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Implications on System Integration and Standardisation within Complex and Heterogeneous Organisational Domains

Difficulties and Critical Success Factors in Open Industry Standards Development

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Abstract

Numerous standardisation and integration initiatives within the use of information and communication technologies (ICT) seem to fail due to lack of acknowledging the socio-technical negotiation that goes into standardisation work. This thesis addresses the implication of open standards development within organisational use of ICT. A standardisation initiative for data transmission, the PRODML project, within the domain of the Oil & Gas industry is investigated. This initiative strives to increase interoperability between organisations as it focus on removing the use of proprietary standards. By using Actor-Network Theory, this thesis try to articulate how such standards emerge, and the critical factors that can lead to their success. It emphasis the need to consider the importance of aligning interests in standards development, and the importance of creating the right initial alliance, building an installed base, for increased credibility and public acceptance.

Preface

This Master's thesis concludes my degree as a Master of Science in Informatics, at the Norwegian University of Science and Technology (NTNU). My inspiration for doing this research is mainly based on two reasons. Firstly, with background in the research field of Systems engineering and Human-Computer Interaction (HCI) I have found particular interest in investigating implications of use of ICT systems in and between large organisations. Secondly, being introduced to Statoil ASA, via the AKSIO (Active Knowledge System for Integrated Operations), and later the Statoil Summer project 2005, gave me a rare opportunity to study my field of research within a large organisation.

I would like to give a special thank to my supervisor at NTNU, Knut H. Rolland, whom have given me good advices on my research. I also want to give a special thank to my supervisor at Statoil Research Centre Rotvoll, Vidar Hepsø, whom have guided me through my empirical approach and introduced me to the "Production Optimisation Tools" project. From this project, I owe thanks to Øivind Berggraf, Jan Richard Sagli, Andrew Howell, Eric Klumpen and Gustavo Nunez for their contribution and support.

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Finally I would like to thank my friends, whom I studied with – for all the long and pleasant coffee breaks, my girlfriend, my friends and family.

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Table of Contents

List of figures

List of tables

Abbreviations and definitions

API	Application Programming Interface
BTG	Brønn Tilvirknings Gruppe
CSCW	Computers Supported Cooperative Work
CERA	Cambridge Energy Research Associates, Inc., an IHS company, is an advisor to international energy companies, governments, financial institutions, and technology providers. CERA delivers independent analysis on energy markets, geopolitics, industry trends, and strategy *(Source: CERA web site, www.cera.com)*
E&P	Exploration and Production (oil industry)
HFD	High Frequency Data
HTML	Hyper Text Markup Language
ICT	Information and Communication Technology
IIP	Integrated Information Platform
IO	Integrated Operations Also called: e-field, i-field, smart-field, digital oil field.
ISO	International Standards Organization or International Organization for Standardisation
IT	Information Technology
LFD	Low Frequency Data
LWD	Logging While Drilling
MWD	Measurement While Drilling
NCS	Norwegian Continental Shelf
NPD	Norwegian Petroleum Directorate
O&G	Oil and Gas (industry)
OLF	Norwegian Oil Industry Association (Norwegian: Oljeindustriens Landsforening). OLF is an interests and employer's organisation for Oil Companies and Service Companies operating on the NCS.
OPC UA	OPC Unified Architecture
POSC	Petrotechnical Open Standards Consortium
PRODML	Production (Extendible) Markup Language
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol. SOAP is a XML based protocol used for invoking web services and exchanging structured data and type information on the Web.
TCP/IP	Transfer Control Protocol/ Internet Protocol
TRO	Target Remaining Oil
W3C	The World Wide Web Consortium (W3C) is an international consortium that primarily pursues its mission through the creation of Web standards and guidelines (www.w3c.org).
WITSML	Wellsite Information Transfer Standard Markup Language
WS	Web Services
WS-*	Web Services specifications

