

In phase one, the two cards authenticate one another. They exchange their identity numbers and prove that they are valid by signing random numbers provided by the other. What kind of cryptographic algorithms are used is not disclosed, except that the more recent version of the Mondex technology use asymmetric encryption. They also exchange certificates through which they authenticate one another as legitimate Mondex cards. The Mondex system is algorithm independent, so it can switch between different signature schemes if necessary.

In phase two the payee asks for the money and signs a request (message A). The payer acknowledges message A and confirms that the funds are valuable by sending message B. The cards set the value aside and add this transaction to the list of pending transactions. The payee gets the acknowledgment (message B) and sends its own acknowledgment (message

C). This effectively finalizes the transaction. When message C arrives, the payer's card deducts the money: the details of the transaction are now moved from the list of pending transactions to the list of completed transactions. A new message D is sent confirming the end of the transaction. On receipt of message D, the payee adds the money to its ledger and moves the details of the transaction from the list of pending transactions to the list of completed transactions (Wayner 1996, pp.211-212).

Mondex value is not stored in tokens of various denominations, like coins and bills, but as a balance indicating the total amount only. Mondex, like most other smartcard based ecash technologies, is a "secure counter system" (Furche & Wrightson 1996, pp.31-32). From the outside, it appears as if value has been transferred, but it is more accurate to say that value has been symmetrically created and destroyed.[71] This has significant consequences for the security requirements of the system.

The sequence of messages B, C, and D guarantees the integrity of the transaction. If the transaction is interrupted and not all of the messages are exchanged, the transaction is moved to the exception log which can only be cleared by the card issuer. The exception log has a limited capacity and, if full, locks the card.

Whether this amounts to a secure transaction or not is subject to considerable controversy, partly because various parties have different concepts of what comprises security. This controversy will be addressed in detail later (Section 6.3), for now I focus on the layout of the security concept, independent of its merits.

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[71] If the balance of the card of the payer at the beginning of the transaction is B1, and after the transaction is B1', the value transacted is t, and the balance payee's card is B2 and B2' respectively, then $B1' = B1-t$, $B2' = B2+t$ and $B1+B2 = B1'+B2'$

The Mondex technology supports a three layered approach to security. The first layer concerns the *prevention* of intrusion, the second layer the *detection* of such intrusion and the third layer the *recovery* of the compromised system.

The *prevention* strategy relies on the two basic elements in the Mondex technology – the hardware of the chip embedded in the card and the software which controls the movement of value between cards. Mondex uses specially configured chips: in the early trials (1995-1999) Hitachi's H8/3102, in the later trials (1999-2000) Hitachi's H8/3109 and H8/3112. All cards released in the 1990s used 8 bit processors, with releases after 2000 being expected to use 16 bit processors. These chips are tamper resistant, that is, they have a special physical and logical architecture designed to make unauthorized access difficult (Rankl & Effing 1997). The second aspect of the prevention strategy is based on secret or public key encryption, depending on the chip, which makes it difficult to intercept and alter the information transferred between two card during a transaction. These two elements make it difficult, time-consuming and expensive break into the system, though, theoretically, it is not impossible to do so. However, this sets "the height of the wall", as John Beric, head of security at Mondex International, put it (Beric 1997). Furthermore, if the *exception log* is full the card is effectively disabled until examined and reset by an issuer. This is intended to disable cards that are implicated in unsuccessful attempts to compromise the security of the system.

Detection relies on the fact that whenever the Mondex card comes into contact with the financial institution, statistical data is collected upon which some behavioural analysis of the card's usage can be done. This provides the ability to determine the profile of individual cardholders and also comparative portfolio analysis of transaction flows with other similar types of customers. If a merchant card or consumer card is found to have unusual patterns of exchange with bank cards, the latter can instruct the former to lock itself and

the holder must present it to the issuer to redeem the value stored on the card. However, the issuer can lock a consumer or merchant card only when it comes into contact with a bank card. As long as a card communicates only with other consumer or merchant cards, and the logs are not full, then the card cannot be shut down. However, the flow of value in the Mondex system is structured with the intention of maximizing the number of contacts, particularly between the merchant and the bank cards.

Recovery of the system if its compromise has been suspected can be carried out in three ways. First, since the Mondex system is algorithm independent, it can switch among different encryption schemes. Indeed, the Mondex cards employing the second generation of chips store two sets of algorithms (with the corresponding keys) A and B. If it is necessary to switch to another key version or to use a different algorithm, an appropriate parameter is set in all smartcards that go on-line to the issuer's background system (all bank cards and a subset of the merchant cards). These cards in turn have the capability of setting this parameter in all cards with which they execute a transaction.

> This snowballing effect, due to the exponential increase in data distribution, leads within a very short time to a system-wide switch to the new global parameters. This would even be the case if the background system only modified the parameter in a single card. This is a very effective, fast and simple method of changing global data in a decentralized payment system. (Rankl & Effing 1997, p.345)

Such *software migration* is planned as a routine upgrade that can be initiated either according to a standard schedule or whenever perceived as necessary. Additionally, it is also possible to introduce software upgrades to cards by installing the upgrade on the bank cards, which will then automatically upgrade all the cards they come into contact with. However, these upgrades *on the fly* cannot cascade through the system in the same way as the switch from protocol A to B because each card needs to come directly in contact with a bank card. Furthermore, the physical cards are to be exchanged for

Felix Stalder

new ones on a regular basis, similar to credit cards, which have a life-time of only a few years.

The three layers that make up the security concept are playing off each other and are intended to make it economically unattractive to break the Mondex system. Given the possibility of unannounced changes in the software protocols, the resources that need to be invested to accomplish such a break would have to be recovered quickly by inserting large amounts of value into the circulation. If such large amounts were deposited in a bank account, they would create a unusual transaction pattern that could be detected through the statistical sampling done by the issuer.

Such is the basic concept of the security of the Mondex system. Whether or not this is sufficiently efficient is being debated, and this debate concerns, as I will show, not so much the Mondex chip as isolated technological artifact, but the specific configuration of many actors that make up the Mondex network. Consequently, even many of the seemingly technical characteristics of Mondex are determined through the card's specific position within the emerging actor-network of Mondex and they cannot be fully assessed in the artificial isolation of a technical blueprint. Tracing the emerging actor-network will be the subject of Chapter 6. First, however, some methodological considerations on how this tracing of the Mondex environment can be done.

One should never speak of "data" – what is given – but rather of sublata, that
is, of "achievements." (Latour 1999a, p.42)

5. Methodological considerations

5.1 A constructivist case study

Methodologically speaking, this study belongs to the broad category of "constructivist, interpretivist approaches" which, as a text book states, are generally concerned with "how particular actors, in particular places, at particular times, fashion meaning out of events and phenomena through prolonged complex processes of social interaction" (Schwandt 1994, p.118). Most studies of this category, including this one, aim at contributing to our *understanding* of the complexity of the lived world as it emerges through the interaction of various actors.

In this section I apply the label *constructivist* with particular reservations. Not only because my approach differs from more conventional *social constructivism*, as I have detailed in Chapter 2, but even more because of the differences between the present study and what is typically treated as *constructivist approaches* in the literature on methodology (Creswell 1994; Mason 1996; Schwandt 1994). In this literature, constructivist approaches and their methodologies typically aim at understanding the production of *meaning*. The focus of my study, however, lies on understanding the dynamics that shape a particular *effect:* the artifacts of Mondex electronic cash.

The main methodological implication of concentrating on effects, rather than meaning, is that actors no longer need to be cognitive subjects, capable of producing meaning, but can be anything that contributes to the generation of

Felix Stalder [121]

the studied effect. Hence, actors can be both humans and non-humans and it becomes necessary not only to account for people and their interaction, but also to include non-human actors that contribute to such interactions in characteristic ways. In the context of electronic cash, the most important non-human actors are technological artifacts.

But how does one account for non-human actors that, in themselves, do not have a voice or an intention? ANT's main argument, as we have seen, is that there is no ontological difference between the action of humans and of non-humans. Hence it is possible, and necessary, to account for them symmetrically by using the same theoretical vocabulary and the same methodological tools. The methodological advice that ANT offers, though, is rather basic: "follow the actors" no matter what their materiality is (Callon, Law & Rip 1986b, p.4). *Following*, in this context, means describing how an actor behaves in particular instances, how the actor interacts with other actors, how this interaction contributes, over time, to defining the characteristics of each actor, and how new actors are created and shaped in this process. The emphasis, at least initially, lies on describing "neither with fear nor with favour, what actors do" (ibid., p.5).

Typically, *following-the-actors* has been done in the setting of case studies. Most relevant to the work of this thesis are those studies that focussed on a particular technological artifact, or clusters of artifacts, and the socio-technological relationships they shaped. For example, on electric vehicles in France (Callon 1986a), on bicycles (Bijker 1994), on the development of nuclear missile guidance in the US (MacKenzie 1990), on a barrier at a university parking lot (Vigden & McMaster 1996), on patient record systems in hospitals (Monteiro & Hanseth 1998), on a subway system project in Paris (Latour 1996a), to name but a few. Most of these studies used a mixture of document analysis and interviewing to follow the actors. These are also the most important techniques used my study to generate data (see below, section 5.2).

Case study is also the format of the empirical section of this thesis that is concerned with the development of a particular artifact in a particular setting, Mondex electronic cash in Canada. Putting a technological artifact at the center of the case study does not imply that technological artifacts are the dominant actors, but it facilitates cutting across disciplinary boundaries by tracing connections, wherever they arise, among heterogeneous actors in relation to the focal artifact. For the case study, it is the proximity to the focal artifact that determines the importance of each actor. A case is a "bounded system" (Stake 2000, p.436) in which the boundaries are determined by the case's inner structure. It is the relation to the artifact at the center of the case rather than the boundaries of the discipline that determines whether or not an actor is to be included in the study. This makes it possible to conduct a transdisciplinary study and still retain a distinct research focus. However, my study is different from the ones quoted above in two aspects. First, this study traces the actors in real time, that is, I followed them around as they were engaged in an open-ended networking process, rather than reconstructing this processes after the fact. Second, artifacts and social actors were not locally bounded, but they were globally distributed. The communities in which Mondex was tested were only two of multiple sites that made up the environment of Mondex. The headquarters in Toronto and London, the hackers in the Netherlands, the complaint regarding the privacy-invasiveness of Mondex filed in the UK were also constitutive part of this process (see Chapter 6). Even though the focus of the study lies on the Canadian introduction, the process itself was irreducibly global and hence the actors had to be followed around the globe. Extensive use of the Internet made this possible.

Case studies have an intrinsic tension because, as Robert E. Stake put it, "the search for particularity competes with the search for generalizability" (Stake 2000, p.439). Each case is individual, but much of the value of a case study is gained by generalizing the research findings beyond the boundaries

of the case itself. Mondex electronic cash in Canada is both particular and representative for other cases. The case is particular, some of the actors are specific to the Canadian actor-network, but many actors are the same as in other Mondex implementations around the world. In the eyes of most of the social actors the Canadian Mondex case was representative for Mondex everywhere as well as for smartcard-based electronic cash in general. The banks even spoke of the first public trial in Canada as a global "showcase" (Mondex Canada, press release February 13, 1997).

Like in most heuristic, explorative studies, the research process of this thesis has been reflexive and reiterative, rather than linear, that is following a script that was defined before the research began (Creswell 1994). I began my research with open, explorative questions: What happens in the process of introducing Mondex electronic cash in Canada? How does the social setting change in the process of integrating the new artifact? In particular, does this affect civil society?

When I started the research in the mid 1990s, I expected, like most people in the field, that the development of electronic cash would be smooth: a more or less rapid roll-out of a stable set of artifacts. As the research progressed the full complexities of the relationships between human and non-human actors in the development of Mondex electronic cash came into view and the research focus was adjusted accordingly. Rather than focussing on a rapid adoption and its impact on society, the slow mutual adaptation of social and technological actors became the focus of research. Of central interest became the work of interdefinition among the actors and the difficulties of stabilizing the network in its original configuration. It was a reiterative process of observing the actions that constituted Mondex in Canada and developing the conceptual framework most appropriate to understand these actions. Finally, the research became to be guided, as already mentioned, by three interrelated questions:

- What is the relationship between technological innovation and social change in the development of Mondex?

- What are the political and social implications of the transformation associated with the still ongoing development of new technologies of money?

- How do these transformations around Mondex relate to broader socio-technological change?

5.2 Data generation

I purposefully use the somewhat unusual expression *data generation*, rather than the more commonly used *data collection,* because, as Jennifer Mason wrote,

> it is more accurate to speak of generating data than of collecting data, precisely because most qualitative perspectives would reject the idea that a researcher can be a completely neutral collector of information about the social world. Instead the researcher is seen as actively constructing knowledge about the world, according to certain principles and using certain methods derived from [his or her] epistemological position. (Mason 1996, p.36)

As already indicated, the main principle derived from the conceptual framework that underlies this study is the need to account for human and non-human actors. The data to analyze the environmental dynamics of Mondex electronic cash was generated through *following the actors* using a combination of techniques: document analysis, interviews and observation.

5.2.1 Document analysis

The most important method used to generate data was the collection and analysis of documents that were produced during the on-going work of (inter)definition and coordination among the various actors, and the ways in which they related one another. The Internet was the primary tool to collect documents. The websites of the main actors in industry, governments and the civil sector were surveyed over the entire period of time. Government

agencies and civil sector organizations, in particular, had virtually all of their publications available on-line. Contact with some of the actors and other researchers provided me with documents that were not available on-line but only published in difficult to locate printed sources (e.g Trusty 1998a; 1998b). These starting points initiated a snowballing process not only because of the hypertext structure of the WorldWideWeb but many of the documents explicitly referred to earlier publications. This made it possible to locate articles in highly specialized print journals (e.g. Chaum 1983). Several resources pages of other researchers working in the area of electronic purses (particularly, Van Hove 2000a) were very useful for locating further documents and getting a sense of completeness. Specialized search engines, such as the ones provided by the Financial Times[72] or by Moreover,[73] made it possible to scan for keywords (usually the name of the actor, e.g. Mondex or MULTOS) in a large number of targeted daily or weekly publications around the globe. This facilitated considerably the tracing of actors in real time. Close to 500 electronic documents, ranging from short articles to extensive reports, were collected.

The assembled documents fall into four categories:[74]

- *Technical documents* focussing on the description of non-human actors (technical books, proceedings of technical conferences, white papers, specification sheets, specialized news letters).

- *Public policy documents* aiming at determining the interest of various social actors, ways to balance them and assessing the impact of the non-human actors in affecting those interests (various national governments, national banks and international organizations such as the Bank of

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[72] http://www.ft.com/search/home

[73] http://www.moreover.com

[74] It is unnecessary to differentiate between print and electronic documents, since many documents existed in both formats, and, even if they existed only in one format, they routinely refer to documents of the other format.

International Settlements, BIS, or the Organization for Economic Cooperation and Development, OECD).

- *Publications by interest groups* trying to advance special interests or single issues (industry, consumer, civil rights, religious groups).
- *Articles in newspapers and journals* of various types describing and/or analyzing the unfolding events (trade and technical publications, mass media, academic journals).

The texts of the fourth category – articles in newspaper and journals – can be said to be somewhat different from the other documents since they were primarily written by observers aimed at describing the dynamics of the environment, rather than shaping them. They constitute what is conventionally called *secondary sources*. Secondary sources contain information collected by observers, researchers, journalists whereas *primary information* is thought to be generated by the actors themselves (Stuart and Kamins 1993). While this distinction can be useful in certain cases, particularly if there is a temporal distance between the primary and the secondary sources, it would have been of little use to maintain it in the context of this case study. On the one hand many actors produced texts that would normally be classified as secondary information sources because they were published in mass media (see, for example, DeLaurentiis 1999; Jones 1997). On the other hand, the development of a complex technological artifact is a highly reflective process and the actors themselves rely on scientific processes (e.g. surveys) to coordinate their actions (technical research, marketing). A marketing study, for example, is at the same time an analytic (secondary source) as well as a strategic (primary source) document. Similarly, even clearly strategic material, for example, press releases and promotional literature, contained frequent references to scientific studies or technical descriptions. Additionally, some actors, for example consultants, based their authority to act on the claim of being objective analysts (see, for example, Birch 1996; 1997; 1998). Finally, in a process that is highly influenced by public opinion any coverage in the mass

media is likely to feed back on the development it describes. All of this eroded the distinction between primary and secondary information sources in my case study to the point where such a distinction no longer fits the material it tries to describe.

The way actors defined one another did not always match in all the documents analyzed. On the contrary, significant debates were carried out over what the actual properties of the actors were and how they should, or should not, be developed. In these debates, and the disagreements over the shape of the actors that fueled them, the open-ended process of mutual shaping among the actors was carried out.

Building up stable relationships among these actors, or sets of actors, required a considerable amount of interdefinition. This interdefinition was sometimes smooth, with the involved actors readily agreeing on their respective identities. Sometimes this interdefinition was problematic and full of tension as the actors did not agree on the identity they were assigned by others or, which amounts to the same, they did not agree on the shape of the object-world to be created. As a researcher, I was fortunate that much of the activity of interdefinition, and the occasional controversies that ensued around it, took place in the public domain, or that at least traces of the interdefinition appeared in the public domain. It was therefore possible to base the document analysis primarily on material available in the public domain. The fact that so much material about Mondex electronic cash was available in the public domain was directly related to the characteristics of the actors that constitute the Mondex world.

First, Mondex electronic cash can only become a form of money if it is accepted and used by a large number of people, hence, it must, in some way, be visible to everyone. Contrary to a technology that aims at a select group of users, say neural networks to analyze the financial markets or military technology, the public needs to be engaged to some degree for

electronic cash to be successful. Actors have been making conflicting claims about one another and the emerging object-world, provoking reactions and counter-reactions that were, ultimately, aimed at the public, i.e. researchers, consumers, merchants and regulating agencies.

Though articulated, at least partially, in the public domain, these conflicting claims have not added up to a "critical public discussion" in the "public sphere" in any Habermasian sense (Habermas 1962). Many of the interventions have been strategic – that is goal-oriented rather than truth-oriented – attempts to shape the (inter)definition of actors. This should not be seen as a Machiavellian plotting of hidden agendas or a deplorable triumph of instrumental reason, but as an acknowledgment that even a technical academic paper is not only a description of a set of facts, but also a trace of the (attempted) creation and definition of a (non-human) actor.

Second, the Internet made it possible to retrieve pieces of this interdefinition no matter where it occurred – as long as a document was on-line.[75] This made it possible to (re)construct it as a single interdependent process even though the interdefinition has been and continues to go on in a decentralized, distributed and piecemeal fashion. A strong interest of the press in so-called leading-edge technology and e-commerce has generated a considerable number of accounts of various aspects of this process of interdefinition. Of course, not all of these accounts can be taken at face value and the reliability of (on-line) information sources varied considerably, but the redundancy of the data generating process provided a certain control mechanism or, at least, highlighted which of the claims were the most contested ones and required further examination.

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[75] The subject matter, a high-tech product, as well as the involved actors, tech-savvy and often with a strong interest in publicity or public awareness, have both contributed to putting a large number of documents on-line, sometimes even against the explicit intention of the document's author (see, for example, CIBC 1997)

Third, the regulator as an actor has produced a large number of policy documents in which this interdefinition of the actors has been discussed the some aspects of the development of the object world have been monitored and measured.

5.2.2 Interviews and observation

Of course, not all data necessary to follow the actors could be generated from publicly available documents. A second method used to trace the actors employed in this study was to allow them to themselves describe the path they have taken and the actors they have interacted with. This was done through interviews aimed specifically at supplementing and clarifying the conflicting claims that emerged from the document analysis.[76] Of course, non-human actors cannot be interviewed directly. However, similar to the way institutions that have formal spokespeople – employees that speak on their behalf – so can artifacts have (self-appointed) spokespeople. The engineers or marketing people who talk about the capabilities of a technological actor, its requirements and sometimes even its nature can be understood to be spokespersons. They were interviewed on behalf of the non-human actor they represented and whose development they promoted.

15 in-depth interviews were conducted with some of the central actors or their spokespersons, representing the operating system [I.7], the electronic cash application [I.8], Mondex Canada [I.1, I.2, I.3, I.4, I.5, I.14], the Originator [I.13], the regulator [I.10, I.11, I.12], student activists [I.9, I.15] and merchants [I.10]. Each of these interviews lasted between one and two hours. They were conducted as semi-structured interviews with open-ended questions (Fontana & Frey 1994). The interviews were taped and then

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[76] All interviews followed the research protocol approved by the human subjects review committee at the Faculty of Information Studies. In particular, all interviewees who are identified by the full name gave explicit consent to being identified in this manner. Some interviewees chose to be identified by pseudonyms only. Quotes from interviews are identified by square brackets containing the number of the interviews as listed in section 8.1.

transcribed. They were semi-structured in the sense that I used a list of written questions, however, the sequence in which they were asked changed according to the development of each interview, and I added questions to the list as it became necessary. Each interview had unique questions tailored to the actor interviewed (rather than a standardized survey or questionnaire). This was necessary because the interviewees were selected not to document differences among similar actors (for example, among staff members of various financial institutions), but rather to find connections among very different actors. This required a higher degree of openness in each interview. However, all interviews had a similar structure. Each began with questions aimed at the background of the individual speaking. The second set of questions was aimed at understanding the main lines of the development of the actor (e.g. the development of the Mondex ecash application, the Mondex Canada consortium, the students protesting). This served to establish the chronology of events and trace the changes of the actors in the process. The third part of the interview was devoted to mapping the various partnerships and relationships that each actor was most closely involved in. This brought into view what other actors were most important to the interviewed actor. The final part of the interview was a look ahead, how each actor anticipated that events would unfold in the near future. This served to gain an understanding of how each actor saw the current dynamics of the actor world.

Apart from these in-depths interviews I also conducted casual interviews with actors, particularly consumers and merchants, during three observational trips to the test sites of Mondex in Guelph, ON (1997, 1998) and Sherbrooke, QB (2000). These were shorter and unstructured and covered mainly the experiential side of encountering the Mondex electronic cash. The field trips were important to get a sense of the atmosphere of the different test sites and the way the new artifacts were encountered by their potential users.

Additional data was generated through email exchanges with actors and researchers in the field. Three of them generated enough additional data to be cited in the bibliography, Section 9.2, while others helped to uncover information sources that were then accessed directly or served to double-check information with other researchers.

5.2.3 Actors in the network

Which actors had to be followed in order to understand the dynamics of the development was determined by a kind of "snowball method". I began with the self-description that was offered on the websites of the various organizations devoted to the development of Mondex electronic cash. In these texts a host of additional human and non-human actors appeared. Following these actors, one encountered additional actors, which then led to further actors. Initially, the range of actors expanded quite rapidly, but as the research progressed, the new actors increasingly began to refer to actors that were already located within the network. This indicated a growing saturation of the number of actors that need to be traced. Over time four clusters of actors emerged as central to the understanding of the networks of Mondex electronic cash.

- The non-human actors such as the Mondex electronic cash card, the related technological infrastructure as well as other payment instruments.
- Mondex Canada, an association of major national financial institutions and part of a international franchising system, which has been providing much of the resources to initiate and sustain the network-building effort.
- The national and international regulatory agencies which have contributed, through action or inaction, to the definition of some of the characteristics of important actors.
- Consumers and merchants as they encountered the technology and decided to join the network or to stay outside of it.

The coordination among actors within each of these clusters was highly specific. The documents produced and the actors involved were connected by a specialized vocabulary. Like all specialized vocabularies, these had strong assumptions about which actors and which relationships were most important. While this allowed a highly focussed internal discussion among the actors, it made the connection of issues across these clusters very difficult, the classic trappings of specialism.

For the purpose of this study, which is focussing on the relationships across the distinctions built and maintained through such specialized vocabularies, it was important to transcend the boundaries thus established. To this end, I have broken down each document into small segments. The size of each of these segments was defined so that each segment contained information about a single actor and its relation to others.

In this process, I treated all data in the same manner, independent of whether it had been generated from documents, interviews, observation notes or email exchanges. This resulted in close to 500 text segments, varying in length from a few lines to a few pages, each containing information about an actor and a particular relationship to other actors.

I programmed a relational database (Filemaker Pro 3.0) to facilitate the ordering of these segments according to a simple classification scheme indicating - besides conventional categories such as author, document title, year of publication - the actor speaking, the actor(s) spoken of, and the date the statement was referring to (e.g. a condition in the past, or a desired/anticipated state in the future). This database was re-organized several times to accommodate the various actors as they became visible in the course of the iterative research process. Initially, only the actors mentioned in the original blueprint (Figure 3, p.112) where included: the Originator, financial institutions, the smartcard, consumers and merchants. As I started to trace the interactions of these actors, the cast became more

differentiated in the following ways. First, additional actors came into view, most importantly, national and international regulators and independent computer specialists, security experts and (potential) hackers. This latter group, which the original blueprint had assumed to be irrelevant and effectively marginalized due to the strength of the Mondex smartcard, insisted vigorously that the technological actor did not have this assumed ability and that they were relevant actors (see section 6.3). Second, what was assumed to be a homogeneous group of actors - consumers, for example - proved to be heterogeneous, and its members did not respond uniformly to the other actors in the Mondex network. While some consumers saw Mondex as quite convenient, others, quite literally, detected the presence of the devil (see section 6.5). Finally, the Mondex smartcard was not a black box as the original blueprint assumed. Rather, it was made up of three quite different actors - the chip card, the operating system and the application(s) - that did not easily fit together and had to be traced as individual actors (see sections 6.8 & 6.9).

In its final stage, the database generated one cluster of data per actor which contained every trace of the actor's actions I had generated, as well as the other actors' (attempted) action upon this actor, independently of the context from which this trace originated. So rather than reproducing the privileging of certain relationships built into the various specialist vocabularies, each cluster contained the heterogeneity of the relationships in which a single actor was implicated. However, since each document was also identified conventionally, it was possible to reconstruct, at any point in time, the position of each segment within the original information source.

In order to construct a narrative out of these clusters, the data in each cluster was ordered along two vectors. One was the different, matching or conflicting, definitions that existed of this actor which rubbed against one another in the process of interdefinition. This served the purpose of drawing

out the characteristics that each actor was supposed to exhibit in order to fit, or not, into the emerging object-world.

The second vector was provided by the chronology of events. The attempt to build up the actor-network of Mondex electronic cash has been very dynamic. Subjected to the process of interdefinition, actors changed their characteristics over time. Some became different actors. Merging the two vectors, that is, tracing the changes of actors in relation to one another over time provided the main direction of the case study's narrative.

In each cluster certain aspects of the interdefinition among the actors emerged as particularly contentious. Interested in the political and social questions that emerged from the Mondex project, I concentrated in these contentious aspects. The interdefinition of smartcard, financial institutions, and independent security specialists, for example, centered around the question if the card was powerful enough to marginalize hackers and secure the value flow through the Mondex system. Computer science provided the vocabulary through which the relevant characteristics of the actors were discussed. In order to account for the dynamics of this interdefinition, I integrated parts of the broader literature on computer security to flesh out the assumptions in, and the ramifications of, this debate (see section 6.3).

In the interdefinition of consumers, financial institutions and the smartcard, security concerns were less prevalent, in part because consumers and their spokespersons did not have the resources necessary (e.g. specialized knowledge, a lab and an ion-beam) to participate in the debate on computer security. Their interdefinition focussed, among others, on who would have access to the personal information generated by the Mondex card. Should it belong to the consumer only, or also to the bank? Where did one end and the other begin? The vocabulary in which this interdefinition was negotiated was that of informational privacy. Again, in order to map the ramifications of this

interdefinition I integrated relevant aspects of the broader literature on informational privacy (see section 6.5).

Each of these clusters was characterized by the dominance one or more particular vocabularies through which the interdefinition of some aspects of the actors that made up this cluster -was carried out, or at least, attempted (see chapter 6).

While the different aspects of the interdefinition of the actors were negotiated through specialized vocabularies, they were connected by the fact that these interdefinitions involved overlapping casts of actors. The smartcard, for example, was present in the vocabularies of security, privacy, as well as, monetary policy and stability of the payment system. The fact that most actors were present in several clusters made it possible to follow the various interdefinition processes carried out in different vocabularies and still integrate them into a single, coherent narrative encompassing the entire network.

5.3 Closure and trustworthiness

Each actor is simultaneously implicated in multiple networks. For example, electronic cash has been by no means the only payment system that consumers could use and consumers themselves are defined by much more than simply the way they pay for a product. Hence, every actor is part of many networks and therefore connected to a multitude of actors which in turn are connected to even more actors, and so on. This creates the immediate problem of how to limit the number of actors to be followed. Additionally, the trajectory of actors is long since the case study covers several years. Of this trajectory a potentially unwieldy amount of data can be generated.

The twin problems of the potentially unmanageable number of actors and the potentially overwhelming amount of data generated to account for these

actors point to the problem of when an actor-network study can claim *completeness*.

There are two main indicators for completeness. First, the number of actors stabilizes as the snowball method no longer yields additional actors but continually refers to actors that are already being followed. Nobody knows better than the actors themselves which other actors are directly important to them. Hence the snowball method, in which the informant, the actor, indicates which other actors are important to him/her/it is the central means of defining which actors should to be included. Even though every actor is connected to, and defined by, a multitude of other actors, not all of them are relevant in the context of a particular study. For example, most consumers are not influenced by their religion in regard to the payment system they use. Hence religion beliefs normally do not have to be taken into consideration for a study of electronic cash. However, a small segment of consumers considers smartcards as evil because of their particular reading of the bible. For them religion is directly relevant to how they viewed electronic cash and their relation to it (see section 6.5). Completeness, then, means completeness of capturing the relationship between the actor and the focus point of the research, rather than completely accounting for the actor in all of his/her/its dimensions.