XML eXtensible Markup Language

1 Introduction

"The aim of strategy is to use standards for competitive advantage" (Grindley, 1995:20). This statement describes *the* reason why organisations strive to integrate and standardise their information and communication technology (ICT) solutions. It is to maximise their profits and increase their competitiveness once the standard is established. A lot of effort has been put into standardisation of ICT within, and between, organisations with focus on technological integration and interoperability. However, many researchers have pointed out the need to look at socio-technical issues and negotiation of such solutions. They emphasise the need to take these issues more seriously: Monteiro & Hanseth states that "these standards are neither ready-made nor neutral: they inscribe organisational behaviour deeply within their "technological" details" (1995:325), Hasselbring utters that the task of "bridging heterogeneity" is the most difficult task of system integration (2000: 37), and Monteiro & Hepsø, when speaking of infrastructural development and diffusion, emphasises the importance of identifying the "characteristic features of the underlying, socio-technical process of negotiation" (1998:256).

For present purpose I elaborate the rapid change and organisational ICT issues of the O&G industry. Increased competition in the oil market and decreasing E&P activities force O&G companies to increase their returns from production, and at the same time reduce costs by atomising their operations. On top of that, new technologies for the O&G industry are emerging faster than ever, tempting and inspiring oil companies to accelerate the utilisation of new tools and technologies that will give them a head start in current and future competition – by automating and standardising their work processes and operations.

O&G companies (from now on called operators) are eager to integrate with their suppliers, the service companies (from now on called vendors), for improved collaboration and data exchange. Due to proprietary standards and one-off customised solutions provided by vendors – operators have little chance in streamlining their work processes. This again is believed to reduce efficiency and hinder experience exchange, since work processes are tightly coupled with diverse and locally customised information management solutions. What is needed is a uniform standard between operators and vendors so that operators can plug-and-play vendors, meaning that they can switch from one vendor to another as the circumstances require. In other words, it should be a simple but efficient data transmission standard that can move data from point "A" to point "B", without worrying about what, when or who "A" and "B" might be. It sounds simple, does it not?

This thesis looks at an ongoing open standardisation initiative for the E&P industry, namely the Production extensible Markup Language (PRODML) standard, for collection of the empirical data presented. The goal of this initiative is to create better interoperability between operators and vendors, as described in the above paragraph. The project was initiated in September 2005, and will continue its first iteration until August 2006. This implies that no final results are ready to be investigated and evaluated, thus the empirical findings presented in this thesis is largely based on indications, expectations and beliefs rather than hard facts and evidence.

The purpose of this thesis is to articulate the difficulties and critical success factors of open standards developments within organisational use of information and communication technologies. It also tries to answer whether actor-network theory, a theoretical framework from social studies of science and technology (Monteiro & Hanseth, 1995:325), can help for a better understanding of standardisation work and design of standards.

More precisely, to understand the complexity and heterogeneity of an global and open standardisation process I have used actor-network theory (Latour, 1987, 1991, 1999; Walsham, 1997; Hanseth & Monteiro, 1995; Bygstad & Rolland, 2004) to identify the different human and non-human stakeholders for achieving an understanding of how they are influencing, and are being influenced by the standardisation process. In addition, I have supplemented with various sources of theory dealing with strategies and politics of standards (e.g. Grindley, 1995) and information systems integration (e.g. Hasselbring, 2000). The methodological approach to this case study is interpretive in nature, where the collected data came from interviews, observations, meeting participation, and documents analysis (Klein & Myers, 1999; Walsham, 1993). Out of scope of this thesis is looking into technical implications, data schemas, and other technical details surrounding testing and development of the investigated standard.

My motivation for doing this research is two-fold. For one, with my background within system engineering and human-computer interaction (HCI), I want to illuminate the socio-technical issues in standardisation processes for organisational use of ICT. This has been the main reason why I started studying use of ICT in organisations in the first place. Second, from my work practice in Statoil, and the introduction to Integrated Operations, I found interest in development of data transmission standards for use within the E&P industry.

The outline of the following thesis is: First (chapter 2), I present the theoretical grounding necessary for understanding the implications of standardisation work. Here, actor-network theory is introduced, along with important concepts such as heterogeneity, autonomy and infrastructure within standardisation processes. Second (chapter 3), I clarify my research methodology and evaluate my empirical work. Chapter 4 contains background information where the concept of Integrated Operation is clarified, and enabling technologies for the current standard is presented. The next chapter (chapter 5) takes us to the current status of the O&G industry where the complexity and nature of oil and gas production is explained. Also, the PRODML projects, its participants, its inspiration and the competitor are revealed. Hopefully, this will provide the reader with the necessary information required to understand the standardisation initiative and its purpose. Chapter 6 discusses the findings of my empirical research in connection with theory presented in chapter 2, as to understand how the concept of PRODML finally becomes a standard, the critical factors for its success, and the difficulties of disparate interests. Finally, we come to the conclusion in chapter 7 where I sum up the findings from my research.

2 The role of human and non-human stakeholders in design of standards

As initially described, I will try to articulate the difficulties and critical success factors of open standardisation initiatives. In order to do so I need a system of concepts that can help me understand the drivers and the processes of this initiative? One that identifies the different stakeholders, human as non-human, that are involved in the standardisation process. As the headline implies, my approach to the innovation process of standardisation work is inspired by Actor-Network Theory (from now on called ANT), which hopefully will afford me with understanding of how stakeholders are influencing and are being influenced by the standardisation process. However, using this theory as a framework is apparently not a casual choice. In the following chapter I explain some of the key features, for present purpose, in ANT and how it has been used in Information Systems (from now on called IS) research. Further, I point out reasons why ANT can be a good approach in studying complex and heterogeneous settings such as global standardisation initiatives. Finally, I would like to dwell on some theoretical aspects concerning standards strategy, information infrastructures and heterogeneity.

2.1 Actor-Network Theory

First of all, what is ANT? I have already mentioned the words 'human' and 'non-human', which constitutes the *actors* in the actor-network. In addition, ANT is based on a large number of concepts. Some key concepts that are of purpose for this thesis are: actor-network, translation, enrolment, inscription and irreversibility. I will explain them in order. An ‘actor’ is, as more precisely defines by Callon (1991:140), any entity able to associate text, humans, non-humans and money. Other definitions of actors, or *actants* introduced by Bruno Latour, may be: individuals, organisations, technological artefacts or the current standard itself. Actors, all of which have interest, are influencing and are being influenced by other actors. They are trying to create an alignment of the other actors’ interests with their own interests. The network in the title of ANT is not a network in its symbolic or practical sense (as in relation to the Internet). It is, as put into words by Latour, the *woven fabric* of tight or loose relations and forces connecting the *actants* in a stable or unstable network of actions. In other words, when the alignment of the actants interests is achieved they form a stabilised actor-network. This alignment, a process of enrolling existing actor-networks interests – creating a body of allies, is achieved by “translating interests” (Latour, 1987: 108), which I later describe in more depth. When these translations of one’s interests are put into material form they result in inscriptions (Callon, 1991). Monteiro and Hanseth (1995:6) further explains: “in general, any component of the heterogeneous network of skills, practices, artefacts, institutional arrangements, text and contracts establishing a social order may be the material for inscriptions”. They go on with four aspects of the notion of inscription: “ (I) what is inscribed, that is, which anticipation of use are envisioned, (II) who inscribes them, (III) how are they inscribed, that is, what is the material for the inscription and (IV) how powerful are the inscriptions, that is, how much effort does it take to oppose an inscription. Callon (1991: 150) state that the degree of irreversibility of the translation depends on two things: (a) the extent to which it is subsequently impossible to go back to a point where that translation was only one among others; and (b) the extent to which it shapes and determines subsequent translations.