Once the number of actors has stabilized, the question becomes how much data is necessary to account for each of them. An actor, for example a multinational bank, can be extremely complex, with a rich inner life that could yield potentially large amounts of data. Whereas the number of actors that make up an actor-network is determined by the actors themselves, the way that each actor should to be described depends on the interest of the researcher. Depending on the research question, different aspects of the actor are more important than others. While the actors stay the same independent of the researcher's intention, the way they are described must change in relation to the research question.

Ultimately, the resulting narrative must satisfy a number of criteria through which its quality as a *scientific text* can be assessed. Ian Hodder (1994, pp.400-01) lists four central characteristics that such a study needs to exhibit: *Coherence, Correspondence, Fruitfulness,* and *Reproducibility.*

Coherence is produced if the different parts of the study do not contradict one another and if the conclusions follow from the premises. Coherence is, on the one hand, a matter of standard argumentative logic. On the other, a requirement to present all the necessary elements that were used to reach the conclusions, and all the elements that are needed to argue why the conclusion are justified, or, perhaps, even imminent. Coherence is particularly important an indicator for the quality of a study if the field of inquiry is itself heterogeneous, and/or if various methods to generate data were used. Besides such an internal coherence, there is also an external coherence. How does the study relate to other studies in the various disciplines that it touches? This indicates the degree to which arguments of the study fit into the broader landscape of the discipline. The internal coherence of my thesis is based on the close relationship between the theoretical framework and the structure of the case study. Using the same terminology, both reflect one another. The external coherence is achieved by including other studies for the tracing of the actors of the Mondex network as well as of earlier environments of money.

Correspondence is closely related to coherence and indicates the degree to which the theory fits the data and vice versa. A study can be said to exhibit correspondence if the theory contributes to interpreting the data, or, if the data helps to support, or criticize, a particular theory. Furthermore, correspondence indicates that the type, density, and extent of the data support the type of claims made by the theory as well as their reach. This criterion is particularly important if the study sets out to produce theory, or to test an existing theory in the field. This study aims at a high degree of

correspondence. It is one of the main strengths of the theoretical framework to facilitate integrating coherently sets of data from very heterogeneous sources.

The *fruitfulness* of the study is related to the degree to which the study opens up new perspectives on the subject and generates further lines of inquiry. The study's potential to inspire other researchers to adopt some of the arguments made; its contribution to the shaping of the discourse of the discipline; the degree to which it contributes novel insights that are relevant to others; and the new areas for further studies that the study can suggest are all aspects of its fruitfulness. This study hopes to be fruitful in two respects. First by offering a new perspective on the role of technology in social change through the concept of the technological environment. Second, it aims to raise our understanding of the implications of the development of Mondex electronic cash.

Reproducibility, in the humanities and social sciences, has three aspects. First, can someone else, with the same premises and the same data generating techniques come up with a similar study and conclusion? The second aspect concerns whether the same researcher, or someone else, could arrive at the same conclusion using another theoretical model and another methodology to generate data. The third aspect of reproducibility is related to the study's potential to be conducted in a different setting. Can the research strategy, the theory as well as the data generating methods, be used to address a different question, perhaps even in a different field? Particularly this last aspect is closely related to the fruitfulness of the study, which is enhanced if the approach can be applied to more than just the case(s) for which it has been developed. This study aims to offer not only a transparent analysis of the Mondex environment, but also a template for the study of other technological environments. In this sense, to study is reproducible both for this case as well as its theoretical framework for other settings.

Felix Stalder   [139]

Coherence, correspondence, fruitfulness, and reproducibility ensure the *objectivity* of a study and with that its status as a scientific text. Objectivity in such qualitative research, however, is not marked by the detachment of the researcher simply gathering self-evident data to which s/he bear no relation at all. As Stephen Jay Gould argued,

> objectivity must be operationally defined as fair treatment of data, not absence of preference. Moreover, one needs to understand and acknowledge inevitable preferences in order to know their influence – so that fair treatment of data and arguments can be attained. (Gould 1981, p.36)

My preference for an inclusive civil society over an exclusive market-dominated society led me to this investigation and to the particular research question that drives it. While I tried to account for all actors fairly and respect all the data that was generated, rather than selectively force it into a preconceived framework, I must surrender to the critical reader the judgement whether fairness has been achieved in the following two chapters.

6. Emergence of the Mondex environment

6.1 Locating the work of translation
6.2 Arrival of the object
6.3 (Reverse) engineering the Mondex card (translation 1)
6.4 Creating the Originator (translation 2)
6.5 Enrolling consumers (translation 3)
6.6 Enrolling merchants (translation 4)
6.7 Transforming the financial industry (translation 5)
6.8 (Re)engineering the Mondex card (translation 6)
6.9 Beyond cash replacement (more translations)

In the previous chapter I have described the new technological system rather conventionally: a set of stable artifacts with unambiguous functionality and well-defined usage patterns. The *Diagram of value flows in the Mondex system* (Figure 3, p. 112) provides a concise high-level overview of the system architecture. A very similar diagram appeared in the only official Canadian publication dedicated to the subject of stored value cards, published by the Bank of Canada (Stuber 1996), and I have used it in previous publications on the subject (Stalder & Clement 1998, 1999). Mondex International itself uses a similar diagram in its promotional material.[77] The advantages of such a description of Mondex are exemplified by the very fact that it can be condensed into a simple neat diagram. However, these advantages are offset by a number of blind spots that such a conventional view introduces.

6.1 Locating the work of translation

The diagram, contrary to its simple appearance, is populated by entities of rather complex ontological status. These entities are hybrids: strongly bonded humans and non-humans. Even more vexing, when the diagram was drawn, in the second half of the 1990s, it was not clear that any of these hybrids existed in actuality. Rather, as the following closer examination will

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[77] Mondex International. The Structure of the Mondex System (promotional brochure, undated)

show, the boxes, drawn so tightly closed in the diagram, were wide open, some of them so wide they could hardly be considered boxes at all.

The figure shows a set of *black boxes*. As we have seen, a black box is any setting that, no matter how complex it is or how contested its history has been, is now so stable and reliable that it can be treated as a simple (arti)fact (Latour 1987). A black box acts as a single entity with a predictable input-output. We know what we can expect when we encounter it. What the diagram does not reveal, however, is that this *predictability* is the main achievement of a black box. Before a hybrid configuration of humans and non-humans turns into a readily available black box, the entities that make up the black box, as well as the network which produces the input and receives the output, need to be in place and stabilized. How this stabilization of the Mondex network would take place, if at all, was unknown at the time when the diagram already depicted it. In general, the process of stabilization of a network can only occur if its actors adapt to one another in such ways that they become mutually dependent on each other.

How, or if, such a mutual dependency would emerge and stabilize the Mondex system was, essentially, unknown. Additionally, it was unknown what shape the actors would take on in the process of mutual adaptation and hybridization. In short, the shape of the overall network was open. If those who created the *Diagram* could neither be certain that the interlocking of humans and non-humans into hybrids capable of building and maintaining the Mondex system would happen, nor how the different elements would be shaped in the process of mutual adaptation what, then, does this *Diagram* depict?

The diagram depicts an *ideal*, an end-state desired by the engineers of the system at the outset of its development. And the depiction itself, they quite sensibly expected, would help to actually achieve its uncertain goal. The diagram shows entities that the engineers wanted to create in order to

maintain the Mondex world. In this figure, the controversies that were a part of the process of the development of Mondex are already settled, the different actors have developed according to the engineers' plan. Their definitions are so deeply imbedded in the actors of the network that they become self-explanatory, that each hybrid element seems to exist without context.

The diagram is like a map that shows the desired destination, but is mute on how to get there. However, the destination that the diagram shows so clearly is itself dependent on the means of getting there. And this path is missing from the chart. Furthermore, the chart shows only one single destination, the one intended by the system's designers. However, at the beginning of the Mondex development, there was an unknown number of *potential destinations, potential futures* and advance knowledge about which would be realized was unavailable. Like any complex system, the stabilization of the actor-network of Mondex was extremely difficult, if not impossible, to predict. And the chart itself is not a neutral visualization of the technology. It implied certainty for a future that was, indeed, uncertain. Not that it was impossible to realize the particular set of black boxes that populated this chart, but it was only one of, perhaps, many possibilities. The network that might eventually emerge could be slightly different from the one depicted, or it could be so different that we would not recognize its relation to our figure.

Not assuming the reality of the black boxes makes it easier to see the work that went into assembling them in the face of all kinds of difficulties. Hence we can focus on the different dynamics that interact in shaping the emergence and (potential) stabilization of the network. Rather than assuming an all-or-nothing realization of a predicted future, we can see if and how potential networks were converging into an emerging network. Instead of a black-and-white picture of success or failure, we can trace the surprising, meandering directions that the different actors took as they became entangled in, or disentangled from the network.

A first, rather rudimentary step to focussing on the emergence of the Mondex network, rather than assuming its final shape, is to separate the most obvious social and technological actors. Not because they are independent, but to indicate that the specific hybdrization through which they contribute to the maintenance of the Mondex world would be an achievement that is to be explained. It is necessary to shift our perspective from a static survey of a binary condition (success/failure) to a dynamic view of gradual achievements.

In other words, we are required to be modest. Rather than starting with an analysis of a final condition of the network as if we knew the future, we must investigate the attempts to create the actor-network in the face of the meanderings of uncertainty.[78]

Figure 6 puts into focus the unpredictable process of joining, or hybridization, -ф- of human and non-human actors. And not simply joining in any way, but in such a way that the human and the non-human would become a particular hybrid, one that was part of the Mondex world. This, indeed, would be an achievement, because all elements are active and, to varying extents, unpredictable. Users, for example, might enthusiastically accept Mondex cards, not as a means of payment but instead as a collector's item to be safeguarded at home and displayed at trade shows. The established hybrid – the collector of smartcards – however would not contribute to the stabilization of the Mondex network as outlined above. Even though the card itself might have acquired stability by being turned into a museum piece.

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[78] Looking backwards on the historical development of bicycles Bijker (1994) advocated the principle of symmetry, which says that success and failure of different models *should* to be explained equally, that we cannot speak of innate qualities of the winning model that made it a winner. Looking forward, that is tracing the development of a technology as it happens, we can do nothing but embrace this principle because we cannot know which artifact will be successful, that is, which network configuration will stabilize.

Figure 6: Value flows in the Mondex system (social and technological actors) separated)
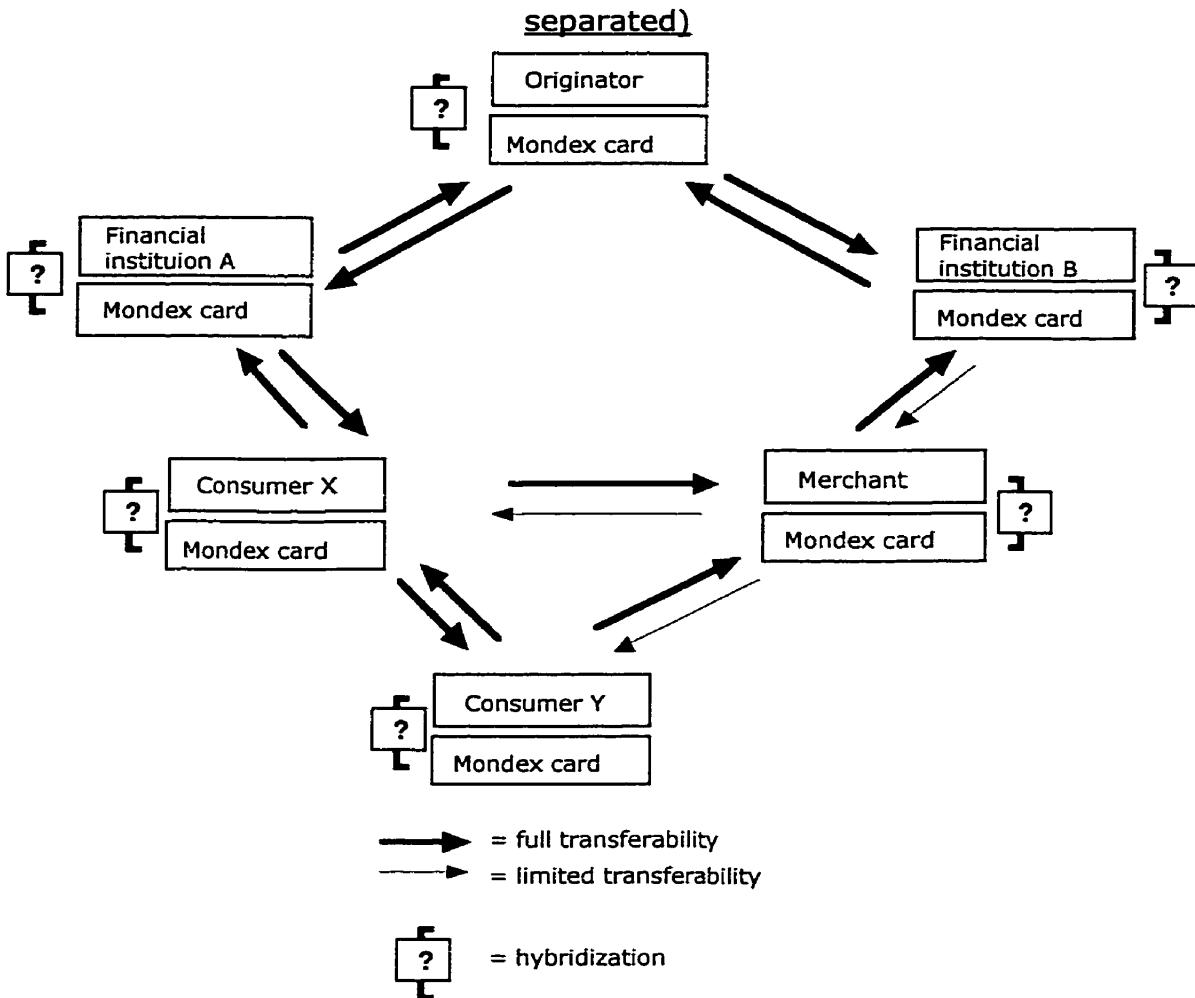
The above figure introduces a locale of action into our analysis of the Mondex world which has so far been entirely taken for granted: the process of joining the social and the technological. This is a first step, an as yet small crack in the black box that needs to be enlarged to develop a more comprehensive view of what has been happening in the emergence of the new artifact. *Joining* suggests that two entities are bonded together, like two freight cars coupled to one another in a train. This is a good expression insofar as it is active, and thus implies someone, or something, actively engaged in a process which would not happen otherwise. But the metaphor does not carry us very far because it does not include the notion that this connection can

only happen when the two actors adapt in ways that is conducive to their joining. Contrary to freight cars, which are designed to remain stable in the act of joining, actors in a network are defined and shaped by their relationships to other actors. As Bruno Latour puts it, "each element in a network is simply defined by the heterogeneous list of its associates" (Latour 1996d, p.303). Hence, the joining of actors with one another is a constitutive element in their (inter)definition.

One of the difficulties of building up and maintaining the Mondex network was that none of the preexisting actors initially fitted into the new network. The reason for this was simple enough. These actors had been shaped by and were part of other, well-established networks. The existence of an actor implies the existence of a network through which the actor's identity, that is, what the actor is and what he/she/it can do, is defined. Hence the building of a new network required these actors to change. They needed to loosen, perhaps even cut, some of the connections that had made up the network of which they were part of before Mondex came along, while, at the same time, forming and sustaining the connections that would be the new network. This transition would prove difficult, as certain connections were constitutive of the actor's identity and could only be changed with great effort. Other changes were barely noticeable.

An actor is rarely entirely new. New actors are most often created by translating already existing actors. This focus on translation does not mean that nothing ever changes. The translation can be a creative, productive process in which substantial innovation can occur. There are new actors, but even they have a history: as we have seen, existence precedes essence. Hence, there is a continuum between old and new. In this continuum, the two extremes are the exceptions: Actors that are entirely new are as unusual as actors that, entangled in a emerging network, remain entirely unmoved.

Such a perspective introduces a second, more substantive locale for action, helping to shift our perspective from conditions to achievements. The translation of an actor – embedded in an already stabilized network – into one that fits into the emerging network. Consumers, of course, existed before financial institutions began trying to mobilize them into the Mondex world. They have long been actors in complex heterogeneous networks, which involve, say, coins, bills and debit cards in local grocery stores. It would be an achievement, and a difficult one at that, to loosen some of the connections that embedded the consumer in the network of coins and bills, and shift him or her into a network that involves Mondex cards instead. The same can be said about the non-human actor: the Mondex-carrying smartcard. Smartcards have been developed around the globe since the mid 1970s. When Mondex began its development in 1990, such cards were already used in cell-phones, pay-TV and other applications. Various types of smartcards and the necessary encryption algorithms were well-known to engineers. To fuse all of these components creatively so as to achieve a secure Mondex smartcard would be major achievement too. Figure 7 introduces the process of translation.

This figure is still rudimentary, but it contains the basic elements for an empirical analysis of the translations that were initiated by the financial institutions in order to generate an actor-network that would stabilize Mondex electronic cash. The lines symbolizing the translation process are wave-like, indicating that translation is not a straight process but can go in many directions. And, translations can be reversible. An actor can join a network and can drop out again.

Figure 7: Translation of actors in the Mondex system

Originator, blueprint

Financial Institution A

2

Originator

Mondex card

Financial Institution B

5

5

Financial Institution A

Mondex card

Financial Institution B

Mondex card

Consumer X

3

Consumer X

Mondex card

Merchant

Merchant

Mondex card

4

Consumer Y

3

Consumer Y

Mondex card

1   6   Smart cards, prototypes

Encryption algorithms   Manufacturers

Laboratories, experts

☐ = Actor before translation

☐ = Actor after translation

〰〰〰 = Process of translation

All the action, then, lies in the lines, 〰〰〰, in the process of translation. At each end of the line stands an actor, either before or after the translation process. Since the translation is reversible, this "before" and "after" is less a temporal than a logical distinction. The numbers in the lines refer to the different sections that structure the following account of the events that took place during these translation attempts. However, while we have now located the place of the action, a wavey line is a poor approximation of the turbulences that were produced in this process and it is entirely mute on who and what created these turbulences. In order to see more, we have to zoom in and examine in detail how the entire network was involved in shaping the direction of each line and the characteristics of each actor.

6.2 Arrival of the object

On Thursday, February 13th, 1997, representatives of Bell Canada, the Royal Bank and the Canadian Imperial Bank of Commerce (CIBC) joined together

to donate $132.97 to the Guelph and Wellington United Way, a charitable organization located in Guelph, ON, a mid-sized town an hour's drive west of Toronto. The event was full of carefully planned symbolism. Not only because the amount of the donation, $132.97, symbolized the date of the event, but the contribution itself, $10 000 in total, was to indicate that the representatives were to announce good news. The donation was "to commemorate" with the chosen community that "the future of money arrives today", as the press release (13.02.1997) put it.

This future of money, of course, was not the donation itself. The celebrated stars of the events were neither the corporations nor the charity, but a few distributed objects. They made it possible to conduct this charitable act in a new fashion. The industry representatives, a Mondex-compatible Nortel Vista 360 personal screen phone and a smartcard loaded with Mondex value were in an office in downtown Toronto. In Guelph waited a charity representative, a Nortel Millennium payphone and an empty Mondex card. In between was Canada's reliably functioning telephone system. In this setting it was possible to conduct the donation as "the first commercial transfer of money over telephone lines in North America" (ibid.). This arrival of the future of money in the Canadian province was widely noted, not the least because Reuters distributed the unmodified press release through its news service and a series of articles in the mass and specialized media were beginning to (un)cover the unfolding events in Guelph.

This future, though, was not very new at all. Not even in Guelph. It had arrived there already in July 1996 when the banks started a small Mondex test including about 50 of its employees and 12 merchants. A year earlier, on June 3rd, 1995, in Swindon, an equally mid-sized town, West of London, UK, the National Westminster Bank (NatWest), British Midland Bank (Midland) and British Telecom (BT) launched the same Mondex card in their own much publicized test (see, for example, Beugge 1995). But even then, the future was not all that new. As the Mondex promotional material noted, Mondex

electronic cash had already been "invented" more than five years before, in March 1990 by two employees of NatWest, Tim Jones, Deputy Director of Payment Services, and Graham Higgins, Manager at the company's Smartcard Strategy Group. It would be possible to trace the arrival of the future differently. Perhaps to the introduction of the first multi-purpose electronic cash card, Denmark's Danmønt system in 1993; maybe further back to the introduction of chip-based payment cards by France Telecom in 1984; possibly to the first prototypes for smartcards in the late 1960s and early 1970s, or to the announcements of the arrival of the cashless society around the same time (Anderson 1966; Hendrickson 1972).

However, I do not want to argue that the future is already old, on the contrary, the future, quite sensibly, still lies ahead of us. The various launches of Mondex, the "invention" of the object, the series of precursor events which would get longer if we looked closer, were all part of the slow, continuous and uncertain metamorphosis of the environment of cash into the environment of electronic cash. All these events were part of an ongoing struggle to find out where exactly this future would lie, what it would comprise and how human and non-human actors might be translated, or transported, into this unknown future.

6.3 (Reverse) engineering the Mondex card (translation 1)

By 1990, the first elements of the virtual money system that reached large numbers of consumers – credit and debit cards – were well established in England and other industrialized countries. Their future expansion through the addition of more consumers, more merchants and more infrastructure, could be expected to be cumulative rather than transformative. However, this achievement of stabilization provided the basis for further change. As Tim Jones explained the thinking at the time,

> we were looking for the next paradigm shift in banking....We began looking at stored value cards, but couldn't make the business case. The need to account for every transaction was holding us back. We eventually concluded that the answer was RSA, cryptography in a

smartcard, with no settlement for individual transactions. The
economics of a transaction model with no settlements was very
desirable - the lack of computing and communications overhead would
permit transaction payments of a fraction of a cent....This was the
kind of concept breakthrough that we had been looking for.
(quoted in Ives & Earl 1997)

The central concern at the moment of the "invention" of Mondex was not so
much the new technology, but the business case. This case, as Tim Jones
explained, was constituted by the elimination of a central settlement
requirement. So far, centralized, or third party, clearing was a requirement
for all payment mechanisms of the virtual money system, from debit cards
for medium-sized consumer transactions to S.W.I.F.T. for very large
interbank transactions. Central clearing was a significant factor in the cost
structure for those parties who were running a system. Put simply, the fewer
users a system had, and the more parties involved in each transfer of value,
the more expensive a single transfer became. This was also important for the
users of the system because the third party clearing requirement set a lowest
limit on the amount that could be transferred using a given instrument. If the
transaction costs exceeded the profit derived from the transaction, the
transaction became economically undesirable.[79]

For the financial industry the transaction costs of the retail payment system -
cash, debit, credit - were highly visible. For consumers, on the other hand,
the costs, other than of the lowest transaction limit, were almost invisible,
due to the fact cash was so engrained and to the strategies employed to
overcome the chicken-and-egg problem that was encountered when credit
cards were introduced (Evans & Schmalensee 1999).[80] Consequently, the

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[79] Such a calculation does not include any of the indirect benefits that could make a
transaction economically viable even below this limit.

[80] The same was true for the Interac debit system. On the one hand, member financial
institutions paid the association a certain amount for each transaction, on the other hand, to
many who obtained the card as part of a service package, the service was offered at no direct
costs. For the consumer, the costs were "hidden", for example in low interest rates on
chequing accounts or a required minimum deposit in their account. Merchants paid their bank a
charge per transaction. (Interac 1997)

twin prospects of reducing the transaction overhead and expanding the highly profitable virtual money system into a new area, low value payments, constituted for the financial institutions a good business case. Technically, this business case was to be supported by joining two technologies – smartcards and RSA public key cryptography – which were both well known and more than a decade old at the time. The objective of this fusion was to translate two already existing technologies into a new actor that would play a key role in enabling the financial institutions to run an electronic cash system in which transactions were settled directly between the involved parties, the payer and the payee.

Based on the strength of this business case, NatWest allocated the necessary funding to the in-house team, the NatWest Development Team (NWDT), which comprised computer scientists from a variety of sectors, such as security design, financial services, the public sector and the semiconductor industry.[81] "Tightly cloaked in secrecy" (Ives & Earl 1997) this team worked under laboratory conditions on the first design prototype(s). To create the first physical prototypes, relationships with a select group of manufacturers were established early on: with Hitachi Ltd. to produce the chips and other equipment, with Dai Nippon Printing to produce the cards, and with Matsushita Electric and OKI Electronics to produce the card readers and other peripherals.

However, it turned out that the two technologies of public key encryption and smartcard could not be joined easily. Public key cryptography, developed for conventional computers, was a computing-intensive procedure and required considerable processing power. The first chip that Hitachi produced for the Mondex system, H8/3102, was equipped with 8K of EEPROM, 16K of ROM, 512 bytes of RAM and could run at a speed of 5 or 10 MHz, depending on the

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[81] In May 1999, the NWDT became a separate company, platform seven, and in March 2000 it was acquired by the Datacard Group. http://www.platform7.com/about/background.htm [09.08.2000]

voltage supplied. This configuration could not handle the computationally intensive process of public key encryption at a speed that would support quick, low-value transfers [I.8]. Consequently, the first version of the Mondex application did not incorporate the RSA algorithm but used "a well-known 'symmetric' encryption algorithm for security" (Jones 1998), which was computationally less intensive but less secure.

In March 1992 a first version of the Mondex technology stabilized into a tangible object: an electronic purse application (pilot version) sealed into a dedicated chip and running on a proprietary operating system (version: MM1) [I.8]. This stand-alone electronic cash card was named "Byte" and NatWest moved it out of the secrecy of its laboratories into the semi-private arena of NatWest's cafeteria, where 6 000 employees used it to pay for their lunches. In April 1994 NWDT published a set of technical specifications in which certain parameters of the card's design were revealed. Based on these specifications all interested manufacturers, not just the select manufacturers of the earliest phase of the network's development, could develop artifacts for the Mondex world, such as chips, readers, point of sale (POS) terminals, wallets (for peer-to-peer transfers), telephones with built-in readers, load boxes for ATMs, back-end infrastructure, parking meters, etc.

The Mondex technology developed into four clusters of artifacts, each supporting the different functionalities of each of the four types of purse classes: the Originator card, the bank card, the consumer card and the merchant card.

The "Originator card" was actually an entire box full of Mondex cards. Since the cards were used to authenticate one another, each card could only handle one transaction at a time. To achieve multiple transactions in parallel, multiple cards were needed. Attached to the box was a risk management system. This system was based on a database that contained records of the transactions between the Originator and the financial institutions, as well as

between financial institutions and their clients (consumer and merchants). Non-disclosed algorithms were to be used to analyze transaction logs to find suspicious flow patterns that might indicate a security breach. Hitachi, one of the vendors of back-end systems, described its system as "capable of picking out discrepancies quickly and accurately".[82] However, the accuracy of this advertisement copy was questioned by various actors, as we will see.

The "bank card" consisted of three components. The first was again a box stacked with Mondex cards needed as the back-end repository of value. The second component interfaced between that box and the client in order to remotely authenticate the client. It allocated a specific Mondex card from the central repository box to handle each particular client request, and settled the Mondex transaction over the telecommunication network. The third part of the "bank card" was a component of the risk management system which captured the transaction logs. These were then transmitted to the Originator for analysis [I.13]. It also had to initiate possible actions to protect the integrity of the Mondex system such as stopping the transaction, limiting use of certain cards, locking out cards and even software migration. Whether or not this last action was possible was also disputed.

The consumer card was surrounded by peripheral objects such as balance readers, electronic wallets and Mondex enabled telephones. It was also planned to connect it with a reader to home computers and mobile phones for e- and m-commerce, but these plans were not realized as of 2000.

The merchant card, located in its own back-end system, was connected to both POS readers and the banking back-end system. Its main function was to receive money from customer cards and to send it to the bank.

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[82] Hitachi product description.
http://www.hitachi.co.jp/Div/nfs/solutions/mondex/index.html [15.08.2000]

In this configuration the Mondex technology reached a first stabilization. The technology was now understood to be secure, it represented the most advanced approach to smartcards to date,[83] and was sophisticated enough to support a full-scale alternative to existing cash. Paradoxically, on the surface, at the level of advertising, all this innovation was to achieve apparent continuity. One of the first commercials announced: "Mondex is cash is Mondex is cash".

Even though the initially envisioned technological configuration could not be realized due to hardware limitations, the Mondex card and its peripherals were moved out of the semi-private rehearsal room of a corporate lunchroom into the general public arena and the spot-light of the media. The community-wide trials began, with plans for national roll-outs. In the Mondex scheme, *Diagram of value flows in the Mondex system*, introduced in the previous section, the public consisted of two human actors: consumers and merchants. Each was defined by a commercial activity, as buyer and seller of goods or services. It quickly turned out that the actual public was much more heterogeneous. It consisted of more than complacent consumers and merchants interested in shopping convenience in a mid-sized town. The public for Mondex was constituted by two distinct communities: one gathered locally, the other distributed globally.

In 1995, smartcards were not new anymore and their use was not restricted to the banking sector. On the contrary, they were already well established in a wide variety of settings: in prepaid telephone cards, pay-TV set-top boxes, cellular phones and many more. Consequently, the expertise and the equipment necessary to reverse engineer smartcards was also widely distributed.[84] The experts in the laboratories constituted a globally distributed

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[83] In 1994, Mondex received the ESCAT (European Smartcard Applications and Technology) award for the "most innovative Smartcard Application of the Year."