2.1.1 Why ANT?

> *“Data standards reduce complexity. As a result, successful standards typically lead to lower industry cost, increased work productivity, freed capital, and shortened cycle times. (CERA – “Can E&P Data Standards Success be Predicted?”, 2005).*

The latter statement is of, what is called, a deterministic view on technology, implying that standards lead to a direct effect of integration, both within and between organisations. What it means is that technology has its own power or force that changes society. An example would be that the Internet, as a technological artefact, is leading to democracy. Another approach for understanding technological development is that of social constructivism, or “Social Construction of Technology”, where properties of technological artefacts do not have a given objectivity, yet have the potential of being given a distinct purpose by relevant social groups (Bygstad & Rolland, 2004: 70). ANT, although in the same school as social constructivism , differs from these approaches by its attempt of understanding the symmetry between human and non-human stakeholders. What I strive for in this thesis, as ANT suggests, is to avoid *a priori* discrimination of neither social nor technological aspects in my explanation and understanding of the actants and interests that goes into standardisation. For such purposes it is important “to deals with the social-technical divide by denying that purely technical or purely social relations are possible” (Tatnall & Gilding 1999: 957).

2.1.2 ANT and IS research

A question arises: why is ANT useful for IS studies? As actor-network theory has become more widely known in recent years and explicitly used in understanding the socio-technical nature of information systems this question has been thoroughly discussed by a number of researchers (e.g. Walsham, 1997; Monteiro & Hanseth, 1995; Tatnall & Gilding, 1999; Bygstad & Rolland, 2004). Walsham (1997: 472) reviews the status of ANT in IS research and critically considers the theory’s advantages and disadvantages. Further, he points out the importance of being aware of this criticism and thus be able to generate an informed view of the usefulness and limitations of this theory. There is one point, in particular, made by Walsham (1997: 477) that I find interesting for the purpose of this thesis:

> *"[...] it is noticeable that the authors of the IS studies [...], while they all used the theory for analytical purposes, did not normally appear to use it as the basis for their field research. Does this represent a failing on their part? The view of this author is that it does not, since if actor-network theory can be used to illuminate the result from field research, that is sufficient justification for its inclusion in published work. Nevertheless, there must be concern that, if the full conceptual apparatus of the theory is not applied during the field research, important aspects and processes may not have been studied and documented".*

The methodological aspect of the latter statement will be discussed in the next chapter, however, the conclusion of applying ANT as an illuminator for analytical purposes is unanimous with that of this thesis.

Bygstad & Rolland (2004: 81) asks, from an epistemological perspective, whether we are better equipped to acquire knowledge in IT/IS studys. The answer they give is absolutely positive; "ANT has given IS a richer terminology to describe its empirical findings in more depth". In another perspective, this terminology is important, and useful, for handling the complexity and heterogeneity that is found in IS studies and standardisation work. Hepsø (2004:1) describes this perspective in more depth: "ANT gives a language to describe the heterogeneous network of people, artefacts and concepts that moulds a design and innovation process, also opening up for examination the power of non-human stakeholders in such a process. It aims to study how stakeholders inscribe their interests into various materials and how institutionalisation of design and innovation take place on a concrete level". Tatnall & Gilding (1999: 959) point out the fundamental principle shared by ANT and other qualitative approaches, especially such as ethnography, where they emphasise that ANT, like ethnography, is useful in handling complexity without simply filtering it out. Moreover, Tatnall and Gilding (1999: 963) argues that ANT can be useful in situations where interactions of the social, technological and political are regarded important. Further, they claim that ANT can be useful in situations "where the researcher needs to develop a holistic narrative that relies on the use of a common register to investigate the contributions of each of these factors".