[84] Reverse engineering means taking something apart with the objective of understanding how it is made.

community of researchers. They could easily mobilize the necessary resources to contribute to defining some of the characteristics of the new card. The local community also contributed to the definition of some of the characteristics of electronic cash. Though not through the resources they could mobilize in laboratories but in their daily routines of paying for goods and services.

The local (of consumers) and the global community (of scientists and engineers) were indirectly related. The latter was engaged in an attempt to define some of the characteristics of the card, mainly: Was the card secure? The result of this definition played an important role in how the local community defined the new technological actor and its relation to it: Was it trustworthy or suspect? In addition, they also defined by individually deciding: Was it useful? While it was ultimately the members of the local community that were to be translated into Mondex consumers, the global community, through their authority of "experts", had a certain impact on whether or not this would happen.

The global community appropriated the role of spokesperson for the new technological actor. Its members spoke about the actor's characteristics, seemingly uninfluenced by personal interest. However, this global community spoke with many different voices, and the question of who exactly was the more reliable spokesperson remained as hotly contested as the question of what the actor really was.

The fact the Mondex card attracted multiple spokespeople, giving diverging accounts on its behalf, indicated, as I will detail in the following, that the actor itself had not yet stabilized. The multiplicity indicated multiple, diverging paths of development. One of the reasons why the spokespeople gave conflicting accounts was they themselves were part of different networks. Some were within the financial and telecommunications industry and its affiliated developers/manufacturers. Others were members of

academic institutions (in England, for example, the universities of Cambridge, Edinburgh and Southampton had advanced smartcard laboratories). Still others were employed by the private sector (for example in consulting companies like Cryptography Research in San Francisco) or by government agencies.

One of the things they all had in common was an expensive piece of equipment: an ion beam to reverse engineer a smartcard by manipulating the flow of electrons through the circuits. In 1995, all in all,

> the number of organisations worldwide which can do electron beam lithography is of the order of 100-200. These potential attackers include a number of universities, all the big chip makers and the governments of the USA, Canada, the UK and China. Of these, the US and Chinese governments appear to have the greatest experience at chip breaking.
>
> For a respectable firm to join this club costs about US$ 2m – 1.5m for the electron beam lithographer and ancilliary equipment, plus a year's salary for about five professionals to get it all going (typically a physicist to deal with the ion beams, a chemist to deal with packaging, two computer people to write software, and a chip person to run the whole operation). (Anderson 1995)

However, placing a smartcard under an expensive ion beam in one of the world's best equipped laboratories was not the only procedure that made it possible to attack smartcards. Several attacks on the integrity of secure smartcards had been developed and published, requiring special, but low cost equipment: these attacks include differential fault/power analysis, chip rewriting and memory remanence (Anderson & Kuhn 1997).

In 1995 Markus Kuhn, a student at the time, gained prominence by breaking the BSkyB SkyCard, a smartcard widely used in Europe in Pay-TV decoders. The vendor had claimed that its encryption system was unbreakable. After this incident, the card had to be updated frequently. By 1997, the card was in its tenth generation, but still PC emulators and pirated cards were commercially sold. Between 5% and 10% of viewers in Europe, it was estimated, used such pirated technology to access Pay-TV illegally (Brown

1997b). Despite all efforts of broadcasters, "smartcard piracy has become a common occurrence" (Kömmerling & Kuhn 1999, p.1).

Based on this and similar experiences, Markus Kuhn and Ross Anderson, Professor at the Cambridge University Computer Laboratory, issued a cautionary note on the security potential for tamper-resistant smartcards. In 1996, they wrote:

> We conclude that trusting tamper resistance is problematic; smartcards are broken routinely, and even a device that was described by a government signals agency as 'the most secure processor generally available' turns out to be vulnerable. Designers of secure systems should consider the consequences with care. (Anderson & Kuhn 1996)

Based on this general assessment of the potential of tamper-resistant smartcards, the Mondex card was insecure, vulnerable to attacks and an insufficient basis for a full-scale alternative to cash. Anderson concluded "that 'floating systems' such as Mondex [are] probably not viable given that they embod[y] all the conditions necessary for their encryption key material to be retrieved – including multiple instances of the device, unhindered access to it and huge financial incentive" (quoted in Brown 1997a). Anderson had never actually attempted to reverse engineer a Mondex card, because Mondex had never provided him with cards and the assurance not to prosecute him under the British Computer Misuse Act, which made it illegal to break into a computer system (Carroll 1996).

The diverging assessments of the characteristics of the Mondex card – for its developers it was secure and stable, for independent security experts it was insecure and, potentially, unstable – reflected more than self-serving strategies on each side. More importantly, it reflected a fundamental disagreement within the global community on how to achieve and how to evaluate computer security. The Mondex engineers based their assessment of the security on the quality of their own engineering and on the secrecy of their methods. The card was secured by three lines of defense, one based on

hardware, the second based on software and the third on legal restrictions. The last made any attempt to infringe upon the integrity of the card, successful or not, a criminal offense. It also sealed off the algorithms through intellectual property, copyright and non-disclosure agreements. Effectively, it prevented this information from becoming part of the public knowledge-base accessible to all members of the global community.

Such a reliance on secrecy and a trust in the superiority of their own methods was not untypical for large institutions (military, governmental or commercial) which have traditionally held what, following Harrold Innis (1950), one could call "monopolies of knowledge": bodies of knowledge only available to a select set of elite members. The financial industry had always relied on such monopolies. Until now, the entire virtual money system was based on closed computer networks, proprietary algorithms and non-disclosure agreements. However, the critics argued that such a monopoly no longer existed. Not only because smartcards had become commonplace at the end of the decade, but also because key pieces of the Mondex system – consumer and merchants cards – were available for public inspection in settings that the financial industry could not control, for example, in independent laboratories as well equipped as those of the financial industry.

The independent computer security community criticized this approach – dubbed "security through obscurity" – as harmful because it made independent security testing impossible, thus potentially leaving the vulnerabilities open to be exploited in secret, by criminals. The proposed counter-strategy was to make systems available for testing and to publish security weaknesses so that remedies could be found. Publicizing vulnerabilities was important so that the community as a whole could learn, rather having to make individually the same mistakes over and over again. Anderson, in an article entitled *Why Cryptosystems Fail* (1994), described the need for such an open learning mechanism:

The practice of cryptology differs from, say, that of aeronautical engineering in a rather striking way: there is almost no public feedback about how cryptographic systems fail.

When an aircraft crashes, it is front page news. Teams of investigators rush to the scene, and the subsequent enquiries are conducted by experts from organisations with a wide range of interests – the carrier, the insurer, the manufacturer, the airline pilots' union, and the local aviation authority. Their findings are examined by journalists and politicians, discussed in pilots' messes, and passed on by flying instructors.

In short, the flying community has a strong and institutionalised learning mechanism. This is perhaps the main reason why, despite the inherent hazards of flying in large aircraft, which are maintained and piloted by fallible human beings, at hundreds of miles an hour through congested airspace, in bad weather and at night, the risk of being killed on an air journey is only about one in a million.

In the crypto community, on the other hand, there is no such learning mechanism.

The assumption underlying such a call for open review processes was that virtually all systems could, and eventually would, get compromised. Particularly if they could be accessed without the operator's knowledge, that is, if the operator could not control the settings in which the technologies were employed. Mondex cards, to be distributed to hundreds of thousands of users (merchants and consumers), certainly belong to this category. Other elements of the virtual money system, ATMs for example, did not fall into this category because they could not be removed from the controlled premises of the financial institutions which provided them and they were connected to back-end systems that were entirely inaccessible to the (criminal) public. An d, according to Anderson, the problem was getting worse. Given the rate of proliferation of laboratories that had the necessary resources to carry out a hostile attack, the likelihood of it actually happening

was increasing. He concluded, "tamper resistance at the chip level is getting further and further away" (quoted in Brown 1997b).[85]

Anderson's argument, purely theoretical in the context of Mondex, was soon experimentally demonstrated. At the Eurocrypt conference in 1997, Ernst Bovenlander, from the Dutch consulting firm TNO, detailed a successful attack on a Mondex-like chip. The attack exploited a common feature of tamper-resistant smartcards. In order to protect the memory content, a fuse on the card was blown after the card had been initialized. This blocked access to certain parts of the card's memory. The published attack consisted of bridging the link interrupted by the blown fuse with two microprobes. In this fashion, the link activated a test mode in which the card contents were simply dumped to the serial port and hence made accessible.[86] Bovenlander also told the Eurocrypt audience that microprobing attacks would become harder once the feature size dropped below one micron. However, this only made the attack harder, not impossible. In the new attack a focussed ion beam would be used to plate a sufficiently large contact for the microprobe on each bus line. He showed a micrograph of a 0.8 micron chip treated in this way. He also related that undergraduates at Delft University routinely broke smartcard chips using microprobe workstations as part of their assessed course work, rather than as personal hacking (Bovenlander 1997, quoted in Anderson & Kuhn 1997). Hitachi subsequently upgraded its chips to the next generation, H8/3109, with a feature size of less than one micron. This turned Bovenlander's approach from a relatively low cost attack into a high cost attack requiring the use of expensive laboratory equipment.

A chip of the newer generation was successfully attacked using another strategy: the *differential power analysis* also described by Anderson & Kuhn

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[85] In a similar vein, the Bank of International Settlements wrote: "It can be assumed that even the most sophisticated tamper-resistant features may eventually be breached, potentially permitting analysis and reproduction of the contents of the device" (CPSS 1996, p.22).

[86] This type of attack is documented in detail in Kümmerling & Kuhn (1999).

(1997). This time the attack was carried out by Paul Kocher, a researcher at the private laboratory, Cryptography Research, in San Francisco. Differential power analysis monitored the power used by the chip on a smartcard as it operates. The integrated circuits on a microchip are built from individual transistors, which exhibit observable electrical behaviour. Small fluctuations in power use could be recorded and subjected to statistical analysis to reveal binary code, including PIN numbers or encryption keys, to be extracted from the chip (Kocher 1997; Kocher, Jaffe & Jun 1999). Bruce Schneier (1998) contrasted this type of attack with conventional attacks in the following way:

> There are two ways to look at a cryptographic primitive: block cipher, digital signature function, whatever. The first is as a chunk of math. The second is a physical (or software) implementation of that math. Traditionally, cryptanalysis has been directed solely against the math....On the other hand, timing attacks, power analysis, and fault analysis all make assumptions about implementation, and use additional information garnered from attacking those implementations. Failure analysis assumes a one-bit feedback from the implementation – was the message successfully decrypted – in order to break the underlying cryptographic primitive. Timing attacks assume that an attacker knows how long a particular encryption operation takes. I like to think of these attacks as biological. There are some things you just can't learn about an organism by taking it apart. Sometimes you have to look at the inputs and outputs. How does it move? What does it eat? If you thwack it in a particular way, how does it react? If you break it, what happens?

This attack was sophisticated and complex, but it required only low cost equipment, hence it could be relatively easily replicated. Kocher expected that "as the expertise becomes more widely available, the threats will become more than academic" (quoted in Wayner 1998). In a private email, Paul Kocher indicated how easily these attacks could be replicated. He wrote:

> in the case of DPA, for example, the initial characterization of a card and the development of the software required to break it can be considerable, such as 100 hours of a highly-skilled engineer. In addition, the equipment can cost anywhere from US$ 5000-100 000, depending on the sophistication of the analysis lab and willingness to spend money on equipment that saves engineering time. Once the analysis hardware and software have been configured, the attack can be scaled easily and can be completely automated. In addition, it can be optimized to use lower-cost equipment. As a result, the cost

to repeat the attack is much lower and is governed by factors such
as depreciation on the equipment and unskilled operator time to
insert/remove cards. A typical DPA attack would involve US$ 10 000
in equipment and 2 minutes of processing, though this could go as
high as about 60 minutes. [E.4]

After it had been demonstrated that, under laboratory conditions, it was
possible to crack open tamper-resistant smartcards, the question of the exact
characteristics of the Mondex chip was, however, still not settled. On the
contrary, in September 1999, Mondex was awarded a security rating of Level
E6, the highest possible rating achievable in ITSEC (Information Technology
Security Evaluation Criteria). It was the first commercial product to be
awarded a rating of this level. ITSEC, a set of criteria for evaluating computer
security, were originally published in 1990. They represented a uniform
standard supported by governments across Europe and Australia. The UK
ITSEC scheme, which awarded the rating, was managed by the
Communications-Electronics Security Group, the British government's
National Technical Authority for the use of cryptography and information
security in generally.

However, while the ITSEC process was popular with governments and likely
to ensure the regulator's confidence in the technology,[87] the program's
authority was not undisputed. As Ross Anderson (1994) wrote:

> Even a cursory comparison with the ITSEC programme shows that this
> has a long way to go....It is clear that ITSEC (and TCSEC) will
> have to change radically. Component-oriented security standards and
> architectures tend to ignore the two most important factors, which
> are the system aspect and the human element; in particular, they
> fail to ensure that the skills and performance required of various
> kinds of staff are included, together with the hardware and
> software, in the certification loop.

> Our work also shows that component-level certification, as embodied
> in both the ITSEC and TCSEC programs, is unlikely to achieve its
> stated goals. This, too, has been admitted indirectly by the
> military (at least in the USA); and we would recommend that the

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[87] See section 6.4

next versions of these standards take much more account of the environments in which the components are to be used, and especially the system and human factors.[88]

Consequently, the characteristics of one of the central actors in the Mondex scheme, the chip, were still disputed after some 9 years of existence. Was this hardware and software able to effectively render hackers of all sorts ineffective? Was it secure or not? Did it provide a reliable basis for a currency system?

The difficulty of assessing the chip's characteristics revealed a second conceptual disagreement between the independent security analysts, most notably Ross Anderson, and the staff of Mondex International. Their disagreement was not only over how to achieve security, but also what constituted security.

Many computer scientists approached security from the point of view of cryptography. Such an approach, according to Bruce Schneier (2000),

> can be summed up pretty easily: Security threats are to be avoided using preventive countermeasures.

> For decades we have used this approach to computer security. We draw boxes around the different players and lines between them. We define different attackers − eavesdroppers, impersonators, thieves − and their capabilities. We use preventive countermeasures like encryption and access control to avoid different threats. If we can avoid the threats, we've won. If we can't, we've lost.

However, he continued, no longer thought this to be correct but now understood

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[88] Anderson underscored his critique of the ITSEC process: "In general I'm not impressed with the whole common criteria process. Too many evaluations are based on political rather than technical criteria, and the real bugs are often hiding in the protection profiles. The smartcard PP, for example, basically requires security-through-obscurity of the mask design - yet no real attacks on real systems involved leaks of mask data. In other words, the common criteria often provides a convenient smokescreen for people who protect what they can rather than what they have to" [E.1].

that security was about risk management, that detection and response were just as important as prevention, and that reducing the "window of exposure" for an enterprise is security's real purpose.

Anderson (1994), though, reminded his readers that "we should never forget that information security is at heart an *engineering* problem" (my emphasis). Put simply, this engineering problem could be stated as: Did the system resist all attacks? If yes, then the system was secure. If some attacks were successful, the system was insecure. This created a very clear assessment of the characteristics of a technology as having only three possible, mutually exclusive states: secure, insecure or untested. In this approach, the technological artifact, the smartcard chip in this case, was understood as an isolated actor that created security. This promise was to be assessed based solely on how the technology behaved under various circumstances, for example, under an ion beam. Security was determined in terms of the actor's impenetrability.

MXI, similar to Bruce Schneier, understood security not exclusively as an engineering problem but rather in terms of *risk management*. The technology under attack, the Mondex smartcard, was only one component of an entire risk management system. Mondex, as I have described elsewhere,[89] developed a security concept based on three elements: prevention, detection and recovery. Prevention, the engineering problem of breaking open the chip, extracting and altering its information, only "raises the barriers against potential compromise,"[90] by setting the "height of the wall" (Beric 1997). What was crucial was less: Can the wall be climbed? or, Is the system impenetrable?, but rather: How high is the wall and what happens once the wall has been passed? In such an approach, the technology can be simultaneously *compromiseable* and *secure*. Credit cards, for example, were secure despite a high rate of fraud. They were secure in terms of consumer

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[89] See Chapter 5

[90] Mondex promotional material, available at http://www.mondex.com [17.03.1998]

and merchant confidence as well as in terms of systemic stability. Losses due to fraud were absorbed in the profitable process of running the credit card system.

The focus, then, was not exclusively on the card and its qualities, but rather on the interaction of all the elements within the network, in particular the relationship between the card and the back-end risk management system. This system monitored the balance of funds sitting in the "float" account held by the Originator as well as uploads and downloads between financial institutions and merchants/customers. If usage patterns deviated outside normal fluctuations, in the order of 3-4%, then an alarm was raised to investigate (Jones 1998). It was the interplay of high wall and monitoring capabilities of the issuers that made a secure system, argued MXI. However, the characteristics of the monitoring systems were shielded from independent evaluation and only indirect assessments were available to the public. MXI, unsurprisingly, saw the monitoring system as highly sophisticated and of proven reliability. In their promotional material, they wrote:

> Mondex's physical chip security is backed up by the same risk management systems that protect the world's financial economy today.

> ...Mondex International's risk management strategy involves comprehensive behavioural analysis and statistical projections to identify inconsistent rates of value flows. Such types of statistical forecasting and response are widely used in the financial industry.[91]

The Bank of International Settlements, however, was more hesitant. They wrote: "It is not clear, at this stage, how effective a tool statistical analysis will become for detecting specific instances of fraud, or how difficult it would be for sophisticated attackers to disguise their activity within these normal payment patterns" (CPSS 1996, p.20).

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[91] Mondex promotional material, available at http://www.mondex.com [17.03.1998]

David Jones (1998), president of the Electronic Frontier Canada (EFC) and professor for computer science, on the other hand, called the risk management "crude" after meeting with Mondex Canada officials in Toronto to discuss security issues. During the first 18 months of the Guelph trial, for example, the monitoring system detected 5 cases of suspicious behaviour with none of them, as it turned out, related to anything fraudulent.[92]

The most critical assessment is made by Thomas M. Trusty, who was a research director of Interfraud, a consulting firm hired by banks in New Zealand to evaluate the Mondex system. He said the key problem with Mondex

> is a complete absence of any fraud detection, other than a very crude comparison of how much money has been spent. While you have a dozen transactions a day, it's easy to say that an increase to, say, 20 transactions a day might indicate unusual activity. But once you have hundreds of thousands of transactions in the system, with no fraud detection, you're relying on statistical analysis beyond the wildest dreams of economists. Unless this is assessed, there will never be any way to determine if fraud is underway until it is too late. (quoted in Brown 1997a)[93]

Officials at the Bank of Canada also expressed some reservations about the current ability to monitor value flows precisely.

> Unfortunately, the present techniques they [the Originator] have for doing this [transaction analysis] aren't very effective. These basically are float measures. It could be some period of time before they realize that there has been counterfeiting going on and

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[92] While 5 error messages is 18 months might seem like relatively little, it is quite significant in relation to the low number of overall transactions (see section 6.5.).

[93] Belgian Banksys, developer of the Proton, a fully accounted Mondex competitor, made similar allegations. It released a report claiming to show that "the lack of an audit trail [in Mondex] will eventually lead to the crime of all time." NatWest said it would sue Banksys over the Belgian company's claims about faults in a Mondex protocol, but never filed any action (Brown 1997a). On the other hand, Mondex argued that a fully accounted system such as Proton was not scaleable and that, in the case of wide-spread adoption, aggregation would be necessary and hence Proton would have to change their system to something that would be, effectively, very similar to Mondex [I.13].

that counterfeiting can actually be almost equal to the value of
the true float by when they can find out.

Then there is the mechanism for dealing with it, at that point,
because it is such a large problem, is basically a poison pill
mechanism. They basically just close the system down. My
understanding is that they stop issuing, they stop taking value for
what is out there. So you can end up losing if you actually have
real Mondex value. Too, they have to convince everybody else in the
regime world wide that they have to switch to a different
revaluation mechanism and everybody else in effect has to reissue.
I don't know if they moved beyond this mechanism at this point, but
that was the early mechanism they had, and so, situations which
countries like Canada, which simply didn't have big enough value
going through it, they didn't have a strategy for dealing
effectively with it. [I.11]

However, given the extremely small amounts of money that were actually
flowing through the system during the trials, the Bank of Canada did not see
this as an urgent problem for the time being.

On the level of the risk management system, the problem was no longer akin
to preventing and detecting fraudulent money, because once money had
been inserted it could no longer be distinguished from legitimate money
(Trusty 1998a, 1998b).[94] As senior officials at the Bank of Canada put it, "if
people are going to produce fraudulent e-money, it's much more like a
money laundering world for the merchants" (I.11). Similar to money
laundering, the legitimacy of the money could not be assessed by examining
the money itself, as was the case with forged bills that could be examined
one by one. The only way to assess whether value was legitimate or not, was
to assess its source. This was, essentially, the same problem as preventing
money from the drug trade from being laundered. In the drug trade, in order
to accumulate the profits made from transactions that are most often carried

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[94] However, it was effectively impossible to reconcile - or even to evaluate accurately - these
conflicting views on the qualities of the risk management system. The technology was
effectively black-boxed by the very restrictive information policy of MXI. Tom Trusty explained
how he, when working on risk assessment for an Australian bank involved in the national
Mondex scheme, was unable to get access to documents detailing how the risk management
system works. He came to the conclusion that the system had to be vaporware [E.3].

out in cash, it was important to convert the cash into an electronic form of value by depositing it to a bank account. Once the money was inserted into the mainstream financial system, it could be very difficult to trace it back to the illegitimate source. Extensive measures have been taken in the last decades to prevent drug money from flowing into the mainstream financial system – so far, rather unsuccessfully.[95]

One of the differences between the fight against conventional money laundering involving cash and the risk management of the Mondex Originators was that the latter was closely related to the technical specifics of the smartcard. Since these were supposed to be changeable at any time, the window of opportunity to launder money was, perhaps, small, forcing the perpetrator to insert large amounts of money in order to redeem the investment involved in cracking the card.[96] And, the higher the amounts deposited, the better the chances for the statistical sampling to spot irregularities. On the other hand, the high number of transactions in a fully implemented system might make it more difficult to detect fluctuations among all the statistical noise. Not even Fenton Ho, Mondex Canada Originator's Director of Risk Management and Analytics, could predict how the system would change if the number of transactions would dramatically increase [I.13].

However, the characteristics of the Mondex card and its ancillary artifacts, as far as they pertain to the overall system integrity, could not be determined in isolation or derived from theoretical models. Mondex security, particularly

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[95] The 1994 United Nations Conference on Global Organized Crimes estimated the global trade in drugs to amount to US$ 500 billion. The OECD reported in 1993 the laundering of at least US$ 85 billion a year from drug profits. The G-7 Financial Task Force declared in 1992 that at least US$ 120 billion in drug money are laundered in the global financial system (quoted in Castells 1998, p.169). In Canada, the amount of drug money laundered was estimated to be between CND$ 3.5 and 7 billion per year (Solicitor General Canada 1998).

[96] The investment is estimated to be $100,000 and two to four weeks of work for a specialized commercial facility which does not need to be very large to be able to succeed (Anderson, quoted in Brown 1997c).

when understood as "commercial viability", was an extremely complex process that was not determined by a single variable, but by the interplay of all of them. These included such entirely non-technical aspects as market performance (ability to absorb losses) as well as collaboration between issuer and law enforcement agencies in case of a security breach [E.2]. Ultimately, as Sholom Rosen, vice president of emerging technologies at Citicorp's Citibank unit said, "nobody will know how secure a system is until large volumes of money are flowing through it" (quoted in Templin 1996).

In February 1997 when Mondex was introduced to the local community in Guelph, ON, hardly any value had ever flowed through the Mondex system. Many of the translations were still in progress and their fate was far from certain because unless the entire network would stabilize, the effect of each translation could not be fully assessed. As long as the Mondex world as a whole was unstable, each of its actors, defined through this world, was unstable too. Consequently, the characteristics of the non-human actor, even in regard to such seemingly technical and "objective" aspects such as security of the chip, could not be fully determined. Depending on the development of entire network, the chip might either turn out to a secure basis for an electronic cash system or not. However, for all practical purposes, the translation of encryption technology and smartcards into an electronic cash card was successful, at least for the moment. $132.97 were indeed transferred from a Mondex card in a downtown office in Toronto to one at the offices of the Guelph and Wellington United Way.

6.4 Creating the Originator (translation 2)
The money transferred in the symbolic first transaction was not created by the Canadian Mint or issued by the Bank of Canada. Nor was it created by the financial institutions themselves. Rather, they distributed value that had been created somewhere else, by a third party, the Originator. This third party, even though it didn't appear in the press releases promoting the event, was a very important actor in the planned Mondex network. Its

function was to issue electronic cash and sell it to financial institutions which would then sell it to their customers. As an issuer of currency, the Originator had no recent precedent in the private sector. It had to be created from scratch, envisioned in the Mondex blue-print as an independent entity with the technological capability and legal authority to operate an electronic currency scheme. The Originator was designed to be the equivalent of both a mint and a central bank, acting as the central issuer of electronic currency in a society in which cash was to be replaced to some degree by Mondex [I.13].

The idea of a cashless society had been around for several decades (Anderson 1966; Richardson 1970) without gaining much credibility among bankers and regulators in the financial industry. Central banks, though, would have had reason to be concerned. It falls under their exclusive authority to issue currency and most of them are financed by the profits derived from this activity (seignorage). Any replacement of coins and bills would infringe upon the central banks' monopoly to issue currency, a monopoly many of them have held since the mid 19th century.[97] However, predictions of a cashless society were met with considerable skepticism and caused little actual concern. Too often the promised future had failed to be realized [I.10]. Less than ten years before, in the late 1980s, tele-banking had failed to fulfill its promise of revolutionizing the retail financial industry (Chorafas 1988; Kirkman 1987; Valcin 1988). It was very slow to alter significantly the way financial services were delivered to and used by the majority of consumers [I.11]. The technology that had helped to change consumers' relationships to banks and cash most significantly was the ATMs, introduced in the late 1970s and 80s. One of its lasting effects was to make access to physical cash much easier by expanding both the locations and the hours in which people could access their accounts (Socioscope 1981). Rather

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[97] In North America central banks were established later. In the US in 1913, in Canada in 1934 (Davies 1994; Powell 1999). However, everywhere the establishment of central banks intended to stabilize the financial system and to extend government supervision.

than ushering in the new era of the cashless society, ATMs consolidated cash as a ubiquitously accessible means of payment.

The reserved and highly skeptical attitude of the supervisors of the financial industry regarding the potential for the cashless society unthawed in the early and mid 1990s. For Charles Freedman, Deputy Governor at the Bank of Canada, this change was connected with a particular event.

> In 1995, the Mondex people...came in to show us what was going on and demonstrate both the Mondex card and reader and, perhaps, they also had a telephone. I was intrigued, impressed and realized there were a lot of implications of this. And at that time, what was particularly interesting was, that although there have been discussions of the cashless society for 30 or 40 years, I never took it the least seriously. This, although I wasn't all sure whether it would lead to the cashless society, had at least the theoretical potential for the very first time, it seemed to me, and did raise a number of questions in my mind. [I.10]

Early on, Mondex had actively sought contact with regulators in order to better forecast and influence the development of relevant policies. The mutual adaption of regulator, technologies and financial institutions was understood to be of major importance before any public trials would begin [I.8; I.11].

This encounter with the Mondex technology in the hands of the Royal Bank, the largest bank in Canada, set in motion a number of activities at the Bank of Canada. One was to conduct its own research into the area of electronic purses (Freedman & Goodlet 1998; Stuber 1996). Another one was to initiate consultations with the other government agencies within the national regulatory community. In addition to the central bank, this community included the Department of Finance, the Superintendent of the Financial Institutions and the Canada Deposit Insurance Corporations (CDIC).[98] These consultations were based on a shared presumption that

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[98] The regulatory community was not only composed of government agencies, but also of private association, e.g. Canadian Bankers Association, and institutions that brought together

new information technologies, new financial services and instruments, and increasing number and widening range of institutions interested in providing payments services, and growing cross-border payment flows are changing the demands on the payment system. (Bank of Canada & Department of Finance 1997a, p.1)

In June 1996, prompted by the fast rate of change in the virtual money system as a whole, the Canadian government initiated a review of the retail payment system, as part of a more general reassessment of the regulatory framework governing the financial industry (Department of Finance 1999). The review of the payments system was conducted by the *Payments System Advisory Committee*, a newly formed group which included not only government officials, but also individuals from the financial sector, consumer groups and academia (Bank of Canada & Department of Finance 1997a; 1997b; 1997c; 1997d). Despite these efforts on a national level, to which I will return later, there was an opinion that electronic cash in particular, due to its novel character and technological difficulty,

> raises a whole lot of very important and very interesting policy issues. We are a small country here, we do not have the resources...to do all the research ourselves. At the same time, just as we should be thinking about this, so should every other central bank. [I.10]

At the time, in 1995, little work had been done by other central banks. Many of them felt like the Bank of Canada, that it was necessary to develop quickly a better understanding of the issues and the implications for the future of (central) banking. On the one hand the new technology might be nothing but another vain attempt to usher in the cashless society, on the other hand the technology might deprive the central banks of their revenue and change the financial landscape significantly by introducing an entirely new and as yet undefined institution: the Originator, issuer of a private currency.

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the private and public secto, e.g. the Canadian Payment Association (Bank of Canada & Department of Finance 1997a).

The first report, issued by the European Monetary Institute (EMI), the precursor of the forthcoming European Central Bank, expressed the sense of urgency prevalent at the time.

> The possibility of proliferation of such cards is a real one. In the future, if electronic purses were used in a great number of retail outlets, they would become a direct competitor not only to cashless payment instruments already in existence, but also to notes and coins issued by central banks and national authorities. Given the potential of electronic purse schemes to attain widespread acceptance, central banks need to formulate their views on the issues raised by this payment instrument. Once such schemes have been introduced and are widely used, redressing undesired situations might be much more difficult. (EMI 1994)

In order to curtail the new technology's potential to alter the institutional landscape of the financial industry, the EMI's "most important conclusion" was to recommend restricting the issuing of electronic currency to regulated deposit-taking institutions. Beyond that, given the uncertainty of the development, it recommended that the central banks keep monitoring the field.

After the presentation of Mondex by the Royal Bank, Charles Freedman travelled to Basle, Switzerland, to initiate research on the issues of electronic cash through the Bank of International Settlements (BIS). The BIS, bringing together the central banks from the ten largest economies (G10), acted as their coordinating body. In late 1995 the BIS decided to set up a series of committees to survey the landscape of electronic cash and determine what kinds of issues were raised [I.10].

Given the fact that electronic cash, if successful, would constitute a significant innovation, there had been a lot of speculation as to what its influence on the existing environment might be. It was far from clear what sort of relationships were possible between electronic cash and other actors in the international financial system. Consequently, it was not clear what kind of responses might be appropriate to support shared policy objectives. In the

most general terms, these objectives comprised a sets of five interrelated goals (G10 1997):

- Limiting systemic and other risks that could threaten the stability of financial markets or undermine confidence in the payment system;
- Providing consumers with adequate protection from fraud and unfair practices, financial loss, or unnecessary intrusions on personal privacy;
- Encouraging the development of effective, low-risk, low-cost, and convenient payment and financial services for consumers and businesses;
- Ensuring the central bank's ability to conduct monetary policy;
- Not hindering the ability of law enforcement authorities to prevent and detect movements of funds associated with criminal activity.

These five categories called for a comprehensive inventory of potential connections between the emerging and the existing actors of the virtual money system and how these connections might (re)define them. This inventory comprised most of the issues ever raised in connection with electronic cash. One of the purposes of the research was to determine which concerns were wide-eyed speculations and which genuinely applied to the emerging actor-networks of actual electronic cash schemes.

Among the most far-reaching implications the various form of electronic money was thought to have was to disable entirely governmental control over the flows of money (see Wriston 1992). Libertarians giddily anticipated that electronic money would aid the denationalization of currency (May 1997), long advocated by the economist Friedrich Hayek (1976). More recently, Orlin J. Grabbe (1999) argued:

> The whole objective [of electronic money] is to denationalize money, to decentralize it, to put it beyond the control of regulatory authorities who operate to maintain a government or central banking monopoly, to create mobile network banks that do not become sitting targets for Big Brother information collectors, to distribute private currency operations in such a way that they

can be said to exist in no single political or legal jurisdiction – or for that matter cannot be said to exist in any jurisdiction. Electronic monetary transactions will take place out there, somewhere in cyberspace, unobserved by third parties.

Similarly dramatic, though gloomier, views of how the new technologies of electronic money might affect governmental policies and, consequently, national sovereignty, focussed on issues such as the increase of money laundering and tax evasion (Davis 1997; Morris 1997; Kobrin 1997; Kyriakou 1997).

However, after an examination of the existing electronic cash schemes and their position within, rather than outside, the already highly regulated financial industry, the G10 report concluded:

> [E]merging electronic money products are currently focused on low-value, consumer transactions which may present less of a concern to law enforcement authorities because they are less likely to attract the attention of criminals. In many cases, market incentives and supervisory arrangements exist that are complementary to the interests of law enforcement authorities. (G10 1997, pp. 17–18)

This view was supported by the Solicitor General of Canada (1998), who noted "that criminal interest in these cards is low". The various reviews found no direct link between the technologies of electronic cash and the practices of organized crime (i.e. money laundering). This was not surprising. First, there were already a lot of links between organized crime and the virtual money system, through which large amounts of illicit revenues could be processed (Castells 1998, pp. 166-205). A low-value payment system appeared unattractive in comparison. Consequently, the BIS commission concluded that "electronic money systems, particularly those implemented with hardware-based security, can be designed with an adequate level of security relative to other common forms of retail payment" (CPSS 1996, p.2). Finally, there was no system operating at a scale sufficiently large to be attractive to organized crime. This, however, could change with the expansion of the schemes. Some reservation lingered for the security potential of schemes like Mondex that allow for unaccounted peer-to-peer transfers. "It is the potential

Felix Stalder

unavailability of transaction information for security monitoring purposes, rather than the transferability feature itself, which may pose greater challenges to security" (ibid.). For the time being, the central banks deemed the systemic risk created by electronic cash schemes to be manageable.

Similarly, the threat of tax evasion due to electronic cash was assessed to be minimal (Congressional Budget Office 1996). Early musings on the impact of (anonymous) electronic cash foresaw that "the payment of taxes might become more or less voluntary" (Barlow 1993, p.22),[99] due to the government's inability to monitor encrypted information exchanges and the international character of the Internet (Kyriakou 1997). However, as Michael Froomkin (1997) pointed out:

> Most production and even more consumption involves transactions that are easily monitored for tax compliance. Income tax non-compliance requires payor as well as payee to participate in avoidance. Widespread deduction and reporting of tax at source makes this unlikely.

In a similar vein, the BIS committee (G10 1997, p.25) concluded that for card-based electronic money products, the feasibility of an issuer implementing a system from an offshore country was impractical, because of the physical presence and infrastructure needed to distribute and maintain cards and terminals, as well as gain acceptance by consumers and merchants.[100]

The relative ease with which the actual issuers of electronic cash could be identified, and the fact that most of them were already subject to the extensive regulation governing the financial industry as a whole, also limited

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[99] Ray Hammond (1996, p. 188) also suggesting that governments would be unable to monitor the flow of money and concluded that they "must accelerate the already powerful trend to eliminate income tax and raise all [the] necessary state revenues through direct taxation."

[100] This might be different for network based electronic cash systems since they do not necessarily need a large presence outside the networks and could be located anywhere. However, at the turn of the century, no off-shore electronic cash scheme had even been seriously proposed. Consequently, regulators were not concerned about the impact of network-based cash [I10.].

the potential of electronic cash to significantly disrupt the central banks' ability to conduct their monetary policies, contrary to what the libertarian fringe had hoped. Even in the extreme case that card-based electronic cash would replace all bank notes, Charles Freedman concluded that there would still be room for effective monetary policy [I.10].

For central banks, the difficulty of monitoring monetary flows would not arise from electronic cash flows being invisible. E-cash that could flow unaccounted through the banking system would simply not be permitted at all. There were already extensive reporting requirements that ensured that the financial institutions regularly updated the central banks on their current holdings and liabilities. For central banks, extending reporting requirements to electronic cash would be a minor adjustment of the framework that was already in place for monitoring the monetary supply. A somewhat more difficult problem was to correctly categorize the flows (Stuber 1996). However, adjustments in the aggregates in which the monetary supply was measured were nothing unusual. As a senior official at the Bank of Canada explained:

> [E-cash] is in some sense no different than any change or new product. Central banks have defined monetary aggregates to include certain kinds of bank liabilities, along with cash and currency. The central banks had a lot of difficulties when those liabilities have changed in terms of what they could be used for and how they identify them when building their aggregates....Emoney is a bit like that. You would not want to miss it because it is clearly a means of payment, it probably belongs in a narrow aggregate. But it won't be that hard to get. [I.11]

Over the course of their reviews, regulators and central banks relaxed their view of the potential of electronic cash to affect negatively the financial system and their own supervision. The research findings supported the already dominant notion that the best way to encourage innovation and efficiency was to let the private sector lead.[101] This view of the benefit of

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[101] Some central banks, for example in Finland and Austria, were early initiators electronic cash schemes (Bernkopf 1996), but subsequently turned them over to the private sector. The contrary view, argued by Warwick (1998), that the government should issue fully accounted electronic money and that this could act as a law enforcement tool was very isolated.

private sector leadership and minimal regulatory supervision was well adjusted to the general tone of the policy frameworks on electronic commerce adopted at the same time throughout the G10 countries. Overwhelmingly, these also advocated that the private sector should lead and governments should pursue a "hands-off" approach in order not to stifle innovation that would lead to a more efficient, "unmediated" market place (Canada 1997; Clinton & Gore, 1997; European Union 1997; Japan 1997). Ultimately, the reviews succeeded in what they were intended to do: "convinc[ing] ourselves or at least comfort[ing] ourselves with the notion that these [new technologies were] a reasonably solid kind of thing" [I.10] and that there was little need for action by regulators.

The national policy discussion in Canada reflected the international one closely, at least partly because Canadian officials played an active role in the various BIS committees. The policy objectives formulated were efficiency, safety and the consideration of consumer interests. Efficiency was defined in terms of cost minimization in the provision of payment instruments and services, as reflected in service charges, and the services' overall quality. Safety was defined in terms of risk minimization, related to the frequency of payment failure or the expected losses from payment failures. Finally, the consideration of consumer interests referred to privacy rights and the security of payment information, and to the extent to which consumers would have "reasonably broad" access to payment systems (Bank of Canada & Department of Finance 1997b).

Despite these clearly stated policy objectives, it has been noted that,

> while the use of electronic payment methods has become increasingly prevalent, the legal and regulatory framework for these arrangements remains relatively undeveloped... There exists no public statute underpinning the legal framework, and the relative newness of the technology has not allowed time for the courts to establish a strong body of legal precedent, although many of the principles applying to paper instruments might also provide guidance in the electronic context.....

Felix Stalder   [179]

> In the absence of government oversight and intervention, privately negotiated agreements may tend to favour financial institutions over their customers, because of information asymmetries and unequal bargaining power. As a result, liability resulting from loss, fraud or malfunction, could be borne disproportionately by consumers. (Bank of Canada & Department of Finance 1997d, p.10)

The absence of a strong legal framework was echoed in the slogan "achieving public policy objectives through market forces" [I.12]. The market activity was coordinated and supervised by institutions such as the Canadian Payments Association (CPA) which was created by an Act of Parliament in 1980 to bring together the public and the private sector.[102] To ensure security, in the case of Mondex and other electronic cash systems, the regulator relied almost entirely on assessments provided by international standards bodies, such as Information Technology Security Evaluation Criteria (ITSEC) [I.12].[103]

The sense of urgency to develop policies that first encounters with smart-card based electronic cash had created in the regulatory community subdued when it became clear that, once again, the early forecast that the cashless society would soon arrive did not materialize at the end of the 1990s. However, Charles Freedman noted: "there has been the odd meeting with Mondex to come up to date with what they are doing, but it's not a hot issue [anymore]" [I.11].

Neither the European Union, the US, nor Canada enacted any formal policies regarding electronic cash. The various agencies released "recommendations" and "opinions" that indicated to prospective issuers what policies might be expected in case the regulatory bodies decided to enact any. These recommendations in order to ensure long-term coordination between the

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[102] http://www.canpay.ca [CHECK URL]

[103] I will discuss "consumer interest" in the section 6.5

regulator and industry. As officials of the Bank of Canada explain this process:

> I don't think the developer of a new product will want to spring anything onto policy makers. And similarly, policy makers do not have any desire to spring any policy requirements on developers' products. [I.11]

This was, indeed, also the view of the financial institutions. Their early information about and collaboration with the regulator was, at least in part, motivated by a belief that the best government policy would be no policy at all. As Mondex Canada saw it:

> If they would do nothing, that would be just as fine. Generally, governments play a secondary role, unless they are intervening in a negative way. [I.5]

The only issue that could not be resolved was, probably, the single most important one: who should be allowed to issue electronic cash? The question concerned the relationship between the Originator and the regulator. The European view had initially been that only regulated financial institutions should be allowed to issue electronic cash (EMI 1994). This view was slightly relaxed into the recommendation that the issuer should be subject to, at least, "prudential supervision" (EMI 1998; European Central Bank 1998). By including the Originator into the general regulatory framework governing financial institutions, issues such as reserve and reporting requirements, liabilities, and deposit insurance could be easily defined. The American position, on the other hand, was to simply recommend that electronic cash issued by other than deposit taking institutions does not qualify as a deposit, and hence the holder of electronic cash is not insured through the Federal Deposit Insurance Corporation (FDIC) in case of failure of the issuer (FDIC 1996; 1997; Grabbe 1998). Beyond that, the field was left open to all interested parties. The Canadian position was somewhat in between, though not fully developed [I.10; I.11]. For most of the smart-card based electronic cash schemes under development at the turn of the century, this discussion was of limited relevance because they were to be issued through already

highly regulated conventional financial institutions anyway. In the case of Proton/Visa, each financial institution issued its own electronic cash but accepted electronic cash from all scheme members. The balances were settled through an interbanking clearing mechanism similar to settlement of paper cheques. Mondex, on the other hand, intended to set up the Originator as an independent legal entity that could not necessarily be subject to the regulations covering the financial institutions (Crawford 1996). Depending on how the Originator was defined, the risk of this activity was distributed differently among the parties: the Originator, the financial institutions distributing Mondex value, the insurer of the deposits, such as FDIC or CDIC, and the holders of electronic cash (merchants and users). The financial institutions that made up the Mondex consortium in Canada intended the Originator to be a separate entity. This would insulate them from some of the risks of a potential system failure.

When the Royal Bank announced its public trials in Guelph, the Bank of Canada was suddenly faced with the need to make a decision, particularly because this was seen as a first step towards a national roll-out. The Canadian regulator tried to find a position between the European and the American without prematurely regulating the actors that were still in the early stages of network-building and, therefore, not precisely defined.

In 1996, the regulator decreed that an Originator was to be opened-up as a joint-venture between the Royal Bank and the CIBC to operate during the Guelph trial. Faced with a concrete case, the central bank's decision was not to allow this Originator to operate as an independent entity [I.11, I.10], while leaving future options open. They had prevented, for the moment, the creation of an independent institution that was permitted to issue the first private currency in Canada in almost 100 years. They restricted this privilege to a joint venture of highly-regulated financial institutions. However, this (informal) regulation affected only the Guelph trial and it did not set the rules for the future. This interim decision left the Originator subject to future

(inter)definition by the financial institutions and the regulator. After the Guelph trial was shut down, the joint venture was dismantled. For the next Mondex test in Sherbrooke, QB, a new joint venture was set up, this time between the Royal Bank and Le Mouvement des Caisses Desjardins, the two leading banks in this case. As an effect, the Originator could not stabilize but remained in an interim state. As Fenton Ho explained:

> We basically come together for a launch and then dissolve. We are officially the Mondex Canada Interim Originator. We are not really [the final Originator] because of the joint-venture, [but] that will change probably when we ever go to a roll-out stage. [I.13]

Despite this flexibility, the Originator kept operating in more or less the same way, employing the same four people and using the same offices spaces in downtown Toronto that it shared with Mondex Canada. This flexible arrangement reflected the open-ended dynamics between the financial institutions and the regulator, both of which still didn't know what electronic cash really was.

6.5 Enrolling consumers (translation 3)

When the money was sent through the telephone wires from Toronto, it was no coincidence that the recipient of the donation was in Guelph, ON. On the contrary, Guelph had been carefully selected as the test bed for this new technology. The goals were to see how consumers and merchants would take on the roles defined for them in the blueprints of the Mondex world as well as to prepare, as the press release (13.02.1997) announced optimistically, "the national roll-out expected to begin in 1998".

Guelph, the chosen touch-down site for the future of money was a mid-sized town with close to 100 000 inhabitants. The financial institutions deemed it to be varied enough to be representative for the full range of payment situations, yet small enough to be susceptible to marketing efforts aimed at overcoming the initial chicken-and-egg problem – merchants waiting for customer demand while customers wait for merchant supply – that had plagued previous introductions of new payment systems (Evans &

Schmalensee 1999). Located 90 kilometers west of Toronto, Guelph was thought to be distant enough from the larger city to be independent, but close enough to be within reach of the banks and the national media headquartered there. With an eye on the upcoming national roll-out, large-scale national and international media coverage was actively encouraged as part of an extensive public relations campaign. [104]

In addition, Guelph had a large university and, in proportion to the town as a whole, a very large student population. Marketers thought of students as "early adopters" because of their presumed willingness to embrace new technologies and their high level of education. Not only the students were expected to be open to Mondex, the entire population of Guelph had shown a remarkable willingness to take up new payment instruments. Country-wide, Guelph had one of the highest rates of use of debit cards, the last major change in the payment system, introduced half a decade before. Additionally, when the Royal Bank approached the city council in the fall of 1995 with the idea of launching Mondex in Guelph, it was enthusiastically welcomed. With only one dissenting vote, the council voted in favour of the Mondex experiment and "directed the city administrator to spend as much time as he needed to make Mondex feel welcome"[I.9]. In the press release that announced the city's support for Mondex, the city administrator David Creech took up his promotional role and explained that Mondex was "in line with Guelph's prime goals of promoting innovation, partnerships, and competitiveness".[105] The council went so far as to place a sign at the town's entrance that read "Guelph, Home of Mondex".

Finally, the involved financial institutions initiated a market research and telephone campaign through which many of Guelph's residents were first contacted regarding Mondex. Unfortunately, the results of this marketing

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[104] For the Swindon trial, MXI had estimated that the publicity it received was equivalent to advertisement worth £3.2 million (Ives & Earl 1997).

[105] Royal Bank, press release (1.11.1995)

study have never been released. However, a similar marketing study done by another financial institution in late 1996 produced the following figures: 97% of respondents preferred cash over credit/debit cards for purchases under $10, and 41% would be "very interested" in using new payment technologies. 54% said convenience was the most important thing they considered when deciding how to pay for purchases.[106] The consumers, as they appeared in the study, seemed ready to join the Mondex world.

Mondex was designed to be a (partial) replacement of cash and hence to be used by virtually everyone. Individuals were thought of as "consumers", as a relatively homogenous group primarily interested in "convenience" and "time-saving". In order to make this replacement of cash with the Mondex card successful, consumers had to be enticed to join the Mondex network. This meant two things had to be accomplished simultaneously by the actors already involved. On the one hand, the existing networks of cash had to be selectively dismantled, disassociating the consumers from coins and bills. On the other hand, relationships had to be established between the individual consumers and Mondex that would lead to the consumers' acceptance of their new role as card-carrying members of the Mondex world.

The use of coins and bills, however, was deeply ingrained in the pursuit of everyday life and supported by countless highly adapted actors in the existing actor-networks of commerce. Parking meters, coin laundries, many corner stores, street musicians, home delivery services, to name but a few, were so highly adapted to coins and bills that these were the only acceptable forms of payment. Many other vendors, while not depending on cash exclusively, were nevertheless well adapted to accepting cash in exchange for the goods or services they offered. Government agencies were required by law to accept coins and bills as payment (legal tender), symbolizing the government's trust in its own currency. No official statistic was ever compiled

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[106] Figures quoted in a December 1996 press release of the Bank of Montreal, http://www.bmo.com/News/exactk.htm [18.06.1997]

of the volume of cash use in Canada, but in the US about 80% of all financial transactions were conducted with cash.[107] At the time of the Mondex launch, in 1997, about $30 billion in cash was outstanding in Canada, of which the financial sector held about 10%. For every Canadian, about $900 in bills and $100 in coins circulated through the economy (Bank of Canada & Department of Finance 1997a, p.6).

However, people were not just one-dimensional consumers and not all outstanding notes and coins were actually circulating as payment instruments. Some of it wasn't circulating at all, but was destroyed in fires and accidents of all sorts. A gift to the Bank of Canada. Furthermore, coins and bills were actors in multiple networks, and they were not exclusively defined by their exchange value. They were used for all kinds of purposes: thrown in fountains for good luck, put on railway tracks by kids, burnt in artistic performances, or kept as personal memorabilia or as part of a collection. Such additional, often emotional dimensions of coins and bills were actively encouraged by the issuer of currency through the minting of commemorative editions of coins. The Canadian "millennium edition" of 25 cent coins, for example, was widely advertised in the mass media as enabling Canadians to "hold a little bit of history in your hand".

The symbolic dimensions of cash were augmented by the fact that it often depicted heads of state or other figures of importance from the national history.[108] An indication for the importance of these dimensions of cash is the fact that more than 10 years after the dollar bill had been withdrawn from

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[107] These 80% of all transactions, however, represent about 1% of all the value exchanged. The remaining 99% of value are already part of the virtual money system, though a large, albeit decreasing part is still paper-based (ibid.).

[108] This tradition was originated by Julius Caesar (Davies 1994, p.89) and has continued into the present. In Canada, every coin not only shows the current head of state, Elizabeth II, but even still contains a Latin formula, D.G. Regina (queen of god's grace). Only recently have some countries, such as the Netherlands, begun to issue notes adorned with purely abstract patterns.

circulation, 160 million of them were still outstanding [I.10].[109] Another indication of the importance of the non-economic dimension of coins and bills was the heated debate in Denmark over the question of whether it should abandon its Crown and join the Euro. The Danish Crown had been pegged against the Euro since the Euro's inception in 1999, hence joining the Euro would economically make hardly any difference in terms of national independence. However, the emotional value of a traditional national currency, as opposed to money created by far-away bureaucrats in Brussels, gave the debate considerable volatility. Many Danes feared that joining the Euro would "blur [their nation's] own sense of self beyond recall" (Vinocur 2000). On September 28, 2000, 53.1% of voters decided against adopting the new currency, even though this was generally understood not to be economically advantageous (Buerkle 2000).

In order to translate individuals in Guelph into "consumers with a Mondex card", as they were identified in the Mondex blueprint, it was necessary to loosen their connections to physical cash, clearing a space in which to insert the new Mondex artifacts. As Joanne DeLaurentiis, CEO of Mondex Canada, explained: "We have the challenge to change the perception, [to show] that cash is inconvenient and to demonstrate that when it comes to low value transactions, Mondex is much better value than cash" [I.5].

To achieve this, an extensive advertising campaign began. Posters, brochures, and leaflets portrayed cash as "bulky", "heavy", "cumbersome", "making a hole in your pocket", as altogether undesirable because of the embarrassing necessity "to fumble for change", whereas Mondex was portrayed, in line with the what the marketing study suggested Canadians would appreciate, as "convenient", "quick", offering "always the right change", self-evidently "the future of money". Posters that contrasted a cartoon of a helpless-looking man, pockets bulging with coins, to a man who

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[109] It is impossible to tell how many of these 160 million bills were never redeemed due to loss and how many were kept back due to their non-monetary value.

was unburdened and happily holding a Mondex card were put up all over town, particularly in the historic downtown core. As anticipated, the size of the city enabled the promoters of Mondex to create a strong presence that introduced Mondex very quickly to the general public. On the main street, a shop was opened for people to walk in and receive promotional material about Mondex and applications for cards. Promotional events enticed people to obtain and use Mondex cards. At times, cards were issued with various amounts of cash preloaded, at other times, people who could show they had used the Mondex card three times received a one-time bonus.

And indeed, people readily accepted the offers presented to them. Only two months after the launch, the banks issuing Mondex could already announce "an early success in Guelph".[110] More than 5 000 Mondex cards were distributed during that time, and during the month of March an average of $15 339 of Mondex value were issued per day. Contrary to what the theory of network effects would suggest (S-curve representing slow growth in the beginning until critical mass is reached, followed by explosive growth afterwards) the initial growth was very rapid, "exceeding expectations" (Mondex Canada, PR 11 April, 1997).

An important locale for Mondex was the university, particularly the various shops in the University Center. The university administration readily welcomed the introduction of Mondex because it offered the university the opportunity to display itself as being at the forefront of high-tech, as well as obtain donations from the financial industry. For the university's administration, relationships to the private sector were becoming more and more important. Over the past decade, universities had increasingly been driven to look for new sources of revenue beyond government funding. This pressure on universities had been stepped up with the election of a *progressive conservative* government in the province of Ontario which had

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[110] Royal Bank, press release (11.4.1997)

set as its top priorities the shrinking of government, balancing the budget and cutting taxes. The universities' reaction to this new budget pressure was, across the country, to increase tuition, to cut back funding for programs that were considered of little interest to the private sector, and to give private enterprises high visibility on campus in exchange for donations.

One of the side-effects of this transformation of the university was to inspire a new generation of student activists who were focusing on corporations (rather than governments) and opposing the "corporate take-over of the university" (see, e.g. Klein 2000). As a student activist in Guelph explained:

> We are facing tuition increases, and we are facing all these cut-backs, especially to arts programs, and meanwhile banks are getting more and more leeway on campus to hand out to the frosch kids all their literature, credit card offers and all this stuff. So the first week you are just inundated with bank advertising and banks setting up, on campus, info tables and stuff. [I.9]

As a promotional event, the Banks had set up a booth in the University Center to hand out to students cards preloaded with $10. Staff explained the different uses that Mondex could be put to. Some students, however, thought it highly amusing to have explained to them how to use cash. Mocking Mondex, they set up a table of their own, across the hall, handing out 10 cent coins and explaining how to use the coins [I.9].

Student activists were a relatively small group within the student body, but they had a modicum of structural support through the student unions and small organizations such as the Ontario Public Interest Research Group (OPRIG). To them, the Mondex world was part of a possible future they disliked. The massive advertising campaign throughout the city and the expanded presence of financial institutions on campus was a further indication of what they saw as the increasing encroachment of civil society by

dominating economic actors. "The student union already had concerns with the [Royal] Bank, this [Mondex] just added to their concerns" [I.9].[111]

The role Mondex was understood to play in this encroachment of civil society was to generate an audit trail that would give the banks even more precise information about an individual's behaviours, to be used for even more targeted advertising and other attempts to manipulate. Initial research conducted by one student activist on the Internet brought to light that the Guelph students were not the first ones to suspect that the Mondex technology might act not only as a means of payment, but also as one of data gathering and hence be potentially privacy invasive (Clarke 1996). In the first public test of Mondex in Swindon, UK, it was advertised as "anonymous" and "just like cash".

This advertisement prompted Simon Davies, director of Privacy International, to investigate Mondex's claim that their digital cash service was anonymous. In the course of his research Davies came to understand that, contrary to Mondex's public statements, the system was not anonymous and that the bank and merchants could trace individual users (Davies 1996). On September 15, 1995, he filed a complaint at council in Bromley, UK, on the basis of violation of the Trade Descriptions Act (misleading advertisement).[112] In June 21, 1996, Robert Gilham, Area Trading Standards Officer, responded to Davies' complaint by stating:

> It appears the customer is identified to the trader and...ultimately, the bank, by the 300 previous transactions. Each of these will soon be superseded by further transactions and drop

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[111] One of the reasons students had an uneasy relationship to banks was that a few years earlier the federal government had outsourced its student loan program to private financial institutions and many students had the unpleasant experience of interacting with these banks while having mounting debts due to the rising tuition costs.

[112] http://www.privacy.org/pi/activities/mondex/complaint.html [26.04.1997]

off the end of the list. These can be monitored by the bank and could be used for marketing purposes.[113]

This response was based on the fact that all Mondex cards kept transaction logs. The complaint triggered no formal actions by the council because there was no precedent set that determined if material on the Internet was advertisement in the sense covered by the Trade Descriptions Act. Furthermore, Mondex International had in the meantime changed the wording on its web page. Now its electronic cash was no longer anonymous, but was "designed to balance practicality, privacy and the prevention of fraud".[114]

For the promoters of Mondex, Davies' complaint had no merit because it reflected simply a poorly worded advertisement (Birch 1996). For the student activists in Guelph, however, it provided the initial material to launch their counter-campaign opposing the Mondex network in their home town. A central point of contention was the character of the relationship between the customer and the financial institution that would be created by the Mondex card. This relationship was understood as defined by two aspects: people's access to the Mondex world and their privacy within it.

As one of the student activists explained the beginning of their campaign:

> So OPRIG gave us, me and two friends basically, a small budget for photocopying, that was why I made jokes about how $30 worth of photocopying can fight a $70 million ad campaign. Because with the photocopying we did press releases, say the students were concerned about the privacy issues – the tracking element of it. I had done research and found out that Privacy International in the UK had already taken them to court and won over the British Trading Descriptions Act because it was false advertising. They said it was completely anonymous. I also discovered that they had changed their PR but not the technology when they came to Guelph.

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[113] http://www.privacy.org/pi/activities/mondex/mondex_response.html [26.04.1997] (Part of the reason why it took almost a year to reply to Davies' complaint was that the government official had difficulties accessing the Internet to review the relevant material.)

[114]FAQ section, at http://www.mondex.com [15.04.1997]

> So, armed with that info from Privacy International in the UK, and
> the help of the City Councilor who voted against it, we did a
> little facts sheet about what Mondex really was. We were trying to
> draw out some of the people's questions. Do you really know why
> this is happening? Or, do we really need electronic cash? What is
> wrong with just regular cash?
>
> We handed those out in front of the banks, the Downtown main
> square, St. George's Square, has got about six banks facing one
> another around the square, so it was pretty easy to just go in
> front of each bank, hand out flyers and talk to people. [I.9]

Because Mondex had such a strong presence in Guelph, most people were
sensitized to it when the students began to hand out their leaflets.[115] Soon,
the press picked up on the issue because it provided a controversial angle to
an otherwise unspectacular story, the test of a new financial product (see, for
example, Jones 1997; Menzies 1998).

A particular important event for bringing forward the issue of privacy was a
feature-length documentary on electronic cash that aired on national
television (March 27, 1997) which directly accused Mondex of invading
people's privacy.[116] Among others, a number of prominent academics were
interviewed who raised the spectre of what David Lyon (1994) called "the
surveillance society" and demanded safeguards and public accountability.
Additionally, one of the student activists published critical texts on Mondex
on the Internet, which consistently turned up on searches with the keyword
"Mondex", providing journalists with a starting point for their research.