2.1.3 Why use ANT to study standardisation initiatives?

An important basis for an approach to ANT is to analyze the technology, in this case the PRODML standard, as a heterogeneous network existing of more or less woven fabric of human and non-human actants. The answer to whether the PRODML initiative may succeed or fail, according to ANT, lies in: following the actants, "read" the networks, describes the "translations" and estimates the strength in the inscriptions. Further, this means that the success of an innovation lies within the result of a stabilised network (Bygstad & Rolland, 2004:77). Further, the authors argue that ANT will increase the precision and intensity in the researchers narratives. It will help increase the degree of detail that goes into the description of how technological details and functionality connects with other conceptual conditions in the study of IS research. ANT has potential to draw connections between conditions happening at a micro level (e.g. usage will always be "local") with those that we traditionally identify on a macro level (e.g the Internet) (Bygstad & Rolland, 2004:78).

Latour (1991: 103) asks if it is possible to devise a set of concepts that could replace the divide between technology and society? An underlying concept of standardisation is dominance, but there has always been difficult to see how domination is achieved (Latour, 1991). The answer he gives is "to turn away from an exclusive concern with social relations and weave them into a fabric that includes non-human actants, actants that offer the possibility of holding society together as a durable whole" (1991: 103). For the purpose of this thesis it is essential to se how statements, that is, the articulated objectives of the operators, are *loaded* in such a way that vendors all behave in the same manner, regardless of their own objectives (1991: 105). Latour explains that the number of *loads* that one need to attach to the statement depends on the other parts' resistance, their carelessness, their savagery and their mood. Thus, statements do not force a change on their own; they are translated, not transmitted. The fate of the statement is in the hands of others who transports and transforms it:

> *"[…] when studying science and technology, we are not to follow a given statement through a context. We are to follow the simultaneous production of a 'text' and a 'context'. In other word, any division we make between society on the one hand and scientific or technical content on the other is necessarily arbitrary. The only non-arbitrary division is the succession of distinction between 'naked' or 'loaded' statements. These, and only these, are the distinction and succession which make up our socio-technical world. These are the ones we must learn to document and to record." (Latour, 1991: 106).*

Latour further presents program and anti-program to describe how translation is formed. Each actant has a program of action that is opposed by an anti-program. The program is the track that the inventor or initiator wishes others to follow in order to achieve he, she or its objective. The anti-program will be the actions performed by others that derail the initiator or inventor from its track. The program might be the intentional goal, or concept, for initiating a data transportation standard. Development and use of a given technology, in this case a standard, will always be the effect of a stabilised actor-network. In other words, ANT gives a solution to the problem by understanding both the technical artefacts and its surroundings – and the whole they form – without making use of models that favours or theorise the social or the technical (Bygstad & Rolland, 2004).

2.1.4 Translation: aligning interests

In order to explain how innovations and ideas can transform into scientific facts Latour (1987:108-121) takes us through the central notion of *translation*. In order to spread the idea in time and space it needs the action of others. Without these actions the idea will be limited in time and space, so the question then is what will these actions be? To avoid the quandary of unpredictability Latour (1987) points out the need to simultaneously enrol others so that they participate in the construction of the fact (or idea) while controlling their behaviour in order to make their actions predictable. “At first sight, this solution seems so contradictory as to look unfeasible. If others are enrolled they will transform the claims beyond recognition. Thus the very action of involving them is likely to make control more difficult.” (Latour, 1987: 108). Latour gives *translation* as the answer to this contradiction that is further described in the following strategies:

1) Translation one: “I want what you want.”
   To be able to transform a claim into a matter of fact the innovators need the help of others. The key thing here is to get to the explicit interests of the people that will immediately invest in the project. Getting in between the actors and their goals such that the innovation, from the actors point of view, is the best way of reaching their goal among many possibilities.

2) Translation two: “I want it, why don’t you?”
   This strategy deals with the problem of getting people to go out of their way to follow your idea. This can be very difficult especially if your interest group is powerless while they are strong and powerful. There is only one reason why such a fact could occur: “it is if their usual way is cut off” (1987:11).