Managers at the financial institutions were irritated by the unexpected and
vocal hostility they encountered among some of the students who saw

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[115] This is generally typical for anti-corporate activism, which gains some of its strength from
the extensive media presence of the targeted corporation (see Klein, 2000 for an analysis of
this dynamic in the context of Nike).

[116] The documentary was produced by an independent media firm, Channel Zero, that included
some of the Guelph activists. The documentary was commissioned by the CBC in an attempt to

themselves as citizens with a civil agenda rather than as consumers with a shopping list. The managers were concerned that the discussion about privacy would brand Mondex as a malicious device that was secretly snooping on unsuspecting citizens rather than, as Mondex promoters preferred, as a convenient high-tech time-saver for savvy consumers. In an internal memo that was later published on the Internet by David Jones, the CIBC, one of the two major banks involved in the Guelph trial, revealed an acute awareness of the delicate nature of the new, still poorly defined technology.

> However, headlines prevail and we may not have our "day in court" to tell our story in full. Given the current situation in Guelph with Mondex naysayers (University/CSA student protests, store vandalism, propaganda from P.J. types on the internet),[117] it's a significant risk that if any of these groups discover that Mondex transactional data is being collected from merchant logs they would use and create every opportunity possible to stir negative headlines with "Big Brother" accusations. (CIBC 1997)

The memo even contained a worst case scenario with this fictitious headline to illustrate the importance of this discussion: "Mondex Not Private! Banks Collect Data on You -- Data You Thought Was Private" (ibid.).

The ensuing discussion of Mondex was carried out through promotional material, various articles in mass media and also face-to-face. At the University of Guelph, for example, a panel discussion between Mondex staff and critics was held.[118] The disagreements, however, could not be resolved. The characteristics of Mondex could not be defined in a fashion that was accepted by all sides. The difficulty of determining the characteristics of Mondex was exacerbated by the fact that, depending on which part of the network was under examination, the technology appeared to do different

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reach out to the "Internet generation" at a time when pundits predicted "the end of TV" because of the rise of the Internet.

[117] PJ was the acronym used by the student activists who published citical information on the Internet.

[118] In March 1998, I participated in a panel discussion at the University of Guelph as an independent expert, substituting for David Jones (EFC).

things. In the context of the system's privacy, it was said that the card transmitted only the card identifier, the transaction amount and time, but not the transaction record it stored. The banks, for example, would only know the amount a merchant was depositing at the end of the day, but not from which cards s/he had received this amount. In other words, the transactions between the customer and the merchant were unknown to the bank, hence the system was unaccounted and the customer's privacy protected.[119] However, regarding the system's security, it was stressed that it was possible "to collect more data" (Beric 1997) and scrutinize individual transactions to detect the source of a possible insertion of illegitimate value. In the light of these seemingly incongruent statements, the Mondex promoters were accused of "leading a double life" (McKay 1997).

This disagreement over the characteristics of the chip technology arose from the fact that for the critics and the promoters different sets of actors had to be examined in order to evaluate the card's characteristics. The critics argued for an evaluation of the chip in isolation, that is, based on its technical potential. The technical potential was one for "conditional traceability". A unique identifier existed that made it possible to trace transactions, even though this was not necessarily done with every single transaction. For the critics, conditional traceability was a significant disadvantage compared to cash. Clay Ryder, director of Zona Research Inc., a consultancy based in Redwood City, California, pointed out, that "as soon as you begin to keep records, privacy is not possible. There are no records kept with cash; if an electronic cash system stores records it ceases to be like cash" (quoted in McKay 1997). David Jones, furthermore, argued that the limits on transaction logs on the cards – 10 for consumers, 300 for merchants – were not set arbitrarily but cleverly designed to optimize data collection, making it possible to capture, if intended, up to 90% of all transaction. He said: "Think about it, how many times you use cash between

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[119] The competing Proton/Visa scheme, on the contrary, also transmits the entire transaction history, hence creating a fully accounted system.

trips to the ATM (automated teller machine). I have studied this and most people say that they would carry out less than 10 transactions. That means that Mondex is not cash-like and does not offer much privacy" (quoted in McKay 1997).

The promoters of Mondex, on the other hand, argued that what mattered was less the theoretical potential of the chip technology, but the actual practices in which it was employed. Robert Gilham, the officer responding to Simon Davies' complaint, for example, confirmed the existence of an "audit trail and [which] ultimately could be sold to business users for third party marketing." However, he added, "I am assured [by the banks running the trial, that] this does not occur at present."[120] Equally, CIBC's memo, posted on the Internet by the EFC, pointed out that:

> CIBC feels the reward to be gained from collecting this research data do not measure up to the risk. We believe there are other ways we can capture the information necessary to make informed business decisions for rollout. We accept that we are working within [the] limitations of an ``unaccounted'' system and, therefore, are willing to find ways to deal with the limitations of this environment (as we do with cash).

However, the same memo opened a back door by pointing out, that

> regardless of whether we would or wouldn't hire a third party to collect merchant logs for research purposes, CIBC is confident that privacy would at all times be fully respected and honoured. We understand that this data collection exercise would not be a breach of privacy. (CIBC 1997)

Mondex promoters implicitly acknowledged that it was possible to collect the transactional data stored in a merchant terminal. However, they were quick to add that they had no intention to do so, at least for the moment. It was their understanding that it was not the potential of the actor that mattered most, but the conditions of its realization. Such a view also reconciled the seemingly contradictory statements Mondex made regarding the security and

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[120] http://www.privacy.org/pi/activities/mondex/mondex_response.html [26.04.1997]

privacy of its system: if necessary, the system could be highly accountable, however, usually it was not.

While it was within the discretion of the operator of the scheme to define how much transactional data was to be collected, there were a host of actors shaping the actual extent of this discretion. On the one hand, as the CIBC memo pointed out, the customers had a clear preference for privacy and infringing upon it might result in negative headlines alienating them from the Mondex network. On the other hand, the data to be gained from capturing transactions logs was of potentially significant economic value, both for internal and re-sale purposes, hence there could be significant business incentives to use this data. Furthermore, the financial institutions' discretion was limited by a maze of private codes of conduct and regulation regarding the use of personal information.[121]

At the time of the Mondex trial in Guelph, the most important piece in the regulatory framework was the voluntary code developed by the Canadian Bankers Association (CBA) called "Privacy Model Code: Protecting individual customers' personal information" (CBA 1996). This code, the latest in a series of voluntary privacy codes developed by the financial industry, was developed in accordance with the more general Canadian Standards Association Model Code (CSA 1996) and included the latter's 10 principles for the handling and protection of personal data (for a comparison, see Bennett 1997). In a nutshell, these principles defined:

- the accountability of the company holding the data
- the need to identify the purposes of the data collection
- the need to obtain consent

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[121] There "was a complex and interrelated web of laws, rules, standards, codes and procedures that established the legal and institutional basis of the payment system. The general legal framework was comprised of both public and private laws. The former were statutes and government regulations having compulsory application; the latter were embodied in voluntary agreements between the various parties involved in payment activity, and in the body of precedents established by the courts in interpreting these agreements" (Bank of Canada & Department of Finance 1997a).

- the requirement to limit collection
- the requirement to limit use
- the requirement for disclosure and retention
- the accuracy of the information
- safeguards for handling sensitive data
- the individual's access to the data, and
- some mechanism for challenging compliance.

It was unclear, however, how effective this code would be, since not all banks implemented it in the same way. Consequently, it was impossible to determine in any general way the extent to which the CBA's privacy codes actually "worked". As Colin Bennett soberly concluded, "if the banks protect the privacy of their customers' information, they probably do so for reasons that have less to do with the existence of a "code of practice" from the Canadian Bankers Association than with a set of pre-existing business incentives" (Bennett 1997).[122] What made the application of this code of conduct particularly difficult was that the Mondex card was so tightly black boxed. While it was relatively easy to see what went in and what came out, it was impossible to see what went on inside and hence it was impossible to independently assess if and when any of the rules were violated.

The adoption of the code ceased to be voluntary when the Canadian government signed into law the bill C-6, *The Personal Information Protection and Electronic Documents Act,* in April, 2000.[123] This bill, in part developed to meet recent data protection standards set by the European Union (EU 1995), mandated that all businesses implement the 10 principles developed on the CSA model code and established that the federal privacy commissioner could

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[122] This interpretation is supported by the above cited expert from the CIBC memo that states public relations reasons as the reason not to collect transactional data. Concerns over violating privacy codes are explicitly discounted by stating: "We understand that this data collection exercise would not be a breach of privacy" (CIBC 1997).

[123] http://www.parl.gc.ca/36/2/parlbus/chambus/house/bills/government/C-6/C-6_4/C-6_cover-E.html

conduct a privacy audit if there were "reasonable" grounds to believe an organization was violating its obligations.

This new bill, which went into force for the financial industry on January 1st, 2001, did not affect the financial industry's ability to gather transactional data for security purposes, but it seemed to limit its ability to use this data for other purposes. However, how exactly this law was going to be implemented remained to be seen. It also remained to be seen how effective this law would be in addressing the consumer's reservations about trusting the financial institution's promises not to gather data for other than security purposes.

The lack of transparent safeguards for personal information gathered through the transaction logs was the main point of criticism of the Mondex world that the student activists in Guelph brought to the fore. But it was not the only one. Another concerned the question of access to the Mondex world. If Mondex were to succeed in replacing cash on a large scale, what would be the conditions of gaining access to the tools needed to enter the new world of e-cash [I.9]? With cash, it was argued, there were no technical or institutional access barriers to the means of circulation. With a system like Mondex the pre-condition of being able to give and receive money was the possession of the necessary devices. The conditions under which these would be issued were far from clear. During the Guelph trial, customers of the involved banks could receive a card for free and they could even request a card for their family members that did not have a bank account themselves [I.1.]. However, at this time, some 650 000 adults in Canada did not have bank accounts (Department of Finance 1999, p.48) and it was precisely those already excluded from other forms of electronic payment (credit and debit cards) who relied on cash most heavily. They would be hit the hardest if cash were replaced by an electronic substitute.

The federal government recognized the general importance of having access to the virtual money system through a bank account. Without this it would be increasingly difficult to participate in an economy that relied to a large extent on electronic funds transfer. The Department of Finance (1999) recommended requiring the financial institutions to offer a low fee, no-frills bank account to everyone.[124] However, whether such an account would include access to electronic cash products, should they become widespread, was an open question. In Guelph the cards were issued at no charge, but there was widespread expectation among users and issuers that charges would eventually be levied. In a study of an earlier e-cash trial in Kingston, ON, the fear that this technology would lead to service charges was found to be among the main reasons why users distrusted the networks of e-cash (Pluffe, Vandenbosch, Hulland 1999). Anecdotal evidence from Guelph (Stalder 1998a) and the later implementation in Sherbrooke suggests that such concerns remained widespread (Tuck 1999; [I.15]).

The transformation of a sizable part of the Guelph population into Mondex consumers turned out to be very difficult. As the test progressed, it became increasingly clear that their enrollment was very unstable. One reason was that the actor targeted for translation, the simple Guelph resident/consumer, was difficult to locate. In reality people had multiple identities and some of these identities did not fit the Mondex world. This being a highly mobile society, many people who lived in Guelph did not work there, but commuted on 5 lane highways to Toronto. Consequently, Guelph residents were as much Toronto consumers as they were Guelph consumers. However, the limited extension of the Mondex network could not accommodate Toronto consumers. Additionally, many people who were Guelph consumers were not Guelph residents. Not having been issued Mondex cards, they were also excluded [I.5].

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[124] Given explicit requirement of banks to "cash federal government cheques" for the holders of such no-frills accounts, it seems reasonable to assume that this requirement was introduced, in part, to prepare the ground for the electronic delivery of government benefits.

For some Guelph residents/consumers, as already mentioned, the Mondex world conflicted with their agenda as citizens. For others, a small minority, the Mondex world conflicted with their identity as members of a religious community. There had already been a lively underground of religious distrust against advanced technologies. Echoing the 2000 year old Christian aversion to money, a Christian fringe discourse emerged characterizing the virtual money system as branded by "the mark of the beast" to be revealed through various forms of exegesis of names and numbers. Electronic cash had attracted considerable attention among the Christian Fringe that promoted its view in dedicated journals (Gimon 1995), books aimed at a fundamentalist audience (Ice & Demy 1996) and numerous websites and leaflets handed out on street corners. In quantitative terms, the Christian fringe was among the most vocal critics of the Mondex world on the Internet. However, their particular form of logic restricted their appeal to a very limited audience.[125] Critics from other prespective made sure to keep their distance [I.9].

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[125] For outsiders not versed in this kind of Bible studies that used numerology and relied on the revelatory power of names, the argument was difficult to follow. Central was the claim that Mondex was the mark of the beast. This was based on Revelations 13:16-17. "And he causeth all, both small and great, rich and poor, free and bond, to receive a mark in their right hand, or in their foreheads: And that no man might buy or sell, save he that had the mark, or the name of the beast, or the number of his name."

The connection to Mondex was established in the following way:
"Notice that in the above verses, we are told 'in their right hand'. While this may be mere coincidence, it might interest you to know that the name 'Mondex' has some very interesting implications. For example, if we divide it into two syllables, we discover the following:

MON = Latin 'moneta' meaning money.
DEX = Latin 'dexter' meaning of the right side, right-handed

Another interesting way to look at it is like this:
MONDE = Latin 'mundus' meaning the world
X = a mark, as in 'X marks the spot'.

If Mondex is not the actual mark of the world, the Mark of the Beast, then in my view, it is at least the next step in that direction! These money-hungry and power-hungry [sons?] of Satan have now become so sure of themselves, they have become so bold, that it doesn't even bother them to boast about what they are about to do! They have chosen a name which clearly defines their ultimate goal!"

The above quotes, fairly typical for this genre, were taken from an anonymous pamphlet, posted to the web on Feb. 3, 1998 http://www.endtimeprophecy.net/~tttbbs/EPN-2/Articles/Articles-Endt/mndxmrk1.html [07.17.2000]

It is difficult to quantify to what extent the specific concerns over various aspects of the Mondex world influenced the decision of the majority of consumers not to join the Mondex world or to drop out as active members. One of the few published user studies found that concerns about security, privacy and service charges were important factors in people's negative reaction to electronic cash (Pluffe, Vandenbosch, Hulland 1999). Anecdotal evidence, gathered in Guelph and Sherbrooke, supports these findings. This is not surprising, given the fact that security and privacy, in particular, were deeply held concerns regarding all forms of emerging electronic commerce. In other words, people with extensive experience in new technologies, especially the "early adopters", were already sensitized to security and privacy concerns when Mondex arrived. It was a well-trained reflex to expect a new communication technology to raise privacy issues.

The financial industry found that enticing people to become "Mondex consumers" was one thing, but encouraging them to put forth the energy to maintain this role, and with that the Mondex world as a whole, was much more difficult. Initial curiosity and promotional incentives could achieve the former, but in the long run such gimmicks were insufficient to convince people not to drop out again. One part-time Mondex consumer described her use of e-cash like this: "My bank had a promo – use it three times and get $15 in credit. So I bought three packs of gum and then went out for a nice lunch. I haven't used it since" (quoted in Gatehouse & Akin 1998). After an initial successful take up of Mondex cards, consumer involvement in the Mondex world began to falter. Some merchants began to complain that there were not enough consumers using the card to warrant their efforts to keep the readers on their counters, while users found that the Mondex world was

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Signs of the devil could be found everywhere. One Christian author (Beard 1997) wrote: "Another symbol utilized by MONDEX is the butterfly. This symbol has numerous mystical meanings but the most prominent is that of capturing the soul. The Greek word for butterfly and soul is 'psyche'. Can receiving the "mark of the beast", a deal with the Devil, cause you to lose your soul?"

not extensive enough to warrant joining it, particularly given the fact that in most places where Mondex was accepted many other forms of payment (cash, debit cards, transit tickets) were also accepted. Reacting to this, the financial institutions began to work on extending the scope of the Mondex network. While struggling to keep merchants from dropping out of the network, the financial institutions concentrated their efforts on areas where other forms of electronic payment were not present: unattended point of sale devices. Bell Canada increased the number of public pay phones that were equipped with Mondex readers. The financial institutions financed the conversion of parking meters so that they accepted not only coins but also Mondex cards.[126]

However, despite the broadening efforts to increase the utility of Mondex cards, a large number of consumers found it difficult to see reasons to use them. With the "early signs of success" quickly fading, the media coverage became increasingly negative, further contributing to the alienation of users, who simply left their cards at home and continued their daily lifes ignoring the Mondex offers (Buckler 1999; Gatehouse & Akin 1998; Sher Singh 1998, Sternberg 1998).

The absence of consumers put the entire network under strain. It started to disintegrate. Among the financial institutions, reservations grew about continuing to supply the necessary funding to maintain the Mondex network in Guelph. In the fall of 1998, one and a half years after the launch of Mondex, one of the banks, CIBC, announced plans to stop supporting the local trial. Lacking the necessary funding, the trial had to be phased out at the end of the year.[127]

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[126] Mondex Canada, Press release (11. 10.1997)

[127] Despite regional differences, the experience of the Guelph trial were very similar to a trial in NYC, conducted by MasterCard and Visa. It was terminated at the same time for many of the same reasons (see Hansell 1998).

In retrospect, the initial transaction to launch the Mondex network in which money was sent from the offices of a bank in Toronto to a local charity in Guelph, contained another, unintended symbolism: the absence of consumers from the network.

6.6 Enrolling merchants (translation 4)

As one observer noted "a cashless society may be [most] beneficial to banks and merchants. [For them] handling cash is time consuming, prone to error and poses security risks" (Church 1997). And indeed, the financial institutions were relatively successful in signing up merchants to join the Mondex network in the downtown cores of Guelph and Sherbrooke. Particularly, merchants who sold small value items were, at least initially, quite hopeful that joining the Mondex network would be beneficial to them. Electronic cash, they hoped, would help them run their business more efficiently and more profitably by reducing the need to count small change.

One of them was Dan Brown, who sold popcorn in Guelph's Stone Road Mall. He estimated that he spent about four hours a week counting cash, taking care of cash-related paperwork, and standing in line at the bank to pick up or deposit small change (which could not be dealt with through ATMs). Besides being labour intensive, handling cash was also error prone. Despite money-management techniques, shrinkage could (and did) occur at his store. Change was made incorrectly, money was lost or, perhaps, stolen. Additionally, he had to deal with the problem of counterfeited bills. In his worst month, he got stuck with $400 of forged $10 and $20 bills. Electronic cash, he and many merchants believed, would be more difficult to forge and hence would reduce their risk. He hoped that Mondex would soon be everywhere (Menzies 1998).

In Sherbrooke, a grocery-owner expressed a similar attitude towards Mondex at the outset of the trial.

Felix Stalder   [203]

> I would like if people would pay only with plastic, I wouldn't have
> to worry about counting or security — people can't steal
> electronic cash. (Tuck 1999)

The most common attitude of merchants towards Mondex was succinctly expressed by the controller of a large grocery store in New York City. When the electronic cash trial began there, he said: "If it works, we'll keep it. If not, we'll dump it" (quoted in Vittala 1997).

But when, exactly, could the Mondex network be said to be working for a particular merchant? "Working" didn't imply only that the artifacts functioned reliably, though this was necessary, and not always the case during the early trials. Working, for a merchant with a conventional business – say a grocery store –also did not readily mean new business due to electronic cash. There was no obvious new service that Mondex would help him or her offer. Working, then, meant that s/he either would save money due to reduction of labour and decreased risk of losses thanks to electronic cash, or that s/he would lose business if s/he didn't accept it in the face of customer demand. The first possibility, cost savings, was the more immediate incentive for merchants to enter the Mondex world early on. Tim McNaughton, manager at Pilots & Implementation Division, Royal Bank, estimated that the threshold – the point at which the cost savings would surpass the costs of being a member of the Mondex world – was at around 5% replacement of cash by Mondex value [I.1].

To lower the costs of entry into the Mondex network, the financial institutions provided for free the necessary equipment, a reader for smartcards (Tuck 1999). In Guelph, fees initially charged for merchants to deposit money were soon dropped in order to keep merchants enrolled in the network (Hansell 1998). Through these measures, entering the Mondex world created no costs to merchants, apart from training staff to use the new equipment and providing space for the additional reader on their counters. This additional incentive did convince some merchants to enroll who wouldn't have

otherwise, perhaps because so little commitment was required. In Guelph, for example, one retailer accepted the Mondex terminal only because terminals were free during the pilot. She said that as soon as the banks began to charge, she would drop it (Blackwellt 1997). To offer further incentives, the financial institutions introduced various promotions aimed at motivating otherwise reluctant merchants to play a more active role in the network. In Sherbrooke, for example, Mondex Canada went as far as creating the "Mondex Mystery Shopper" promotion. This promotion was especially "designed to reward participating merchants and their staff for supporting the use of the Mondex electronic cash."[128] All merchants accepting Mondex electronic cash were visited twice by a non-identified Mondex Canada employee. Cashiers were awarded an instant prize for merely conducting a Mondex transaction. Their name, along with that of their business, was also entered into the prize draw. The $5000 prizes were awarded on February 21, 2000, to Lise Larouche of Dépanneur Carrefour Portland, and Daniel Lapointe of Brasserie Daniel Lapointe. Ironically, the prize sum was too large to be paid out in Mondex value.

However, not all merchants were swayed by the potential cost savings or introductory offers. In Guelph, the bus drivers, though not merchants themselves, but dealing with customer payments nevertheless, refused to let Mondex enter their buses. They argued that another payment method would add more distraction and stress, due to customer confusion, to their already stressful jobs. Balancing job quality and safety concerns against potential savings for their employers – for example through the layoff of their fellow union member who held a full-time job managing the considerable amounts of cash that the public transport provider had to deal with every day – the bus drivers initially said no to integrating Mondex. They nearly staged a

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[128] Mondex Canada, press release, 21.2.2000

walk-out over the issue.[129] Only after Mondex Canada agreed to advertise extensively in the buses could the public transport system be included in the Mondex network [I.9].

Many merchants remained skeptical and decided to join only when there was real demand from consumers. Others were critical of the Mondex network for other reasons. In Guelph shortly before the financial institutions began to introduce Mondex, many of the downtown merchants had joined together and staged successfully resistance against the arrival of a WalMart superstore at the edge of town. In the wake of this experience, some merchants questioned if Mondex would really help local small businesses. Since they did not experience immediate benefits from Mondex, they suspected it was just another attempt to develop a service that was primarily beneficial to the banks, which were viewed as not particularly interested in small business. This sentiment was exacerbated when the banks did not rule out to the possibility of charging for the use of Mondex at some future point. With this suspicion in mind, the owner of the local, independent video store not only refused to participate in the Mondex trial, but also included the highly critical TV documentary *The Mondex Scenario* (Channel Zero 1997) in his catalogue [I.9].

As the trials progressed, most merchants did not cross, or even get close to, the critical threshold of 5% cash replacement. A large grocery store in New York City that had initially participated in the local electronic cash test, abandoned it after having received, on average, only 7 to 10 Mondex payments per week, out of a total of 50 000 transactions (Foderaro 1998). After one year, two-thirds of all the initially participating merchants had left the Mondex network in NYC (Hansell 1998).

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[129] In Sweden a very similar conflict erupted around the same time during a trial of the local CashCard. Bus drivers there also refused to accept electronic cash in their buses because it meant more work and stress for them (Holmstrom & Stalder, unpublished).

In Guelph, the situation developed similarly. Merchants began to drop out because the transaction volume was extremely low. As one downtown merchant noted, his bike shop had only done 15 transactions in 18 months. Many merchants barely remembered that they were members of the Mondex network. Even those who had believed that electronic cash would have distinct advantages if everyone used it could see little gain from staying in the Mondex world if only a few consumers were taking part. When Mondex Canada announced it would dismantle the Guelph operation, few merchants regretted the decision. There was a certain feeling, though, that the city as a whole had not profited from having been "The Home of Mondex" (Sher Singh 1998).

6.7 Transforming the financial industry (translation 5)

When the "future of money" arrived in Guelph the association of financial institutions designated to guide the assembly of this future had barely made it into existence. "We are just organizing ourselves", said its first spokesperson, Eileen Chatnick, Director of Public Relations [I.3]. The association's physical presence in the office complex of the Royal Bank in downtown Toronto was marked by handwritten paper signs taped to a few doors: Mondex Canada. These scribbled signs were a place holder for things to come and an indicator of the interim state of formation of the organization that described itself as the "project head" (DeLaurentiis 1999) for the implementation of electronic cash.

Mondex electronic cash, from its earliest days, had been developed with financial institutions in mind. Indeed, the main market aimed at by the developers of the Mondex technology, first NatWest, then MXI, were, at least initially, not customers and merchants. Rather, the market was other financial institutions that would purchase the franchise rights to employ the technology in their regions. An analysis of the innovation process of Mondex noted that the financial institutions played multiple roles within the emerging network, "they [were] user-initiators as well as suppliers of electronic cash"

(Srivastava & Mansell 1998, p.ii). Consequently, the technology was explicitly based on a business model that reflected the interests of its "user-initiators-suppliers", which were all financial institutions. Joanne DeLaurentiis described their approach: "technology in banking has been about doing old things better and doing some new things" [I.5]. The promise to do old things better was the main strength of the business case that was developed at the beginning of the endeavour. It centered around the idea that replacing the circulation of coins and bills with an electronic equivalent in which the transactions were not cleared centrally would be very beneficial to the financial industry in the short run and could, somewhat more vaguely, open up new markets in the long run.

In the early 1990s, there was a common understanding in the financial industry that there was a need to do old cash thing better, that is, electronically. Over the last thirty years the virtual money system had dramatically expanded. More and more of the activities of financial institutions had shifted towards automated processing of digital information. Since the introduction of magnetic ink character recognition (MICR) in the late 1950s, and optical character recognition (OCR) in the early 1970s, even the processing of paper-based cheques and credit card slips was increasingly automated and digitized. As a part of the general transformation from the environment of state-credit money into that of virtual money, the number and speed of monetary transactions had increased sharply. While the increase was most dramatic within the virtual money system itself (Evans & Schmalensee 1999; Sinclair 1999), the circulation of physical cash had expanded as well. For example, from 1980 to 1990 the number of coins in the US rose 133%, from 450 to 600 coins per person (Moore 1991, p.50). In the increasingly computerized world of the financial institutions, physical cash became one of the last areas in which information could not be separated from its carrier and processed electronically. Seemingly unaffected by all innovation, transferring cash value still meant that physical objects, coins and bills, had to be moved from one location to the other.

Handling these objects was costly and many aspects of the environment of physical cash, such as armored cars and personnel to transport it securely from one place to another, were viewed as anachronistic liabilities, rather than as normal costs. The maintenance of the circulation of physical cash cut into profits. In the mid 1990s, the costs of handling cash amounted to about 4 percent of the value of all transactions (Fancer 1995). In the US, the Treasury estimated these costs at US$ 60 billion annually (approximately 20 cents per cash transaction). Furthermore, the costs of handling cash were were still rising, and not only because there was more of it. Perhaps due to the generally increasing pace of life, or their shrinking purchasing power, the life span of one dollar bills decreased from 22 months to 6 months during the 1980s (Moore 1991, p.50). Accordingly, the costs of replacement were increasing. Additionally, it was becoming ever more easy to forge paper bills, due to the spread of high-quality copying equipment. Hence the costs of detecting and dealing with counterfeiting were also rising. Finally, contrary to the hopes harboured by the financial industry when ATMs were introduced, maintaining the expanding ATM network was itself not a very profitable business. One analyst pointed out "it is a little known fact that ATM services are provided by the banks...at a significant loss" (ter Matt 1997).[130] However, customers expected their bank to offer access to ATMs as part of the normal service package and charging high ATM fees became, particularly in the US, a politically contested issue (Evans & Schmalensee 1999). All in all, when NatWest began developing its electronic alternative, it estimated that the costs of handling cash had quadrupled since the mid 1970s, the time when the virtual money system emerged (Burke 1997).

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[130] Considered in isolation - the costs of maintenance vs. the service charges generated - the ATM networks were not very profitable. However, ATMs contributed to cost savings in other areas (e.g. number of tellers in a branch, or number of branches in a region).

These costs provided a strong motivation for change.[131] As an economist at the Federal Deposit Insurance Corporation (FDIC) summarized the business case, "assuming only a 10 percent reduction of cash handling costs, cost savings over the next decade would be sufficient to finance [an electronic cash roll-out]" (Sheehan 1998, p.4). The costs associated with the transformation of cash into smartcard-based electronic cash were enormous. An entire new communication platform had to be developed and implemented. Other than the basic communication lines, no element of the existing magnetic stripe infrastructure – assembled over the last 30 years – could be used. In addition to the cards themselves the new technological infrastructure included not only complete new back-end systems for the financial industry, but also the refitting of hundreds of thousands of point of sale terminals to accept smartcards rather than magnetic stripe cards. Additionally, countless vending machines that had been accepting nothing but cash, for example parking meters, would have to be converted. However, a 10% reduction in the costs of handling cash promised savings of up to US$ 6 billion per year in the US, so that "the potential savings alone explain why banks and retailers are willing to invest in such a capital-intensive cash-replacement technology" (Sheehan 1998, p.4).

In addition to the cost savings, however, electronic cash promised to bring back to financial institutions a profitable business from which they has been excluded for more than 100 years: issuing currency. It was a hallmark of the state-credit system that the government had assumed almost total control over the issuance of currency. The banks would break this monopoly by replacing government-issued coins and bills with privately-issued electronic cash. This was, potentially, a very lucrative business. In 1994, for example, the Bank of Canada derived a profit of $1.7 billion from issuing bills (coins were issued by the Canadian Mint) and had, all in all, $28.3 billion in

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[131] The business case outlined below is a rather crude sketch and leaves out many details. It provides only an indication of the overall amounts involved and some of the most important components.

currency outstanding (Stuber 1996).[132] A 10% replacement of cash would, in a rough estimate, create a seignorage revenue for the Canadian Mondex issuer of $170 million per year. In addition the issuer would hold a "suspense account", or float, totaling the amount of electronic cash circulating, $2.83 billion in our 10% replacement example. This float could be reinvested in the virtual money system to create additional revenue streams.

Banks were quite eager to join the Mondex world. It would help them save costs, create new revenues and preserve their central role in the circulation of money. The business case appeared so appealing that many banks were willing to take the potentially higher risk of the partially unaccounted Mondex system, even though alternative, fully accounted systems were available and in use.[133]

In England, after having developed the beginnings of the technology in-house, NatWest licensed the use of the technology to a joint venture it had formed with British Midland Bank to launch the system in Swindon. In December 1993, Mondex UK was established. Quite rapidly, a number of licenses were sold to banks across the world. The first international franchises were acquired by Asian banks in October 1994. In the same year the Wells Fargo Bank began an in-house trail. Mondex USA was established two years later. In June 1996, NatWest granted an exclusive license of the technology to a newly established company, Mondex International, to develop the technology and coordinate the international franchisees [I.8]. MXI itself was a consortium owned by major financial institutions in Europe, North America, Asia and Australia. In November 1996, MasterCard announced its intention to acquire a majority stake in MXI, which it

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[132] In the US, the outstanding currency totaled $410 billion (1995).
http://www.ny.frb.org:/pihome/fedpoint/fed01.html

[133] The most important, fully accounted system competing with Mondex is the Belgian developed Proton, backed by VISA and AMEX since June 1998.

completed three months later.[134] Within two years, Mondex had grown from a regional scheme supported by only two banks into a globally operating organization supported by dozens of major financial institutions around the globe and owned, in majority, by the second largest payment system company in the world, itself a consortium of thousands of financial institutions.

While a considerable number of franchises were sold around the globe, comparatively few implementations or even field trials were actually undertaken. Canadian financial institutions were leading. Nowhere else did such an overwhelming majority of banks join Mondex. This strong support made Canada "an international showcase of Mondex" [I.4]. In March 1995, the Royal Bank bought the rights to the Mondex franchise. A few months later, it sold parts of this license to the CIBC and announced their joint plans to start, together with the local Credit Union, a community-wide test in Guelph, ON, as a lead-up to a national roll-out [I.5]. At the time, other Canadian banks were experimenting with competing electronic cash systems. In June 1996, the Bank of Montreal (BMO) and the Toronto-Dominion Bank (TD), announced a trial of the Proton-based electronic cash system, called Exact, in Kingston, ON.[135] With the additional support of the Canada Trust Credit Union, the trial began in December 1996. At the same time, other banks were making smaller tests with the VisaCash system that had been introduced at the Atlanta Olympic Games earlier that year. For a while, it seemed that several competing networks of electronic cash might emerge.

However, as the business press noted, the competitive situation "changed quickly when Mondex began to gather momentum [after] credit card giant MasterCard International Inc. purchased 51% of MXI, and the international

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[134] A list of owners of MXI and the international franchisees of the technology can be found at their web site, http://www.mondex.com

[135] TD press release, June 26, 1996, http://www.tdbank.ca/tdbank/Press_Rel/june26b.htm 18.06.1997] Since then, TD and Canada Trust have merged, thus further increasing the concentration in the Canadian financial industry.

consortium appeared unstoppable" (Blackwellt 1998). In May 1997, BMO, TD, Canada Trust, National Bank of Canada and Le Mouvement des Caisses Desjardins joined Mondex Canada. Scotiabank was the last major institution to join the Mondex network, in June of the same year, even though it continued its low-profile trial of VisaCash in Barrie, ON. It was announced that the Exact test in Kingston would switch over to Mondex around the same time as a new site in Sherbrooke, at the end of March 1998. The Mondex network was growing fast and had achieved a considerable consolidation within the Canadian financial industry. Such an early consensus on a common technological platform was not without precedent. Rather, it was characteristic for the sector. A collaboration had played an important role in the success of the national debit card system (Sinclair 1999). In a way, this willingness of competitors to collaborate was characteristic for the Canadian financial industry in general. Richard Thomas, Director of Marketing with Mondex Canada, called the competition within the Canadian financial industry, in comparison with the US, "tempered with a sense of oligarchy" [I.4]. The industry was dominated by a mere handful of institutions that operated nationally, and these had a well established history of successful collaboration around technical standards.

On December 10, 1997, Mondex Canada was officially founded as the association of the financial institutions which had bought into the national franchise rights.[136] The association's mandate included,

> putting in place the operations regulations for the venture, developing and executing pilot and national market strategies and campaigns, acting as the project head for Mondex site implementations and managing the stake holder relations, including vendors and regulators. (DeLaurentiis 1999)

Everything proceeded according to plan. Joanne DeLaurentiis, the CEO of the national debit card system, was hired to become the CEO of the new

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[136] At the time of foundation of Mondex Canada, these were the Bank of Montreal, CIBC, Canada Trust, Credit Union Central of Canada, Le Mouvement des Caisses Desjardins, Hongkong Bank of Canada, National Bank of Canada, Royal Bank, Scotiabank and TD Bank.

company, and space was leased in one of the banking towers in downtown Toronto. Brass signs replaced hand-written paper on office doors. All in all, 14 people began working at Mondex Canada. The creation of a new, powerful actor to guide the development of the Mondex world seemed to be going smoothly and the recruitment of Interac's CEO expressed, at least implicitly, the view that Mondex was indeed about doing old things better. A rapid national roll-out could be anticipated. After all, debit cards had needed less than four years from field test to national roll-out (Sinclair 1999). The size of the rented offices reflected not the space requirements of the 14 people who were currently employed, but those of a anticipated much larger organization soon to be coordinating a national payment scheme [I.13].

However, the same article that called Mondex "unstoppable" in March 1998 also noted that the difficulty of recruiting consumers and merchants into the Mondex world was "making the business case for the product dodgy" (Blackwellt 1998). If Mondex could not replace at least 10% of cash, then the entire premise of its development, the business case resting on cost savings for the financial institutions, would evaporate. The cost savings were particularly important since it was far from certain that service charges could provide a significant revenue stream. One year into the Guelph experiment, however, it became clear that the rate in which cash was being replaced was hovering far below the crucial 10% mark, at around 0.1%.[137] Given the increasing disinterest of consumers, and the resulting high number of latent cards, there were few signs that the stand-alone Mondex card would be able to attract sufficient consumers and usage to generate more cash replacement anytime soon.

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[137] This is, admittedly, a crude estimation based on the following calculation: The outstanding currency per Canadian amounts to about $1000 (28.3 billion outstanding in a population of 28 million, Stuber 1996). For Guelph's population of 100 000 people, the outstanding currency totals $100 million. The float generated by Mondex, that is the amount of cash replaced by Mondex value at any given moment, fluctuated between $75 000 and $110,000 [I.11]. $100 000 of Mondex value represented 0.1% of all the cash outstanding for Guelph's population.

During the course of 1998, the vanishing of the business case for electronic cash began to put a strain on the alignment of the financial institutions within Mondex Canada. Three of the recently added members – TD, BMO, and Canada Trust – did not want to expand their role in the Mondex world and decided not to join the Guelph trial as active participants. They preferred to observe the dynamics of the fledgling network before committing any further resources to its development. They soon saw that these dynamics were actually very similar to those they had encountered in their own, recently abandoned trial of electronic cash in Kingston. The abstinence of more than half of the member banks put more pressure on those who were engaged in the Guelph trial. In October 1998 CIBC decided to cease supporting the Mondex network in Guelph, "because the initiative lacked critical mass" (Craig & Blackwellt 1998).

Mondex Canada, as the CEO put it, was now "facing resource constraints" (quoted in Craig & Blackwellt 1998). The network had never reached the critical size needed to generate the resources necessary for its maintenance. At the beginning of 1999, rather than expanding to a national scale, as the initial time table had anticipated, the Mondex network almost disintegrated. The offices in downtown Toronto remained half empty. The future of money was more uncertain than ever.

What had become certain, however, was that electronic cash was not what many had thought it would be. Around 1995, the time when Mondex was picking up momentum internationally, there was a very strong sense, among observers and actors alike, that electronic cash would be "the next big thing". The popular press began carrying enthusiastic stories about electronic cash. *WIRED* magazine, in an ecstatic tone typical of the time, wrote in December 1994:

> The killer application for electronic networks isn't video-on-
> demand. It's going to hit you where it really matters – in your
> wallet. Digital cash, e-money, bit bucks...whatever you call it,

not only will it revolutionize the Net, it will change the global economy. (Levy 1994)

MIT's Nicholas Negroponte, high-priced speaker to the corporate world, declared 1996 to be the "year of electronic money" (quoted in Bernkopf 1997). Countless other magazines and newspapers followed with similar predictions. But the belief in the imminent arrival of electronic money was not limited to wild-eyed futurists and the popular press. Serious books on the topic of electronic cash appeared at the same time, some aimed at specialists (Furche & Wrightson 1996; O'Mahony, Peirce & Tewari 1997), others at a wider audience (Lynch & Lundquist 1996; Wayner 1997). Academics from non-technical disciplines, too, began to write about electronic cash as near future reality (Bernkopf 1996; Froomkin 1996; Kobrin 1997) and to organize conference panels to examine its potential social impact. In 1997 the Computers, Freedom & Privacy (CFP) conference, for example, convened a special panel on e-cash and personal information (Clarke 1997; Froomkin 1997; May 1997). In the same year several academic journals published special issues devoted to it (e.g. IEEE Spectrum, February 1997).[138]

Consultants to the financial industry predicted in their expensive, numbers-filled research reports a rapid growth for electronic cash. In January 1997, for example, Jupiter Communications released an entirely uncontroversial study that announced that by the year 2000 electronic cash transactions using smartcards and network-based systems would grow to as much as US$ 3.5 billion (Macavinta 1997). MXI was even more optimistic at the time. It "expected purchases on the Internet to exceed US$ 200 billion by the year 2000, most for amounts of less than $10" (Ives & Earl 1997). $10 was usually thought of as the threshold for credit card transactions, the implicit argument being that this would lead to a strong market demand for Mondex.

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[138] My interest in the topic also began with the assumption that electronic cash would develop very rapidly. At the outset of my study, in early 1997, I even feared it would develop too rapidly to be manageable within the format of a Ph.D. thesis. Fortunately, my assumption turned out to be incorrect.

The financial institutions were investing hundreds of millions to position themselves as leaders in the field for which everyone had such great near-term growth expectations. The regulators, too, were taking electronic money very seriously [I.10]. In 1996, the Dutch central bank published a study on the potential seignorage loss due to electronic currencies, among other factors (Boeschoten & Hebbink 1996). Even those critics and consumer advocates who were opposing electronic cash over security or privacy considerations spoke with a great sense of urgency. Of the half dozen critical experts that were interviewed for the TV documentary "Mondex Scenario" in early 1997, none expressed any doubts that electronic cash would shortly become widely used (Channel Zero 1997).

The imminent growth of electronic money stood in stark contrast to the almost complete absence of actual use, but that was not thought of as a problem. To the contrary, it almost seemed to validate such predictions as truly visionary. Arguably the most expressive announcement that combined the absence and imminence of electronic cash with a great sense of urgency was made by the US Comptroller of the Currency, Eugene Ludwig. He believed that "there is clearly a freight train coming down the tracks.... Just because it hasn't arrived yet doesn't mean we shouldn't start getting ready" (quoted in Kobrin 1997, p.66).

Barely two years later, many actors, particularly consumers and their advocates, had abandoned the network of electronic cash altogether. Others ceased making any efforts to influence its further development. By early 2000, for example, electronic cash was simply not an issue anymore for senior officials at the Bank of Canada. They were waiting for significant changes in the overall composition of the electronic cash networks before continuing with their efforts to decide what kind of regulatory framework might be appropriate [I.10, I.12].

Felix Stalder [217]

For the financial institutions that remained committed to developing the Mondex world, it became clear that electronic cash was neither the "killer application" which would enable electronic commerce, nor the unstoppable freight train on which the migration from magnetic stripe to chip would ride. Financial institutions had to reconsider their approach to building the network for Mondex. There was a need to include additional actors which in turn would help enroll consumers and merchants. This would distribute the enormous efforts necessary to expand the network to the size at which it would generate all the resources for its own maintenance.

While the initial electronic cash implementations failed utterly in terms of their goal of replacing physical cash – the trial in Guelph was symptomatic of similar experiences around the world (van Hove 2000b) – they succeeded in transforming something else. The financial institutions became skilled actors in the development of the new technological platform of smartcards. Technically, the Mondex tests were, despite some well-publicized glitches (see, Foderaro 1998; Jones 1998; Sternberg 1998), quite successful [I.7]. Furthermore, due to the consortium structure of MXI (and Mondex Canada), the knowledge gained in the trials was disseminated widely among its members. For financial institutions, as Joanne DeLaurentiis explained, one of the most attractive aspects about joining the Mondex network was "you get to benefit from the learning from around the world [and] you can pool the resources of a larger group" [I.5]. This learning experience was of particular interest for MasterCard and, most likely, one of their main reasons for investing so significantly in Mondex, even though cash played no part its business and it would not profit from any cost savings achieved by cash replacement.[139]

On the other hand, credit card companies since their earliest days had been engaged in a fight to lower the percentage of fraudulent transactions. In this

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[139] VISA and AMEX also invested heavily in electronic cash technologies.

struggle technological innovation always played an important role. In the 1970s, for example, magnetic stripes were introduced to allow for easier real time authorization of credit cards, thereby making it impossible to use a card that was already canceled or use a card beyond its credit limit. In the 1990s, neural networks and artificial intelligence systems were implemented to spot suspicious transaction patterns and increase the chances of detecting fraud early. Nevertheless, credit card fraud remained a significant problem (Evans & Schmalensee 1999).

In 1995 MasterCard reported that 9 cents out of every $ 100 in transactions were lost due fraud. All in all, this added up to some US$ 400 million in losses world-wide. In the UK, credit card fraud jumped 11% in a single year, 1998, resulting in losses for the credit card companies of £ 135 million. In part, this was connected to the changing commercial environment in which credit cards were used. Originally, these cards were developed for face-to-face payments where the payee's signature could be checked against the one on the card and where the card itself could be swiped through a magnetic strip reader for quick authorization. However, credit cards became popular in remote ordering systems – mail, telephone, fax, Internet – the growth of which they accelerated considerably. Increasingly, remote use of credit cards became a preferred locale for fraud. In 1998 fraud in remote uses of credit cards in the UK increased by 36%, more than three times faster than the average rate. Electronic commerce, booming in spite of the absence of electronic cash, continued to rely almost entirely on credit cards for business to consumer (b2c) transactions, contributing disproportionally to this increase in fraud.

On-line credit card fraud became popular for several reasons. First, there was an extensive on-line underground economy trafficking in stolen credit card information. Second, for software downloads, there was no need to provide a physical shipping address. This reduced the risk of being identified compared to phone ordering systems that made it almost always necessary to specify a

physical address in order to receive the purchased goods, even if it was only a CD-ROM containing a piece of software or music. Third, on-line, credit cards were also used for low value transactions that off-line would have been transacted with debit cards or cash. But on-line, these alternative did not exist. In order to save transaction costs in low value transactions, many retailers and banks did not make a full check on each credit card order. For purchases of less than US$ 20, banks frequently ran only a quick authorization, relying on a short cut. All valid credit card numbers ended with a "check-sum" digit generated from the credit card's other digits, following a standardized procedure called "Mod-10 algorithm". The Mod-10 algorithm was well-known and illicit programs like CreditMaster, distributed over the Internet, could be used to forge numbers that could pass such a simple authorization check. Fourth, the difficulty of prosecuting small crimes across international borders, and the absence of laws that governed on-line transactions in some countries, further lowered the risk for those committing fraud. For all these reasons, in 1998 web transactions accounted for almost 50% of the total number of Visa's disputed charges and fraud, yet those transactions accounted for just 2% of its international business (Bicknell 1999).

Magnetic stripe technology, which had not substantially changed in close to thirty years, limited the issuer's ability to secure the information on the card. Smartcards, with their "on-board" processors and their capability to carry out encryption and authorization processes, promised the credit card companies the means to cut down on credit card fraud. Once the financial industry became sufficiently knowledgeable about this platform, and various operating systems and applications had been developed "in-house", the credit card companies began to announce their plans to migrate their core business, providing consumer credit, onto the new platform. In March 1999, the British Association for Payment Clearing Services (APACS) – which included all major banks and credit card companies – announced plans to begin immediate transformation of all its 100 million credit and debit cards onto the

new smartcard platform. The APACS hoped that fraud would be cut in half over the 5 years that it would take to complete the migration.[140]

More importantly for Mondex Canada, VISA Canada, with losses to fraud of $150 million per year, announced in March 2000 that it would spend $1 billion to finance the migration to chip cards over the next 10 years.[141] Suddenly, a new and very resourceful actor was joining the networks of smartcards in Canada. However, whether this smartcard network would have a place for the Mondex electronic cash application was far from certain. Much depended on a new actor that could change the dynamics of the Mondex world: a new operating system that could enable a single chip card to carry not just one application, but several at once. What the Mondex trial in Guelph had made clear was that Mondex electronic cash as a single application on a dedicated smartcard was too weak an attraction for many actors – consumers, merchants, and even many financial institutions – to support the Mondex world. The new actor – the multi-application operating system – promised to change that.

6.8 (Re)engineering the Mondex card (translation 6)

Between 1995 and 1998, the most prominent non-human actor in the struggling network, the Mondex smartcard issued in public trials of Swindon and Guelph, remained relatively stable. There were only minor improvements of existing functionality [I.8]. During this time, however, it became increasingly obvious that this actor did not possess all the capabilities the banks initially assumed it had. Most importantly, it connected poorly with other actors, non-humans and humans alike. It did not connect with other payment instruments most notably credit and debit. They continued to be maintained in entirely separate and unchanged networks, hence it was easy for consumers who had been issued a card to simply leave it at home without

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[140] BBC Business News, March 15, 1999
[141] Press Release VISA Canada, March 28, 2000

ever having to think of it again. The result was a large number of cards issued were hardly ever actually used [I.7]. Furthermore, Mondex remained, for all practical purposes, incompatible with the Internet and its booming electronic commerce because only very few desktop computers were equipped with a smartcard reader.[142] Despite considerable friction introduced by high rates of fraud, electronic commerce continued to rely almost entirely on credit cards for consumer transactions.

The Mondex card was, effectively, a tightly sealed black box of which the most important elements – the chip and the software – were created in a closed process by NatWest (later MXI) and its chosen partner, Hitachi. Reflecting this closedness of the Mondex card, the entire Mondex network that held it in place remained more or less isolated from other actors and their networks. Rigid as it was, the Mondex networks fitted poorly into already existing networks yet offered few incentives to abandon them altogether.

With the realization that electronic cash was not, by itself, the anticipated "killer-application" that would lead to widespread adoption of smartcards, MXI began to look for ways to again open up the black box to create more points at which additional actors could connect and contribute to the growth of the Mondex world. This required changes in the technological actor itself. The first step was to no longer view the Mondex smartcard as a single actor but rather as three potentially independent actors: the chip itself, the operating system (OS) on the chip, and the (e-cash) application running on the OS. Once the developers at MXI viewed these elements as separate actors, they began trying to expand the actor-networks of each of these actors while keeping them aligned within the Mondex world they needed to develop.

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[142] The first computers with standard built-in smartcard readers were put on the market in late 2000 in Asia.

The initial work in this direction was done on behalf of MXI by NatWest's development team, which had already drawn up the technical blueprints for the first version of Mondex. As Hugh Kingdon, Business Development Manager at MAOSCO, explained the rationale:

> MXI wanted to be able to write their Mondex program and be able to have the program work on a number of different microprocessors. So they wanted a standard interface to a number of different processors so they could port applications. That was why they needed an application programming interface (API) to separate [application from platform]....They wanted to create a market where people could sell things that met their standards that would enable them to have multiple sources. This was a very key driving point. [I.7]

In the course of opening the black box and separating it into three actors, the operating system, until then a relatively minor component in comparison to the chip and the e-cash application, assumed a new and more influential role. Initially, smartcard operating systems were an "add-on" specific to the application. A card manufacturer, such as Hitachi or Siemens, took microprocessors and create the on-chip operating system and tightly-coupled application for a specific purpose - say a satellite decoder card, a phone token card or a Mondex e-purse. The card would then be sold as part of a product - a satellite dish system, as a 'key' to operate public phones or as electronic cash. Each card operating system was designed and optimized with its specific application in mind, and, compared with the number of card applications, a large number of card operating systems had been developed, probably nearly to 100 (Burbridge & Cannon 1999; [I.7]).

The new operating system, call MULTOS,[143] would define specifications to which any manufacturer could produce chips independently, perhaps even in competition with other manufactures. By opening up this process, more chip manufacturers could be included into the network of the card. Similarly, the operating system would also define standards to which applications could be

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[143] MULTi-application Operating System

written by interested third parties. A standardized application programming interface (API) between the card and an application,

> also open[ed] up [a way] to multiple applications. Because the moment you have the security for one application to run off the platform, that same technology can be used to now do multiple applications. [I.7]

The separation between OS and applications was, technically, a strict functional separation between ROM, etched once onto the chip during manufacturing, and EEPROM, which could be written and rewritten over the entire lifetime of the card. The ROM contained nothing but the generic OS, while the EEPROM contained everything that belonged to the specific application. With this differentiation, it became feasible to think about dynamically loading applications to and deleting them from the card. Figure 8 illustrates this new relationship between the chip, the operating system and a set of possible applications.

Figure 8: MULTOS multi-application card scheme
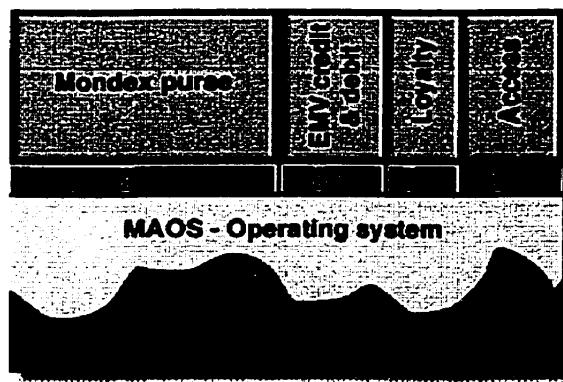
Source: http://www.multos.com [18.03.1998]

Whether the new actor would succeed in making the Mondex world more attractive than before depended on its adoption – by manufacturers, card issuers and application developers – as an industry-wide standard for smartcard OSs. To foster the development of MULTOS as an industry-wide standard, a new company was spun off. In May 1997, MAOSCO[144] was founded, a consortium of manufacturers, application developers and issuers.[145] Its mandate was to "drive the adoption of MULTOS as an industry standard and manage its on-going development."[146] Mr. Kingdon explained the relationships between the MXI and the new company as follows:

> MAOSCO is a 100% subsidiary of MXI. But the legal contract is what gives the consortium members control over the specifications and control over the activities of MAOSCO. So, this is a single product company, and the product, MULTOS, was licensed by MXI to the consortium members. [I.7]

This arrangement reflected the slightly paradoxical goals of the MULTOS development. On the one hand, it was a spin-off of MXI, whose main interest, indeed its *raison d'être*, was to foster the growth of the Mondex world. On the other hand, in order to accomplish this, the OS needed to be independent from MXI so that it could be accepted as an open industry standard by other actors that had no interest in, or were perhaps even in competition with, MXI. An open industry standard meant that anyone interested would be able to write applications based on this standard without having to pay recurring royalty fees,[147] and that its development would reflect the different views of the consortium members, rather than those of a single company. Open access was a condition for connecting as many different actors as possible to the platform, in order to strengthen its

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[144] Multi-Application Operating System COnsortium

[145] For the current list of consortium members and affiliated companies, see http://www.multos.com

[146] Mondex - A brief history, available at http://www.mondex.com

[147] In a report for the University of Exeter, the total licensing costs to develop a MULTOS application were estimated between £4000-5000 (Burbridge & Cannon 1999). This sum did not include potential fees to access an issued card-base. These fees could be set by each issuer individually.

attraction to even more actors. Again, network effects. And this had to be achieved quickly because MULTOS was not the only actor-network with the aspiration of becoming the industry standard for smartcard OSs.[148]

MULTOS changed from version to version with the goal of expanding the range of applications that could run on it. The first released version (v.3) was designed to meet the basic smartcard standards (ISO 8716). MULTOS v.4, released in late 1999, incorporated the additional standards of EMV.[149] Meeting these standards enabled MULTOS to be included in, and supported by, the global credit card networks and all of their millions of affiliated actors. These technological developments directly reflected the changing corporate actors in the networks of Mondex, because

> with the purchase of MXI, and also of MULTOS, by MasterCard they were very keen on also supporting their credit and debit cards. There was a set of changes associated with that. [I.7]

Future versions of the OS, to be released in the first years of the following decade, were intended to provide capabilities for contactless applications and to facilitate integration with mobile phones and other wireless applications.

The stricter separation between functions embedded in the ROM and the EEPROM enabled the dynamic loading and deleting of applications. This could broaden the range of applications on the card and lower the barriers for application developers to enter the Mondex world. However, a complete openness could also potentially compromise the high security desired by the financial industry. Complete openness also collided with the business objectives of the issuers. They wanted to control which applications were to reside on cards that they would have to spend significant amounts of money to bring into circulation. The selling of "real estate", space for additional applications on a successfully launched card, was an important feature of the

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[148] In the payments area, the most direct competitor was the Sun Microsystem's JavaCard, the platform of choice for VISA.

[149] EMV (Europay, MasterCard and VISA) is an association of credit card companies.

business plan for issuers. Mr. Kingdon illustrated the potential of such "real estate deals" with the following case:

> In Taiwan, there was recently a deal where the government said: you consortium, you issue the card and put our application on for free and we make sure that they get to every citizen and you can sell space to other parties. Those kinds of deals are going to be some of the most interesting ones. [I.7]

To ensure the issuer's control over which applications could be loaded onto a MULTOS card, additional organizational and technological actors were created. A new corporate entity was set up, the MULTOS Certification Authority (MULTOS CA). Its main role was to provide the card issuer with a set of digital certificates through which the issuer could control which applications could be loaded on its card. No application could be loaded onto a card that did not possess the valid certificate, obtainable only from the issuer.

Figure 9 maps a segment of the new Mondex world: the main actors directly connected to MULTOS. The figure shows the new configuration of the actor-network of Mondex resulting from the introduction of MULTOS. From the point of view of MXI the character of these changes was ambivalent. On the one hand, more actors would be able to connect directly to the card, thereby expanding its reach. The more actors present on the card, the more resources would be available to establish the rest of the network, most importantly, to include consumers, merchants and the necessary infrastructure. For example, a merchant that would put his/her loyalty program on the card would bring also an entire infrastructure, advertisement and new customers. MXI hoped that this type of synergy would revive the faltering business case for its electronic cash. "The business case for Mondex," Mr. Kingdon explained, "is much better if they do not have to come up for all the costs" [I.7].

Felix Stalder   [227]
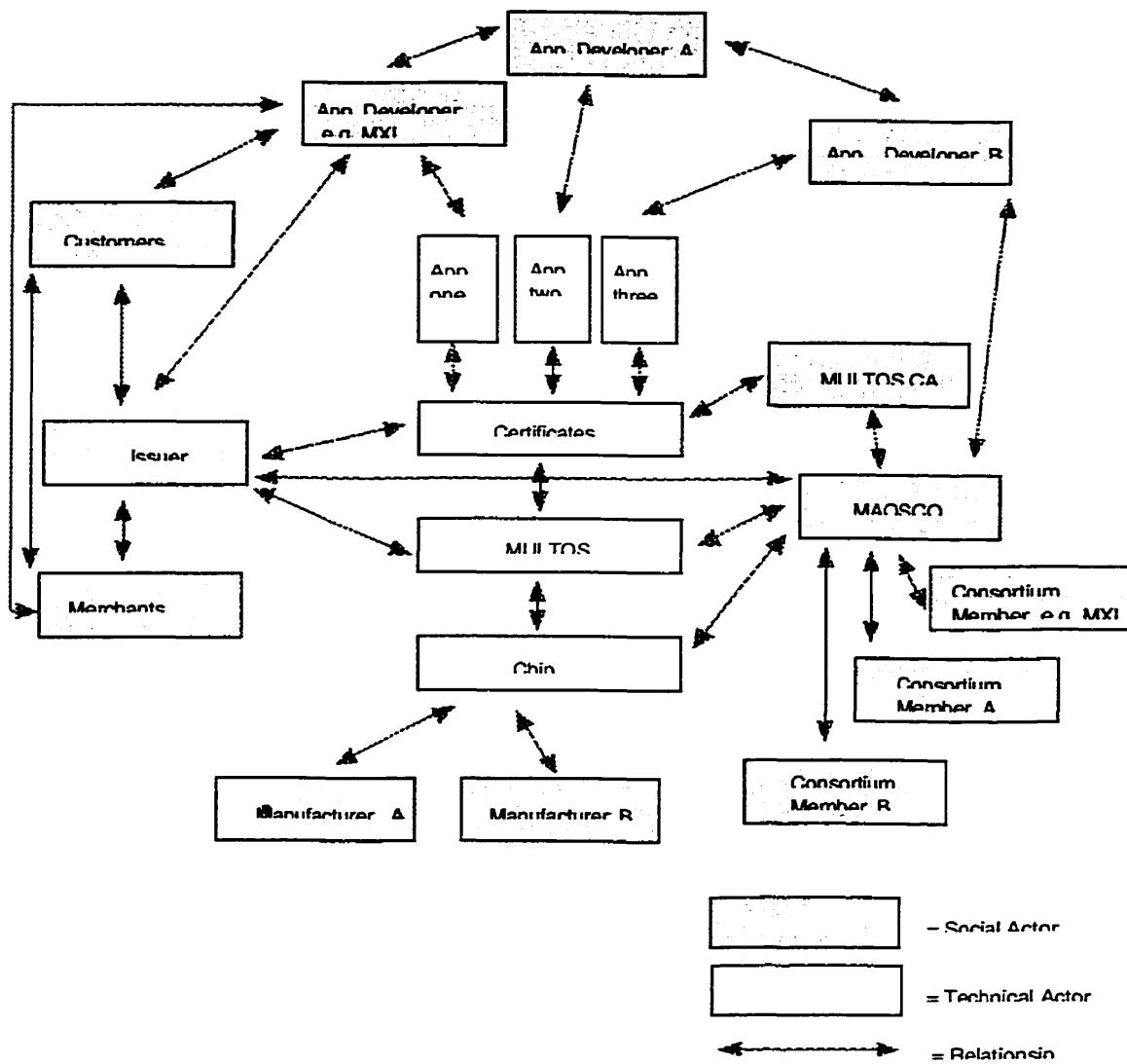
On the other hand, however, the new OS transformed Mondex into one among a potentially large number of applications. Consequently, MXI turned into a comparatively small actor in the OS's development process.[150] MULTOS, in order to stabilize, needed applications to run on it – any applications for that matter, as long they were effective in attracting the

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[150] The consortium decided technical questions by one member one vote. In early 2000, the consortium consisted of 11 members, one of which was MXI, itself owned by MasterCard.

consumers, merchants, and other kinds of users and resources needed to stabilize what was now suddenly the MULTOS network.