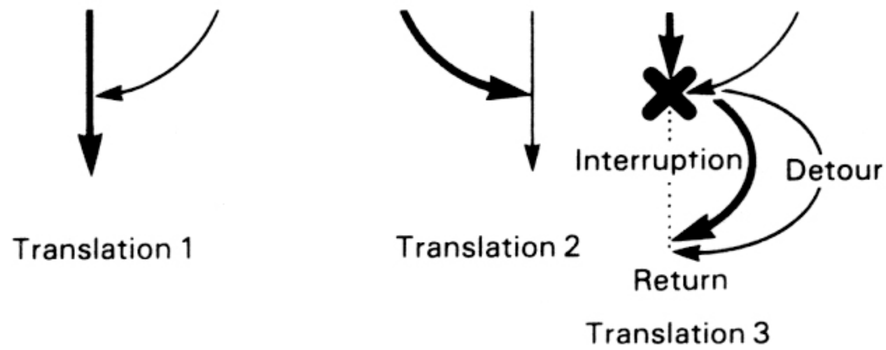

Figure 1. Translation 1-3. Source: Latour, 1987:110

3) Translation three: "if you just make a short detour…"
   Due to the fact that the previous strategy, in most cases, is quite impossible Latour point out the need for a more powerful one. You must convince others that they will reach their goal faster by joining you, since they cannot reach it straight away. You are offering to guide them through a shortcut, which is appealing if these three conditions are fulfilled: "the main road is clearly cut off; the new detour is well signposted; the detour appears short" (1987:111-112).

4) Translation four: "reshuffling interests and goals."
   The fourth strategy is to overcome the shortcomings of the third. It is maybe the most difficult one, namely that of reshuffling or replacing "people's explicit" interests (1987:113). The key action to this strategy is to create new goals that did not initially exist, which can unite the stakeholders and align their interests. These four conditions are presented for this strategy to be chosen:
   a. The length of the detour should be impossible to evaluate for those who are enlisted;
   b. It should be possible to enrol others even if their usual course is not obviously cut off;
   c. It should be impossible to decide who is enlisted and who does the enlisting;
   d. Nevertheless, the fact-builders should appear as the only driving force.

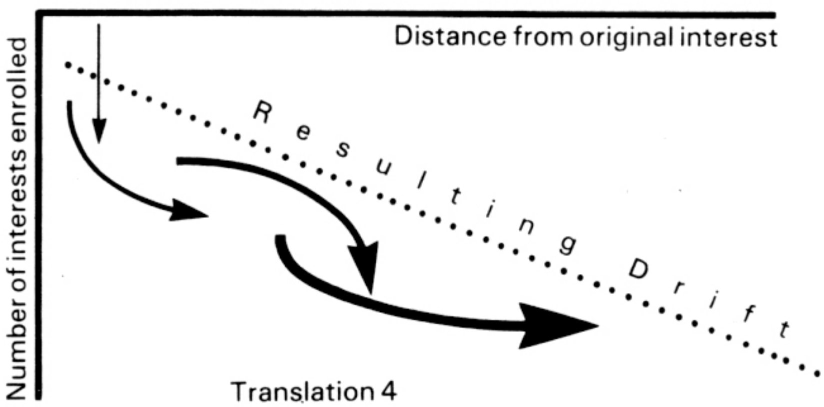

Figure 2. Translation 4. Source: Latour, 1987:117

Figure 2. The figure (translation 4) illustrates how the idea or concept drifts from its original interest as the interests of others are enrolled.