Initially, the separation of the operating system from the e-cash application was but a minor fissure. Their two worlds were nearly congruent. Mondex was the lead application and the most important driving force behind the development of the OS. The first MULTOS smartcards issued had Mondex as their exclusive application. In the first implementation in Britain, at the Universities of Exeter, York and Nottingham, all other functions of the university card – student identification, library loans and access – were supported by conventional technologies such as scanned photo and written signature, magnetic stripe and bar code.

In Canada, almost nine months after the Guelph trial had been terminated, a MULTOS-based version of Mondex e-cash was introduced in Sherbrooke, QB, on August 26, 1999.[151] A small launch ceremony took place at the local shopping mall, Carrefour de l'Estrie, in which a sign for the "Mondex Street" was unveiled and another symbolic initial transaction was conducted. While the press release dutifully announced that "the Sherbrooke region Mondex program will offer many consumer eCash 'firsts'",[152] for many actors important to the Mondex network, particularly customers and merchants, the presence of the new multiple-application OS made barely any difference. At the time of the launch, the card, though MULTOS-based, carried nothing but Mondex on its chip. In terms of chip functionality, the new card was indistinguishable from the old. Nevertheless, the Sherbrooke world of Mondex was different from the one that could not stabilize in Guelph, but the differences were not immediately connected to the new actor on the card.

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[151] This was almost 18 months later than initially announced. The second Mondex implementation, planned in Kingston, ON was scrapped.

[152] Mondex Canada Press Release, August 26, 1999

The card as a whole, though, was slightly different. In order to connect Mondex better with other payment instruments, the Mondex card also carried a magnetic stripe so that it could double as the popular debit card. This connection, Mondex Canada expected, would reduce the number of latent cards because customers used their debit cards regularly and, perhaps, this would spill over to increased use of electronic cash.[153] Other differences in the composition of the actor-networks were created through a more extensive inclusion of the closed environments of schools and universities. Like their colleagues at the University of Guelph, the administrators of educational institutions in Sherbrooke were keen to associate themselves with the Mondex world. The students at Bishop's University and the Champlain College, for example, were issued student cards that combined Mondex with the other conventional functions of their student cards. Technically, these cards were similar to those issued on UK campuses that had electronic cash as the only application residing in the chip. In the limited confines of the closed environment, it was possible to simply convert the entire infrastructure, for example the copying and printing facilities on both campuses, or the laundry at the Bishop's University's dormitory, to accept, in some cases, nothing but Mondex e-cash. This lack of alternatives put some pressure on students to use Mondex [I.14; I.15].

In addition to 600 merchants participating in the trial, Mondex Canada incorporated one of its – rather meager – discoveries from the Guelph trial. Mondex was most popular in combination with vending machines, so called unattended point of sale (U-POS) devices. Building on this strength, several hundred machines were converted to accept Mondex, including coffee, beverage, snack, and sandwich vending machines; parking meters; photocopiers and computer printers [I.5, I.14].

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[153] Many electronic purses issued in Europe had a similar combination of chip and magnetic stripe. While this reduced the number of latent cards, it did little to increase the use of electronic cash (Van Hove 2000b). In Canada Interac, the provider of the debit card system, announced an intention to eventually migrate its application from magnetic stripe to chip, but no date was set [I.5].

The Sherbrooke region, as a whole, also differed from the Guelph region. Located 120 km south-east of Montréal, it was more isolated and self-contained than Guelph, with its close connections to Toronto. Because it was more self-contained most people who lived in the region also worked in the region and, consequently, did not leave the reach of the local Mondex network quite as often as in Guelph. In addition, the relative isolation of Sherbrooke in French-speaking Quebec placed it outside of the spotlight of the English-speaking national media, headquartered in Toronto, that had extensively, and overall, negatively reported on the Guelph trial.

While the introduction of MULTOS was treated as the most significant difference between the abandoned trial in Guelph and the one starting up in the Sherbrooke region (e.g. Bimm 1999), virtually all the changes aimed at making the network more attractive for consumers and merchants had no relation to MULTOS and amounted to only minor variations of what was presented in Guelph. Perhaps not surprisingly, the reactions of consumers and merchants also differed little from those in Guelph. More than one year into the trial, the number of merchants enrolled stagnated at 600, and in downtown Sherbrooke the places that did not accept Mondex outnumbered those where Mondex was welcome.[154] Most of the participating merchants reported low and very low transaction volumes, only a few per day, if any. An exception was the grocery store on the campus of Bishop's University that reported a higher percentage of Mondex usage. Here virtually all consumers were students who had a Mondex card and were already using it for printing and laundry. According to the clerk working at the store's register, "somewhat less than 50%" of all purchases were paid with Mondex. Students used electronic cash also in other grocery stores near campus. However, the book store on campus, selling higher-priced goods, reported "very little use". The clerk thought that the Mondex trial "seems not to be going well" [I.16].

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[154] Personal estimate during on a field trip, 15.09.2000

While students were among the most avid users, some resented the fact that the new student card was now property of the Royal Bank, rather than, as before, of the university. They saw this change in ownership as an indication of the increased role of corporations on campus. Even at the relatively calm Bishop's University this development created some uneasiness (Saunders 1999; [I.15]). Merchants who had joined remained generally unimpressed and only a few were excited about the advantages of joining the Mondex world (Frost 1999; MacCregor 1999; [I.15; I.16]).

In the fall of 2000, Mondex Canada reported that $2 million had been issued to more than 20 000 customers who had received Mondex cards.[155] This averaged out to $100 issued per card during the first year. Close to 8 000 of these cards were issued to students [I.14]. Anecdotal evidence suggests that students, at least in part due to the lack of alternatives, were using the card more frequently than other user groups. While Mondex Canada's already quoted press release noted ambiguously that "these results are in line with our initial objectives",[156] Lynne Gendreau, Mondex Canada's Coordinator of Development for the Quebec Region, said that the amount of usage was "not even close" to saturation and that the Mondex world in Sherbrooke was "not mature enough to stand on its own" [I.14].

The strain that the disintegration of the Mondex networks in Guelph had put on the alignment of the members within Mondex Canada was still visible in Sherbrooke. Only the Royal Bank and its new partner Le Mouvement des Caisses Desjardins were actively issuing cards. All other members, even those that had branches in the region, did not directly participate. Faced with such reduced support from resource-rich members and the difficulties of attracting other resources, the Mondex world in Sherbrooke was, as in

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[155] Mondex Canada Press Release Oct. 4, 2000
[156] Mondex Canada Press Release Oct. 4, 2000

Guelph, faced with "resource constraints" [I.14]. These constraints made it difficult to expand the Mondex world, particularly because even merchants who were interested in joining were not willing to carry the costs of converting the necessary infrastructure. The public transport providers of the region, for example, were only interested in using Mondex if Mondex Canada would supply all the equipment [I.14]. Mondex Canada decided against it. Not only because of the large costs, also because the marketing department feared the transaction would be unacceptably slow to those waiting in line outside during the bitterly cold Quebec winter [I.4].[157]

Despite the apparent disinterest of the public and the growing resource constraints faced by Mondex Canada, the Royal Bank and Le Mouvement des Caisses Desjardins were committed to the Mondex world in Sherbrooke [I.14] and none of the members left Mondex Canada entirely. With the prospect of the addition of several hundred thousands of new actors through the migration of credit and debit services from magnetic stripe to chips with multi-application operating systems, the interest in MULTOS remained strong. Independent from the still not very encouraging reactions to electronic cash, Sherbrooke offered a low key test-bed for this new technology worth maintaining, as yet another learning experience for the financial institutions. Mondex as a cash replacement, once again, showed itself as too weak an actor to contribute significantly to its own stabilization. However, if other applications on the chip would lead the growth of smartcards, electronic cash, Mondex Canada expected, "would naturally come along" [I.13].

In less than 5 years, electronic cash – the revolutionary "killer application" coming down the tracks of inevitability like a freight train – had lost much of its momentum. Rather being rolled out nationally, Mondex was stuck in a

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[157] The winter only exacerbated the widely perceivdd problem that the cards were too slow and that customers were reluctant to seem reseponsible for holding up the lines (Pluffe & Vandebosh 1999; [I.14]).

low-key technology field test in relatively isolated town in Quebec, waiting for new actors to change the environment. And the actors Mondex Canada put its hopes on were credit cards, established more than three decades before.

6.9 Beyond cash replacement (more translations)

In the first year of its presence in Sherbrooke the influence of the new actor, MULTOS, could only be detected indirectly. Looking exclusively at the local part of the Mondex network, it almost seemed that nothing had changed in comparison to the composition of the network that had recently disintegrated in Guelph. The chip still carried only a single application, consumers and merchants were still not convinced why they should make the effort of entering the Mondex world, and the participating financial institutions were still reluctant to commit more than a minimum of resources to such an uncertain experiment. Resource constraints kept the Mondex world in limbo. On the one hand, enough resources were available to keep the network from disintegrating, but on the other, the resources were too limited to attract enough actors to the network for it to saturate and stabilize. However, Lynne Gendreau stressed that Sherbrooke was not a limited trial but a long-term implementation [I.14]. What maintained the Mondex world on this continued life support and kept open its chances for an eventual stabilization, though, was the action of MULTOS. This action, for the time being, was not so much locally, but at a distance, in the headquarters in Toronto and London.

In Toronto, MULTOS pushed forward a slow redefinition of Mondex Canada and its member institutions. Initially, the new actors of electronic cash were understood to assist, as already mentioned, in "doing old things better" – in stark contrast to their revolutionary image. Indeed, they appeared to fit almost perfectly into the existing world of the financial institutions. This made it relatively easy for MXI to enroll banks around the globe into the Mondex world by selling them franchises.

Felix Stalder   [234]

After the first trials had revealed that this fit was "perfect" for the banks only – and therefore not even for them – the new actor, MULTOS, was introduced to change this, to make it "less perfect" for the traditional financial institutions and more useful to other actors. Consequently, for the new non-human actor to be successful – that is, to act as intended by the financial institutions that developed it – the very same financial institutions had to adapt themselves to it. Rather than doing old things better, they had to begin to do new things. Instead of simply offering yet another payment instrument, hoping to replace the one with the other, they had to become developers of a complete technological platform. Instead of being concerned with only one application, Mondex electronic cash, they became concerned with all applications. And given the lack of such applications, they even became developers of applications that had nothing to do with their primary services aimed at managing financial assets.

The Royal Bank, the Canadian bank most committed to Mondex, developed a loyalty program. They expected this program to contribute to enrolling merchants, and consumers, into the Mondex world by offering merchants something more than just electronic cash.[158] The same bank became, thanks to MULTOS, also involved in a technology project that had even less to do with financial services. As part of the Industry Canada sponsored Community Access Program (CAP) the Royal Bank developed an application for Internet access for the disabled. This application would store the personal preferences of disabled Internet users on a MULTOS smartcard to configure the interface appropriately when the card was inserted in the terminal [I.14]. While such an application had no immediate connection to the financial services provided by the Royal Bank, enrolling a federal agency into the network of MULTOS

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[158] In the promotional literature, the loyalty program was described, a bit euphemistically, as "enabl[ing] issuers and merchants to achieve closer, two-way relationships with customers." The next sentence, however, made it clear that this two-way relationship was actually a bit one-sided. The main feature of the program was, that "it makes customer behaviour data available to the retailer" (Mondex 1999, p.30).

could contribute significantly to its stabilization and, perhaps, also to the development of the Mondex world.

Reflecting the new role of the financial institutions in relation to developing MULTOS/Mondex, Mondex Canada began to see itself more as a team coach for the development of an entire industry, rather than as the advanced technological leader blazing the trail into the future. At the outset of the Sherbrooke trial, Joanne DeLaurentiis described the introduction of smartcards as an achievement of the entire nation:

> Canada is fast developing a robust smartcard industry with a wide range of companies creating devices for use here and around the world...Programs such as the Sherbrooke region implementation of Mondex electronic cash create opportunities to test new products, understand consumer preferences, and demonstrate Canadian leadership in providing innovative solutions.[159]

What Mondex Canada's CEO was referring to, in the hyperbole typical of press releases, was the slow emergence of third-party equipment manufacturers in Canada that were producing to the MULTOS standard. Most of these companies were producing the card readers needed to adapt parking meters, photocopiers etc. to Mondex. One of the new roles of Mondex Canada was to certify these third party manufacturers (and potential application developers) to ensure the continuing integrity of the infrastructure [I.13].

While Mondex Canada was slowly changing from an advanced leader in banking into a coordinator of the smartcard industry, some felt that this was not enough. The non-human actors of electronic cash were seen as forcing much deeper changes onto banks. Richard Thomas, Marketing Director of Mondex Canada, saw the need for more change in the financial institutions, and their difficulties with that. He said:

> Even to this day, many Canadian financial institutions assume Mondex as a subset of a direct payment product or a credit product,

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[159] Mondex Canada Press Release (August 26, 1998)

Felix Stalder [236]

which it quickly and consistently worldwide proved not to be. It isn't like debit, it isn't like credit, it isn't like cheques, it isn't like traveler's cheques. It's a whole different thing....And Sherbrooke is, unfortunately, more or less conventional, Marching down main street, lining up every little pet food store.

....

This questions the conventional wisdom of launching geographically. Why do you have to go to Guelph, to Sherbrooke, to Toronto? Maybe you go to the GSM industry,[160] for one application in all of Canada: cell phones. Pay as you go cell phones....You got a maximum of four merchants to deal with, you got an immediate customer base, they all deal with one of the 10 financial institutions anyway.

....

But members are conservative, they think in traditional ways, they're used to selling mortgages and loans, all of those things they know about. [I.4]

During this adaptation to the new actor, the new role of the financial institutions and of electronic cash were unclear and disputed, even within Mondex Canada. The CEO, contrary to the marketing director, still maintained that for Mondex conventional, physical commerce would lead the adoption while electronic commerce would come later, and not the other way around [I.5]. Consequently, the main allies that she anticipated would contribute to the development of Mondex were not cell phones and other smartcard-based actors, but other payment systems, credit and debit cards, that would, in the course of the next 10 years or so, transform themselves into smartcards. Mrs. DeLaurentiis summarized the experience of the failed Guelph trial as follows:

So the conclusion we have come to is that we need, before we can roll out Mondex, to determine what the infrastructure needs are for debit and credit, the other key payments products, work with them to put those in place, and then we will have a much more positive business case and a more positive environment in which to roll out Mondex. [I.5]

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[160] GSM stood originally for Groupe Spécial Mobile (GSM), a study group formed in 1982 by the Conference of European Posts and Telegraphs (CEPT) to foster the standardization of mobile phones technologies in Europe. After 1997, when the standard had been adopted in more than 110 countries, the acronym began to stand for Global System for Mobile communications (Scourias 1997).

Mr. Thomas saw as one of the factors for the glacial pace of development of e-cash the difficulties the financial institutions had adapting themselves fully to the world they were instrumental in creating. The non-human actors, however, were already moving further and further away from physical cash. In November 1999, during a smartcard trade fair in Paris, MXI, in cooperation with the British mobile communications provider Vodafone, demonstrated a mobile phone equipped with a built-in smartcard reader. This combination would allow users to make small value purchases using Mondex e-cash over the GSM network. Assuming a new role, Mondex, according to MXI's CEO Michael Keegan, now "fits perfectly into the GSM environment".[161]

Mondex electronic cash, through its association with a new set of actors, was being transformed. After close to 5 years of being a replacement for physical cash it was aiming to stabilize as something different: a payment mechanism for mobile commerce, leaving physical cash aside, perhaps altogether. The new identity of electronic cash was pointedly expressed by MXI's CEO who said:

> Forget this nonsense about giving it to every granny on the street in New York or Swindon. What we have to do is build the service provider proposition for people who...are not heavily invested in the existing infrastructure.[162]

While the Mondex technology was morphing itself to adapt to the world of mobile communication and, somewhat more slowly, electronic commerce,[163] the actor-networks of Mondex and those of MULTOS started to become more and more different. By now, Mondex electronic cash constituted only one

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[161] Mondex International Press Release, 16.11.1999. On June 1, 2000, Mondex Korea announced plans to launch a similar cell-phone based service at the World Soccer Championship held in Korea and Japan in 2002. (LG Telecom Plans Wireless E-cash Service. *The Korea Herald* (07.1.2000))

[162] Quoted in Mondex Seeks New Investors. *Financial Times* (29.11.1999)

[163] Mondex was still relatively unconnected to electronic commerce over the Internet. While it had aligned itself with an electronic currency, beenz, in late 1999, the lack of personal computers equipped with smartcard readers limited Mondex's usefulness for Internet-based transactions.

application among several that could possibly be a part of the MULTOS network. MAOSCO, aiming to develop MULTOS as widely as possibly, was beginning to enroll other actors. In April 1999, American Express joined the MULTOS network. This came less than a year after American Express, together with VISA, had become a member of the Proton world, Mondex's most fierce competitor in the area of electronic cash. In May 2000, reflecting the changing composition of the MULTOS world, the adoption of the Common Electronic Purse Specifications (CEPS) to MULTOS was announced. With this development, the MULTOS world could now integrate both of the major electronic cash systems, Mondex and the CEPS compatible schemes. With the addition of this new actor to the network, Mondex's importance as an actor in the MULTOS world further decreased. It was not only one among several applications that could reside on its operating system, it was also one among several electronic cash schemes that were supported by it. For MULTOS, it was more important to bring resource-rich credit card companies into the network – perhaps even establish itself as the smartcard OS for all credit cards – than to reserve an exclusive position for Mondex in its network.

In March 1999, Hugh Kingdon reflected on the shrinking importance of Mondex for MULTOS:

> A year ago, they were my biggest customer, today, pure credit and debit card..., without Mondex, is proving to be my biggest segment. So on one level, I could say, in terms of card volume, they are not very important. In term of their continued support and participation, they have obviously been nurturing MULTOS for a very long time and they will continue to be important, There is a lot of technical expertise there....But that said, MAOSCO is neutral. We are working with some of the direct competitors of Mondex and have to regard them as one of my customers and have to look at them as that. [I.7]

On its web site MAOSCO went to considerable length to disassociate MULTOS from its parent, MXI. In its *Frequently Asked Questions* section, MAOSCO wrote:

> There is a clear distinction emerging between platforms, such as MULTOS, and applications, such Proton electronic cash. As an open

platform, we welcome Proton as a potential application to reside on
MULTOS. American Express, a member of MAOSCO, reaffirmed its
commitment to smartcard interoperability and intention to implement
the Proton electronic cash application on MULTOS.[164]

Stressing this point, the section continued by stating that,

> any individual or company is able to take an application license
> and develop their own applications and to load these applications
> onto a MULTOS card (using an application load certificate available
> from the MULTOS CA). These could be financial service applications
> which compete with Mondex International and MasterCard
> International products, or applications for other industry
> segments.[165]

When MasterCard finally began to implement credit functionality on
smartcards, in October 2000, Mondex was not included in the new offering.
MULTOS figured prominently in the new actor-network, but electronic cash,
any electronic cash for that matter, was ranked, together with loyalty
programs, among the potential applications that might, or might not, be
loaded onto the card, depending on the issuer's wishes. In the press release
that announced the British bank HSBC's issuing of MULTOS-based credit
cards, Mondex was not even mentioned. And the fact that MULTOS was spun
off from MXI less than three years before was hardly mentioned in of the new
version of the MULTOS history that appeared, as usual, at the end of the
press release.[166]

Early in the new decade, after 10 years of development, Mondex was still
searching for the right actors to align itself with, actors that would give it a
distinct and stable identity.[167] During all this time, it remained unclear what

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[164] http://www.multos.com/answer.ihtml?id=0000026 [03.11.2000]

[165] http://www.multos.com/answer.ihtml?id=0000012 [03.11.2000]

[166] http://www.multos.com/fullpresscoverage.ihtml?id=0000110 [03.11.2000]

[167] Still trying to find the right set of partners, MXI was rumored, according to the *Financial
Times*, to be interviewing investment banks to advise on picking a strategic partner from
outside the banking industry. Reflecting differences between the two, a split of MULTOS from
the Mondex e-cash system was also considered (Mondex Seeks New Investors. *Financial Times*
(29.11.1999)).

electronic cash really was or what it could be. The only thing abundantly clear was that Mondex was not an electronic replacement for cash. Mondex is cash is Mondex is cash was a fundamental miscalculation. MULTOS, on the other hand, was beginning to stabilize on its own, as a versatile, high-security multi-application OS for smartcards, increasingly unaffected by the on-going identity crisis of its parent, Mondex electronic cash.

7. Conclusion

Ostensibly, Mondex electronic cash in Canada has so far been a failure. The first field test in Guelph, ON, had to be dismantled after some of the financial institutions withdrew their funding – disappointed by the unenthusiastic, at times out-right hostile, response from consumers and merchants. One year into the second field test in Sherbrooke, QB, a similar pattern emerged: waning support within Mondex Canada and a cool response from the public. Mondex tests elsewhere have yielded comparable results. As a consequence, the future of electronic cash is more vague and distant in the early years of this century than it was at the end of the previous. Electronic cash is no longer a *killer application* but a *solution looking for a problem* [I.11]. Can we conclude that Mondex is an irrelevant, failed technology?

No. Such a conclusion would be misleading in several ways. First, the failure of Mondex lies primarily on a conceptual and institutional level and these are beginning to change, though with uncertain results. Second, it was exactly the technology developed by Mondex International (MXI) and its spin-off, MOASCO Ltd., that has been rather successful. Finally, even if Mondex electronic cash never stabilizes into distinct artifacts, many of the human and non-human actors implicated in the network building process have already changed, or at least given indications on directions for future change. These three ways in which the simple conclusion that Mondex has failed – derived from looking at the technology in isolation – is insufficient, indicate areas of socio-technological change that an environmental approach to technologies can bring to light.

7.1 The failure of Mondex

There can be no doubt consumers and merchants are rejecting Mondex as a replacement for physical cash and there is little indication that this will change anytime soon. This is particularly striking in comparison to the history of the previous introduction of new technologies into the retail payment system. The Canadian debit card system in the early 1990s needed only 2 years from its first field test to national roll-out, and within a few more years it was firmly integrated into the daily routines of hundreds of thousands of businesses and millions of people (Sinclair 1999). Implicitly and explicitly, the debit card was the model that the Mondex implementation tried to emulate, hoping to do to cash what debit cards did to cheques: replace them with an improved, electronic substitute [I.5]. This failed. Why?

The primary reason for the failure of the initial replacement project is to be found in the unstable mix of innovation and conservation that the new actors of electronic cash imposed on all other actors. Many of the non-human actors represented substantial innovation. Even though not all controversies around their characteristics could be settled, the development of a smartcard platform potentially suitable for cash-like transactions at a retail level constituted real technological innovation. Over the course of 10 years, a set of new actors emerged: chip cards, a multi-application operating system, applications, various card readers, back-end systems, etc. That these actors were indeed new can be seen by the fact that they required significant adaptations from all other actors that they were to connect to. They did not fit into any of the existing actor-networks, hence they required the assembly of a new actor-network. The "entry costs" into this new object world, i.e., the efforts necessary to adapt to the new actors (and make them adapt in turn), were considerable for all parties involved.

For consumers, these costs were primarily on the level of daily routines, particularly since much of the necessary hardware was given away for free, at least during the trials. They were expected to abandon actors, coins and

bills, that were not only extremely well connected to millions of human and non-human actors within the transactional networks of commerce, but also played important roles in other types of networks serving as the symbolic foundation of the entire economy. As well, ironically, the role of physical cash at the retail level had recently been consolidated by the introduction of new technological actors. ATMs allowed consumers to have virtually all their cash close at hand without having to carry around large sums. This reduced perceived or real exposure to street crime and the need to plan ahead, without lowering the availability of cash, a very attractive combination of freedom without risk. Credit and debit cards contributed to this trend, redefining cash as unproblematic because alternatives existed for nearly all situations that could seem problematic.

For merchants, the entry costs for the electronic cash system were tangible since it required the use of new equipment that was widely believed would generate usage fees once the trials were over. Given the disinterest of consumers, many merchants felt that they were pressed into promoting a new service for the banks which was not necessarily in their own interest. Many small businesses had not the best relations with banks which were seen as concentrating on big businesses and investment, rather than retail banking. For the larger merchants, electronic cash operating on an entirely new smartcard platform did not fit well into their established and integrated infrastructure, which might include everything from inventory to loyalty programs, and a small regional test did not warrant a major investment in new infrastructure. Furthermore, many merchants were wary of adapting too early to a new technological actor that itself might change, rendering their initial adaptation efforts obsolete. This was particularly important for long-term investment in low-margin sectors such as vending machines, which have a life-time of often more than a decade.

For the financial institutions, the entry costs into a world that would accommodate the new actors of smartcard-based electronic cash were also

considerable. Not only did they have to invest in the franchise rights to access the new actors, but also in entirely new back-end systems, as well as into promotional efforts to overcome the initial chicken-and-egg problem that all payment systems face.

In the short-term the least active adaptation was required from the regulator. All that was required was the willingness to let other actors create a new network in which the regulator would play a minor role, at least in comparison to the role it played in the world of physical cash.

However, the new technological actors not only required all other actors to change in very particular ways, it also restricted them from changing in others. Because Mondex electronic cash was thought of almost exclusively as a cash replacement, it enabled neither consumers nor merchants to do anything substantially different from what they were already doing with cash. Besides minor innovations such as downloading cash over the phone or the Internet, innovations which remained theoretical for most consumers due to a lack of hardware, the new actors of electronic cash did not support any activities that physical cash did not also support. The Mondex network did not, for example, help to conduct transactions that could not be made with cash, nor even save the trip to the ATM.

Mondex electronic cash carried with it a peculiar imperative of technological innovation and social conservation across the envisioned actor-network. This fit well into the agenda of the banks for whom it was a project to cut costs and to extend their role in monetary transactions to the issuance of currency. In other words, Mondex electronic cash was a cash replacement aimed at creating an actor-network in which consumers and merchants, and the commercial patterns of exchange among them, would remain virtually unchanged even after having invested in the costs of entering the new Mondex world. The banks, however, had the promise of considerable gain from their investment by raising their efficiency in regard to (electronic) cash

management as well as gaining access to a new revenue stream (issuing currency) at the expense of the regulator. To put it bluntly, the new non-human actors contributed to the agenda of the banks only, whereas they did not contribute to the development of the other actors, particularly merchants and consumers, in ways that were proportional to the adaptation that was required of them.

The uneven way in which the new non-human actors contributed to redefining other actors reflected the configuration of the network at crucial stages of its development. The first of Michel Callon's *moments* in the development of an actor-network, the *problematization*, was entirely dominated by banks. They alone defined the relevant problems and the desired solutions. For nearly the first five years the financial institutions developed the new actors in isolation (together with a few selected manufactures). It was not only that the banks were the "lead developers", they were also their own market: banks developing a new technology aimed at franchisement by other banks. This made the second moment in the development of an actor-network, the *interessement*, also relatively smooth. The banks talked to other financial institutions and aligned themselves with a relatively limited set of actors, smartcards in a laboratory. Consequently, when the technology was presented to the public, the non-human and the institutional actors were well adapted to one another. The smartcard based electronic cash indeed supported the transfer of Mondex-issued electronic cash from card to card and the various joint-venture and consortia among the growing number of banks were a strong statement of the willingness of competitors to work together. Early collaboration with the regulator had indicated that there was little danger of the regulator resisting the loss of its role as the issuer of currency. Some interpreted this as a new innovation paradigm because the financial industry played all roles included in the innovation process itself. They were "user-initiators as well as suppliers of electronic cash and play[ed] the role of a need-forecasting laboratory" (Srivastava & Mansell 1998).

Felix Stalder   [246]

Due to this conflation of roles in one set of actors it is perhaps not surprising that the needs that were forecasted were primarily those of this one set of actors: the banks. Beyond their immediate desires to cut costs in cash management (and gain a new revenue stream in the process), the innovation process was characterized by a striking lack of innovation. Electronic cash was to be like physical cash. Period. There was no intention of shaping the new actor in ways that would also facilitate consumers and merchants to do things in a different way. The influence of electronic cash on commerce was seen as merely adding efficiencies – minor for the public, substantial for the banks – rather than facilitating new commercial relationships. Rather than aiming at extending the promise of the virtual money system – anywhere, anytime – Mondex electronic cash was aimed at the opposite, the *only here, only now* of face-to-face transactions in conventional stores and physical vending machines.

Consequently, problems began to appear at the third of Michel Callon's moments, the actual *enrollment* of all actors. For consumers their role on the actor-network of Mondex was not a particularly inviting proposition: they were required to change their habits substantially without gaining much in return. Due to the lack of a clear incentive for going through the trouble of incorporating the new technological actors, many broad and often diffuse reservations against new technologies and the financial industry came to the surface. The banks were suspected of pushing a technology that had only disadvantages for consumers, but would allow the banks to force new services charges on them and to invade their privacy.

Mondex electronic cash did not create these fears. They were already widespread before Mondex arrived. However, Mondex offered for consumers none of the short-term benefits that often override these concerns in practice. Compared to other recently adopted technologies, for example debit cards or cell phones, Mondex electronic cash was not particularly privacy

invasive, even though a certain gray zone remained as to what kind of data could be – or would be – collected. However, the fact that there were so few immediate advantages for consumers made it seem to the more suspicious ones as if the technology was introduced primarily for the purpose of gathering more personal data. Since the enrollment of consumers and merchants into the actor-network failed, the Mondex network could not reach the fourth, and final, moment in its development, *stabilization,* but remained fragile, with uncertain prospects.

Mondex electronic cash can be understood as an attempt by bank managers, perhaps not fully conscious, to use new technological actors to cement existing social relationships. Already heavily invested in the retail payment system through cheques, credit and debit cards, the banks were clearly not interested in upsetting the marketplace too fundamentally. Every change in the existing market place beyond the most conservative replacement of cash by e-cash may have posed dangers to the already well-established, bank-controlled parts of the retail system.

The lack of vision about what electronic cash could be was, nevertheless, striking, because it took place during a time of rapid commercial innovation both inside and outside the financial industry. Electronic commerce on the Internet was developing rapidly into a multi-billion dollar industry. However, the bank's narrow vision of electronic cash as cash replacement did not include this emerging landscape in which cash had never played a role. Reflecting on the negative impact of this lack of vision and diversity in the phase of *problematization,* Michael Keegan, long-time CEO of MXI, replied to the question: "What was your greatest mistake?" by stating: "Relying only on the banking industry to adopt new technology for e-money" (quoted in *The Guardian,* 11.11.2000).[168]

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[168]<http://globalarchive.ft.com/globalarchive/articles.html?id=001111003974&query=mondex> [15.01.2001]

7.2 The success of Mondex

Underneath this failure, however, the Mondex story is also one of surprising success. The relentless hype of the mid 1990s creating expectations about the immanence of electronic cash had the effect of forcing the entire banking industry onto a steep learning curve about smartcards. Without this initial sense of urgency, many of the banks might not have been willing to invest substantial amounts of resources in order to align themselves with such a new and unproven technology. Perhaps the *speculative self-evidence* – speculative predictions accepted as common sense despite lack of evidence – that characterized the thinking about electronic cash as near-reality, was necessary to give the normally risk-averse financial institutions a (false) sense of security for embarking on a course whose direction was essentially unknowable.

From the point-of-view of one of the most resourceful actors, the majority owner of MXI, MasterCard, the investment in Mondex was justified. Through the consortium and franchise structure of the Mondex, significant amounts of money had been centralized into MXI to develop expertise and products in the area and to disseminate the knowledge and experience to its global membership. Whereas Mondex electronic cash was met with considerable reservation in the marketplace, it contributed significantly to adapting the financial industry to smartcard technology and to shaping the development of the technology in such a way that it was beginning to meet some of the industry's security requirements, even though the full extent of the security requirements remained disputed.

By the end of the 1990s, the financial industry had acquired enough expertise on smartcards that some relationships between the two began to stabilize. Of particular importance was the development of a high-security multi-application operating system as an open industry standard. The fact that a single smartcard could host multiple applications made it easier to expand the range of actors directly connected to the card. The fact that it

was an open industry standard controlled by all consortium members and freely licensable by any interested party, rather than a proprietary technology controlled by a single company as a competitive advantage, expanded the platform's ability to attract more, and more varied, actors into the network, to the extend that even direct competitors of Mondex electronic cash began to support it. With MULTOS, the Mondex development process had created an actor able to flexibly connect to a wide variety of existing and emerging actors inside and outside the financial industry. When Joanne Delaurentiis said in 1997 that she "truly believe[s] Mondex stored value will be....a key force in driving this momentum [chip conversion]"[169] she might not have imagined that Mondex, through MULTOS, could be indeed advance this conversion while at the same time fail as an electronic cash product in its initial conceptualization.

While the operating system might not become the only industry standard – Sun Microsystems/Visa and Microsoft have been competing with their own standards – it has already stabilized enough for MasterCard to begin implementing it in the next generation of credit cards. The first MULTOS-based credit cards were issued in England in October 2000, and later that year MasterCard announced an alliance with KeyCorp. to issue 15 million MULTOS smartcards to replace its conventional credit cards in Australia.[170] In this setting, the same actors that failed so obviously as electronic cash are working very well. The non-human actors help, once again, to address a very tangible problem within the financial industry: credit card fraud. Compared to the magnetic stripe of conventional credit cards, there is no doubt that smartcards are indeed a significant security improvement. Since the new non-human actors require no substantial adjustment from consumers and merchants – their cards or terminals are simply replaced as part of the normal cycle – their enrollment into the new network is entirely

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[169] Mondex Canada press release, 02.12.1997

[170] <http://www.it.fairfax.com.au/hardware/20010123/A15743-2001Jan23.html> [29.01.2001]

unproblematic. As a first step, introduction of the new technological actors is nothing but a relatively minor system-upgrade, at least from the consumer/merchant point of view.

The process of building the actor-network of Mondex, then, produced a very different effect from what was originally anticipated. Instead of creating electronic cash, after 10 years of development it had aligned the financial industry with smartcards in such a way that it created a new platform to be used for very conventional purposes: credit and debit cards. Joanne DeLaurentiis' assessment that "technology in banking has been about doing old things better and doing some new things" turned out to be surprisingly accurate [I.5].

However, the failure of cash replacement signaled only the end of the first phase of the development of electronic cash, but not the end of the entire project. The second phase has already begun with a new *problematization*. What is electronic cash really to be? It has become clear that the vision of a cash replacement is no vision at all. By re-conceptualizing electronic cash as closely aligned with actors whose communications are already electronically mediated, be it through the Internet or cell phones, MXI hopes to interest more partners from outside the financial industry to contribute to the development of electronic cash. However, whether these partners really need banks to develop a retail payment system is far from clear. To some extent, it will depend on legislation. If the EU continues to restrict the right of operating an electronic cash system to regulated deposit-taking institutions, then the banks will remain a crucial actor in any new system. If this regulation is eased, electronic cash systems might be developed entirely outside the financial industry, for example by a mobile phone company that already has many of the necessary human and non-human actors connected to one another. However, the second phase of electronic cash development is just beginning, so this remains speculation, and a possible topic for further research.

7.3 Emerging environmental patterns

As we have seen, not all relationships within the proposed actor-network of electronic-cash-as-cash-replacement failed equally. Some relationships grew robust enough that the resulting hybrids could be inserted into other actor-networks. Most obviously, smartcards and the financial industry have adapted well to one another and smartcards are beginning to replace magnetic stripes on payment cards. Virtually all major credit card companies have plans for world-wide conversion to take place over the next decade or two. This conversion of the infrastructure is likely to influence the case for electronic cash. However, if the experiences in places where the infrastructure has been rolled out, such as Germany, Switzerland or the Netherlands, is any indicator, the availability of the infrastructure itself does not substantially improve the case for cash replacement (van Hove 2000b). In this sense, the hope of Mondex Canada, that once the infrastructure is put in place by the conversion of credit/debit cards electronic cash will "naturally come along" [I.13] appears not to be very well founded. What seems unavoidable is, indeed, a *re-problematization* of electronic cash.

For the political perspective that informs this study two adaptation processes are of particular relevance: that between the customer and the card, and that between the financial institutions and the regulator. The relationship between the card and the consumer was highly imbalanced. The card with the Mondex application was presented as a black box and considerable effort was invested by the financial institutions to keep the box black. They deliberately obscured what was going on inside the box, not only through design measures, but also through policy measures, for example, by prohibiting independent testing of the chip. The justification for keeping the box untransparent was the need for a high degree of security. While it has been disputed whether "security through obscurity" is a viable strategy, the ramifications of this approach went beyond security questions and impacted directly on how the individual user was defined by the technology. If s/he used the card, s/he would be forced to trust not only that the card was secure, but also that the transactional data generated by the card and

captured by the banks were indeed what the banks, speaking on behalf of the card, said they were.

This trust was rendered blind by the fact that the technology was not only entirely opaque, but also extremely flexible and the issuers simply promised not to use it to the full extent of its data-capturing capabilities. Unless, of course, this became necessary for security purposes. And it was at the sole discretion of the issuer to decide when it would be necessary to capture more data. For the user, it was impossible to detect when the banks changed their data capturing mode. While the banks did not trust the users – the design scheme required regular analyses of individuals' transactional data – the user could do nothing but trust that the banks would not invade their privacy, even though the banks were technically capable of doing it at any time. The technology as it was set up gave the banks significant surveillance capabilities that could be exercised in secret while the users were led to believe that the card was still, if not as anonymous as cash, minimally invasive.

This is not to say that the banks in practice invaded users' privacy, but it raises the question of whether blind trust on the part of the consumer is an effective means of ensuring a fair balance of citizen and corporate interests. This, I would say, is doubtful because the imbalance between the center controlling the technology and the user at the periphery is too great. The imbalance of the Mondex scheme is directly related to the opacity of the technology and could have been partly remedied by allowing independent specialists to assess, on behalf of the users, the code and its impact. However, the technology itself closed off this option due to the specifics of the system architecture.

It is indicative of the suspicion created by this imbalance that the Mondex system engendered a much more heated privacy debate than systems that

stated from the outset that all transactions were monitored.[171] While such systems are, in practice, likely to be more privacy invasive than Mondex, they are transparent, hence giving the users a chance to make informed decisions about the technology. The Mondex technology, on the other hand, gave considerable discretion to a very small set of actors (MXI, the national originators) without being required to account for how this discretion was used. Power to make important decisions (e.g. how much personal data is collected) without accountability to those who are affected by the decisions (users whose data is collected) runs counter to our notion of a democratic order in which power comes with checks and balances. The Mondex case, in this perspective, is very illustrative of the subtle shifts that new technological actors can cause in the relationships among social actors.

For the well-being of civil society, then, transparency is not only necessary in its political institutions to ensure their proper working, but also in its key technologies, through which an increasing share of the public's actions is being mediated.

Far beyond the fate of Mondex goes the impact of the second adaptation process between various national regulators and the consortia of financial institutions to which the building of the Mondex network contributed – despite its inability to stabilize in its original configuration. The regulators' willingness to transfer the authority to issue currency to a consortium of private financial institutions is highly significant. For close to 100 years in North America, in Europe even longer, the state's monopoly to issue currency has been one of its central symbols and means of power. The fact that the regulator permitted, with hardly any hesitation, the mounting of a serious attempt to break this monopoly, is likely to set a precedent for future attempts, that might, or might not, involve Mondex electronic cash.

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[171] All electronic cash systems based on the CEPS standard are fully accounted, see Chapter 4.

Despite superficially contradicting the trend of the virtual money system towards *anytime-anywhere*, the Mondex world contained many relationships that closely resembled the type of relationships characterizing the virtual money system in general. These relationships were the ones that were most easy to define, that offered the greatest potential for stabilization. Mondex electronic cash contained the blueprint of a globally-operating institutional network, firmly anchored in the main hubs of the virtual money system, in this case mainly London, Toronto and New York City. Mondex offered an example of how to flexibly link financial institutions around the globe into a highly integrated system that can assume, or supersede, authority previously located in national public institutions (for other examples, see Sassen 1996).

Confronted with such a development, the Bank of Canada, and other central banks, quickly decided that they each were too small to deal with it on their own and concentrated their resources to play a role at the international level of the Bank of International Settlements and other coordinating bodies [I.10; I.11]. This internationalization of national policy-making is an increasingly typical response of governments to the global challenges they face (Castells 1997). The resulting framework that was sketched, but due to the instability of the various electronic cash schemes was not implemented, was one of an internationally coordinated light (Europe) or very light (US) supervisory regime for the private delivery of what was until then a public service: the issuance of currency. Such a framework could be developed relatively easily because it repeated patterns already emerging in other sectors: in the wake of privatization agencies of the national government have more or less actively transformed themselves from the provider of services to the community to the supervisor of services predominantly provided by the private sector (Castells 1996, pp.88-89).

The linking of already powerful financial institutions into a global network allowed those institutions to launch a coordinated effort to build not only a suitable technological platform, but also a global regulatory regime across

the various nation states that would have to support, or at least implicitly tolerate, such a regime. On a national level Mondex was politically active through its franchises. In Canada, this meant regular, voluntary consultations between Mondex Canada, the Bank of Canada and other supervisory agencies. At the same time, Mondex was also politically active on a global level through its global hub, MXI located in London, one of the leading "global cities" (Sassen 1991).

The relative ease with which the Mondex institutional network and the various regulators adapted to one another is an indicator of how deeply these institutions had already been transformed as part of the emergence of the virtual money system since the 1970s. The fact that new technological actors accelerated this process highlights the active role technology plays in opening opportunities and creating a dynamic to realize them. That even after 10 years it is still not clear what exactly these opportunities are, should not overshadow the fact that the search for them actively accelerated the deepening of the virtual money system by bringing key actors of the cash circulation closer to it.

The message contained in the so far failed medium of electronic cash is this: there are no substantial political and only manageable technical roadblocks for a global currency system. For the time being, though, the day-to-day activities of the vast majority of individuals – particularly those activities involving casual, low-value transactions – are still predominantly local and therefore in no need of a global currency system. However, with the deepening integration of the global networks (Internet, wireless) into people's lives this is likely to change.

However, the ease with which critics of Mondex could also share information and at least to some degree coordinate their actions through the Internet indicates that these changes are by no means set to benefit Mondex in particular or the financial industry in general. Belatedly, but parallel to the

institutional framework for a currency system that is anchored nationally but coordinated globally, a global civil society has slowly begun to emerge, anchored in local organizations such as the Student Union at the University of Guelph, but globally cooperating with other groups and institutions such as Privacy International (PI) and the Electronic Frontier Canada (EFC). However, if these slowly emerging networks can really develop into a fully-fledged civil society – "the sphere of intermediate association that serves liberty and limits the power of central institutions" (Ehrenberg 1999, p.xi) – remains to be seen. However, the dynamics of the Mondex environment hint at both, the rise of new global central institutions as well as the rise of a new global intermediate sphere critical of those institutions.

7.4 Reflections on socio-technological change

The history of money connects the Florence and Genoa of the mid 13th century where the first modern coins were minted, to Sherbrooke, QB, of the very early 21st century, where a large-scale attempt to replace such coins with electronic impulses is running out of steam. This entire history can be thought of as a continuous stream of interconnected social and technological changes which, as they accumulated, contributed sometimes to rapid transformations at other times to long-lasting consolidations of the environment they created (for a related, flow-based conception of history, see DeLanda 1997). Each of the four major changes in the technologies of money represented, accelerated and stabilized broad environmental changes. They accelerated change because each of them supported new commercial patterns. They made it easier to do things in a new way. At the same time, they also stabilized change because each of them facilitated only very specific types of commercial patterns while, perhaps, hampering others, and thus contributing to defining a limited number of newly emerging practices. As these practices, involving new technological artifacts, became more and more established, it also became easier to use them for an ever greater number of people. Hence, change accelerated. However, since the new artifacts also give stability to new social practices, new environments

emerged in which what was once a new pattern of exchange became the prevalent one. What was once dubious innovation became common-sense. Change consolidated and the new environment stabilized.

The environment of commodity money connected the then leading-edge techno-science of metallurgy with the localized political system of feudalism and the dominant economic pattern of small-scale local exchange. The environment of money on account connected the then advanced fields of knowledge – reading, writing and double-entry book keeping – to the institutions of private banking and trading companies to the economies of long-distance exchange requiring large and long-term investments. The state credit money connected state-of-the-art forms of minting and printing to the authority of the nation state and an increasingly integrated and unified national economy. Virtual money emerged from, and is currently deepening in, an environment in which high-end communication technologies support institutions with an increasingly global presence to conduct transactions that are not bound by the constraints of the nation states.

The role of technologies in these transformations is difficult to isolate because technologies' roles stem from their integration in heterogeneous actor-networks. New technologies open up/close down possibilities, they are actors with potentials. Like all actors, they cannot act in isolation. Technologies can act only by entering into actor-networks that enable/constrain all their members. It takes the participation of all actors to give shape to the network, and at the same time, one another. If the actors support one another, the stability and irreversibility of the network increases.

Irreversibility, as we have seen, means that it becomes impossible to go back to the condition where the network did not yet exist. This has two implications. First, once a sufficient number of actors have been subjected to change, it becomes impossible to turn back the clock and recreate the condition of the past. Second, it indicates the *path dependency* of socio-

technological change. As a new technology enters as an actor into a network of other actors, a process of mutual adaptation begins in which the various actors define their respective roles in the new or changing network. Many of these actors already have a role in established actor-networks. Adapting such actors to the new technological actors is as much a process in which the new·presses against the old as it is one in which the old impacts on the new. The old – the already existing actors – sets the conditions under which the new develops. It is impossible to develop the new without integrating substantial parts of the old. As a consequence, the old becomes the new and the new becomes the old until both can no longer be distinguished. Innovation, if successful, is not located in a single actor, but is a process distributed throughout the entire actor-network. Hence, even in periods of rapid change there is continuity. However, the opposite is as true. Even in periods of great stagnation there is change because new actors are constantly fitted into existing networks. However, if the adaptation process is suppressed, the stress within the network – poorly integrating the old and the new – rises. Stability and transformation are constituted by the same processes at different speeds.

As a new actor-network stabilizes, the number of potentials for the new technological actor decreases and the emerging artifact hardens: it takes on distinct properties and a seemingly self-evident identity. This convergence of many potentials into a single reality occurs as the new technology becomes more and more embedded into relationships with a large number of heterogeneous actors. All of them contribute to defining those aspects of the new technological actor that are relevant to them. Adding up such partial definitions contributes to a comprehensive definition. If those partial definitions do not add up, as they didn't in the case of Mondex as cash replacement, the artifact as well as its network cannot stabilize. If they add up, the technological artifact turns slowly into a black box that seems to possess the very characteristics it has been assigned by the network from which it emerges. In a parallel movement, the network becomes invisible.

When we pay for a newspaper with a dollar coin, we do not think of the Royal Canadian Mint or of our parents who once taught us how to use these coins. Rather, what makes the coin a coin seems to be the coin itself. However, using Mondex in Guelph, it was impossible not be reminded of the banks issuing the currency because they had to actively tell consumers and merchants that electronic cash was indeed like cash and that it was trustworthy because it was issued by reputable institutions. The Mondex promoters even had to set up a booth at the University Center explaining to consumers, as if to children, how to use electronic cash. However, electronic cash, compared to physical cash, was not intrinsically more complicated, nor had it a more extensive network, nor was it more defined by third parties. The difference was that the various actors did not sufficiently support one another, so the banks had to make extra efforts to keep the network together. It was these efforts, and the jarring they caused with the roles of some of the actors in the network, that made the networking so plainly visible.

Considering the notion that an artifact can only stabilize if the entire network stabilizes too, one could call the emergence of a new technology a *bifurcation point*, to use a term from the related complexity sciences, at which one environment changes into an other, or undergoes a *phase transition* to stay within the vocabulary (Kauffman 1995). One state – held in equilibrium by feedback – flips at one point into another state, stabilized by new feedback patterns. "Point", though, might be slightly misleading because such transformations can take a long time and include many steps. From this perspective, the work that went into the development of the Mondex network has contributed to moving key actors that make up the environment of physical cash away from being centered around the concept of national state-issued currency. However, they have not (yet?) reached the point at which the stabilization of the new artifact would indicate that it has passed the bifurcation point and created a new environment that would sustain a

privately-issued global currency. If this ever happens it will depend on a wide variety of actors that need to contribute to a global marketplace for casual, low-value transactions.

New technological actors require new social actors and vice versa. One cannot stabilize without the other. Behind major social change lies technological change and behind major technological change lies social change. However, "behind" might be the wrong term, because it seems to indicate either a temporal distinctions, first A, then B, or a cause-effect relationship in the sense of the "real" force operating behind the apparent actors. This is a misleading way to think of the relationship between social and technological change. Any social change without technological change is necessarily superficial because it misses all the non-human actors that constitute our society. Technological change without social change creates still-born inventions because new technological actors cannot act without social actors adapting to them. A better way of framing this relationship, then, would be to say: *Within* major social change is technological change and *within* major technological change is social change, indicating that the foreground/background structure between technology and society is created by our perspective rather than inherent in the relationships among the actors. Technologies and social actors together constitute a single, unified *problem space*. They frame each other's existential condition.

7.5 Reflections on Actor-Network Theory

Can ANT be understood as a theory of socio-technological change to capture this *within* of society and technology? Yes, but only in parts. ANT is not primarily a theory in the conventional sense of the term, rather it is a strongly formulated ontological statement on the mutual constitution of human and non-human action: both are ubiquitously, simultaneously and

reciprocally implicated in the existence of empirical reality.[172] Technologies are not primarily passive tools, picked up and used at times, ignored at others, though they are that too. More importantly they are co-constitutive of human action and human action is co-constitutive of their action.

Such a view of the simultaneity of human and object action is becoming more intuitive, the more we deal in our daily lives with dynamic and complex objects, such as constantly upgradable and endlessly customizable computers that very visibly shape our actions and our experience of the world and ourselves.[173] However, this intuition is rather difficult to substantiate because it runs counter to the standard vocabulary with which we try to grasp it. ANT is about replacing vocabularies that are either too human-centered or too technology-centered – vocabularies that lead us to think of technology being *behind* society or society being *behind* technology – with a terminology that allows us to see them on the same level, one *within* the other. Operationalizing its ontological position into a set of basic terms – actor, network, translation etc. – that can be used for the description of empirical reality in a way that avoids the pitfalls of the human-centered vocabulary (social determinism) or the technology-centered terminology (technological determinism) is a major achievement. ANT is successful in making technological environments accessible for empirical analysis in real time.

It enables us, for example, to understand better how our societies change as we introduce new information technologies. "Better" in this context means

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[172] This argument is more provocative in the context of the natural sciences than it is in the context of technological objects which bear more visibly the signs of human action. However, one can argue that every aspect of empirical reality has a human component since the very category is constituted by *empiria*, human experience and the act of experiencing is not passive, but, well, an act (see, Latour 1999a).

[173] Such an intuition might be an important contributing factor to a general shift in the sciences, which are increasingly focussing on relationships among entities and emergent properties, rather than on entities in isolation and inherent properties (see, Dossé 1999; Maturana & Varela 1972; Waldrop 1992).

that we can describe more accurately how dynamics are constituted by considering all sources of actions. This can help us to see over-all patterns of action as they are emerging from conflicting, messy localized actions, rather than having to wait until the patterns have fully formed and hardened into structures before we can analyze them. By putting emphasis on processes of mutual adaptation, of stabilization and destabilization, ANT introduces a vocabulary of verbs aimed at action, rather than of nouns suited for structure. This does not mean, as frequent criticism suggests, that ANT is blind towards structure, but it means that is able to bring to the fore the active elements even within long-lasting sets of relationships by focussing on both how networks emerge and how they are maintained over time through repetitive actions. In this sense, one can understand ANT as a fusion of aspects of structuralism (repetitive action) and chaos/complexity theory (self-organization, emergence of order).

By virtue of its process-oriented vocabulary and its open definition of what can be considered as an actor, ANT enables the tracing of connections among actors that are otherwise difficult to capture. Not only across the conventionally assumed subject/object divide, but, perhaps equally importantly, across what is usually separated into the micro or macro level of analysis. In ANT actors of all sizes can be fitted into the same analytical framework and thus be understood in their interconnection. Just as we are not required to choose between a human and a technology-centered vocabulary, we do not have to choose between an individual or a structure centered view. By drawing attention to the relationships between small actors and large actors, or better, between actors with few resources, few constraints and actors with lots of resources, lots of constraints, ANT can highlight the relationship between innovation and stabilization, between action contributing to change and action contributing to the maintenance of established relationships.

ANT, however, is still an unfinished project. There are deep theoretical and practical problems to be addressed. By focussing on the emergent and on action, ANT has often been accused of being in favour of powerful actors, of having a managerial bias and of being blind to the consequences of actions on those effectively shut out of the network (Star 1991). This need not to be. One of the ways to bring into the picture those missing from an emergent actor-network is to start with the situation before the transformations and then map the translations of the various actors through which some actors become non-actors, that is, excluded from the new network. I developed one way of doing this in my case study by tracing the translation of consumers-with-cash into consumers-with-e-cash. This "before-after" can help to capture some of the effects of translations that are invisible when only the *after* of the translation is being considered.

On the practical side stands out the difficulty of how to make an artifact speak. ANT has solved this problem a bit too elegantly by introducing the notion of the spokesperson, a human who is not an actor but simply the mouthpiece of an artifact. In practice, however, the status of the spokesperson tends to be more ambiguous. For example, while a project manager at Mondex International is being interviewed, it can be said that his point-of-view is framed by the artifact, the Mondex application, that his role is to promote. In this sense, he is the spokesperson for the artifact. On the other hand, his role is precisely to promote the artifact and the social institution associated with this artifact, MXI, so that his relationship towards the artifact is strategic. By promoting the artifact, he contributes to its creation and he will choose to represent it in a way that is most suitable to its creation, rather than most faithful to the artifact. Even more difficult are the cases in which people claim to be spokespeople for other people, without standing in any direct relationship to them. Civil rights advocates, for example, raising privacy concerns of potential users, are as much speaking on behalf of the "common user" and their common public-good interest as

they are actors trying to shape the emergent technology. Sometimes, an actor can be more powerful by claiming to be a spokesperson.

There is a fine and very fluid line between actor and spokesperson and it is well possible that the spokesperson in the pure form – faithfully given voice to the voiceless – does not exist. However, at this point, the spokesperson is an artificial but necessary creation to achieve a radical symmetry in tracing human and non-human actors equally. Reconceptualizing the notion of the spokesperson is certainly one of the important, practical needs for the further development of ANT.

The greatest limitation of ANT is directly related to its greatest strength: the open vocabulary that it introduces to trace heterogeneous actors. Once we accept the premises of ANT, and employ it as an recording device, the question of what to do with the information recorded becomes important. What can be done once we have used ANT to trace the relationships between humans and artifacts that make up a technological environment?

One answer to this question has been to work on the internal differentiation of ANT, to introduce indeterminacy into the networks in order to prevent the accounts from becoming too simplistic and shaped by powerful actors (Law 1999). However, so far, the attempts to turn ANT into a fully-fledged theory have been overly complex and not very convincing because they seem to lead away from its simple but consequential ontology.

Another, more promising approach, would be to concentrate on what is ANT's most radical contribution, the ontology embedded in its recordings, and to apply this ontology to other theoretical approaches (see, for example, Callon 1998). If such an approach were to be widely adopted, ANT's ontology might become the basis of a pervasive shift in the social sciences to a degree that ANT would disappear as a distinct theoretical movement and be transformed

into a transdisciplinary paradigm. This, I think, is where the full promise of ANT lies.

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8.3 Cited publications

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[I.11] 2 Senior Officials at Bank of Canada [24.03.2000]

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[I.15] Graduate Students, Bishop's University, Sherbrooke, QB [15.09.2000]

[I.16] 10 Merchants, Sherbrooke, QB [15.09.2000]

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[E.1] Ross Anderson, e-mail to author.

- Date: Sat, 29 Jul 2000 09:47:02 +0100
  Subject: Re: Mondex' ITSEC Level E6 rating

[E.2] Paul Kocher, e-mails to author.

2. Date: Thu, 31 Aug 2000 00:50:48 -0700
   Subject: Re: economic dynamics of smart cards attacks

3. Date: Wed, 06 Sep 2000 00:59:15 -0700
   Subject: Re: economic dynamics of smart cards attacks

[E.3] Tom Trusty, e-mails to author

- Date: Sat, 19 Aug 2000 22:35:47 -0700
  Subject: Re: mondex

- Date: Sat, 09 Sep 2000 21:15:42 -0700
  Subject: Mondex - Part 1 of 2

- Date: Sat, 09 Sep 2000 21:44:36 -0700
  Subject: Mondex - part 2

- Date: Tue, 12 Sep 2000 10:19:15 -0700
  Subject: Mondex - copy is also attached (Word 97)

- Date: Sat, 30 Sep 2000 22:44:15 -0700
  Subject: Re: Mondex - copy is also attached (Word 97)

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