5) Translation five: “Becoming indispensable.”
   This strategy deals with the situation where *others would do the moving*. The idea or innovation is so convincing that not further strategy would be necessary: *the contenders would have simply become indispensable. Other would flow effortlessly through them, borrowing their claims, buying their products, willingly participating in the construction and spread of black boxes.*

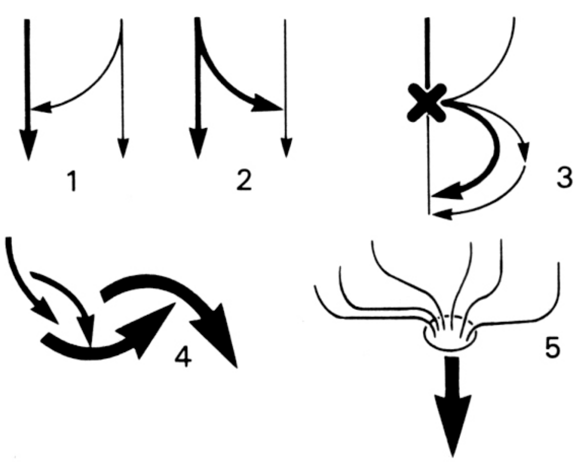

Figure 3. The five types of translation. Source: Latour, 1987:120

Figure 3 illustrates how the role of the contenders have shifted from extreme weakness in the first translation - to the greatest strength in the last translation – where all others are forced to follow them. This apparently unfeasible strategy is quite feasible. However, in order to achieve this situation some non-human allies have to be brought into the translation.

2.1.5 Circulation: from idea to standards

Latour (1999: 98-108) introduces “The Circulatory Systems of Scientific Facts”, which make up “five types of activities that science studies needs to describe first if it seeks to begin to understand in any sort of realistic way what a given scientific discipline is up to: instruments, colleagues, allies, public”, and finally, what Latour call links and knots “so as to avoid the historical baggage that comes with the phrase *conceptual content*” (1999:99). These can, as for present purpose, be related standards development and ICT integration work in and between organisations. These cycles are named: mobilisation of the world, autonomization, alliances, public representation and links and knots. Below is a brief summation of how the cycles relate to each other.

In the first cycle of the circulatory systems, mobilization of the world, we need to answer the question of where the idea comes from? Inspiration to an idea gets transformed into local settings where it is meant to deal with a problem (Hepsø, 2004). Latour emphasises that non-humans are progressively loaded into discourse - that evolves the idea by making it available for arguments. The skills necessary for this phase are to be able to grasp new potential elements and put these together.

Second is the autonomization loop, where it is important that stories are made that can prove the idea and legitimise the use of it. The idea mobilizes colleagues from professions and disciplines who create an innovation activity within an organisation. These stories connect the idea with the real world and help the innovators sell their arguments into the area where it is meant to play its role (Hepsø, 2004).

The third loop is that of creating alliances. These must be built such that the idea can be released from its "owners" over to materialize solutions that can be used by others. The crucial labour of making people interested comes together with the necessity to engage a rich and endowed group for scientific work. This group must be sufficiently large and secure such that it enables the work to exist and endure. Important questions here are: who or what shall be enrolled in the alliance? Why are these actors, human as non-human, important to enrol? And finally, how should these actors be enrolled?

Important for building robustness around a standard is to build and increasing the installed base (Grindley, 1995; Bowker & Star, 1999). Grindley (1995) argues, "One way to build up complementary support is to make the new standard compatible with an existing standard and use this as the initial installed base". In other words, by enrolling existing actor-networks the coming standard has a better chance of success.

Fourthly, the cycle of public representation addresses the everyday activities performed by the people, teams and organisations that are affected by this innovative idea or concept. Questions lurking beneath this banner are: How have societies formed representations of what science is? How is the idea or theory received? The idea needs pragmatic testing that can overturn the normal system of beliefs and opinions, including "bringing people with other qualities and competences into the fray" (1999: 105).

Finally, we come to the cycle of links and knots that describes what holds the heterogeneous sources together. Hard work and control is important to keep allies and the general public interested. Whiteout the links and knots to bind them together the first four circulations will die. Likewise, the links and knots, witch is the conceptual core of the idea, will die "just as quickly if any of the other four loops were cut off" (1999:107).

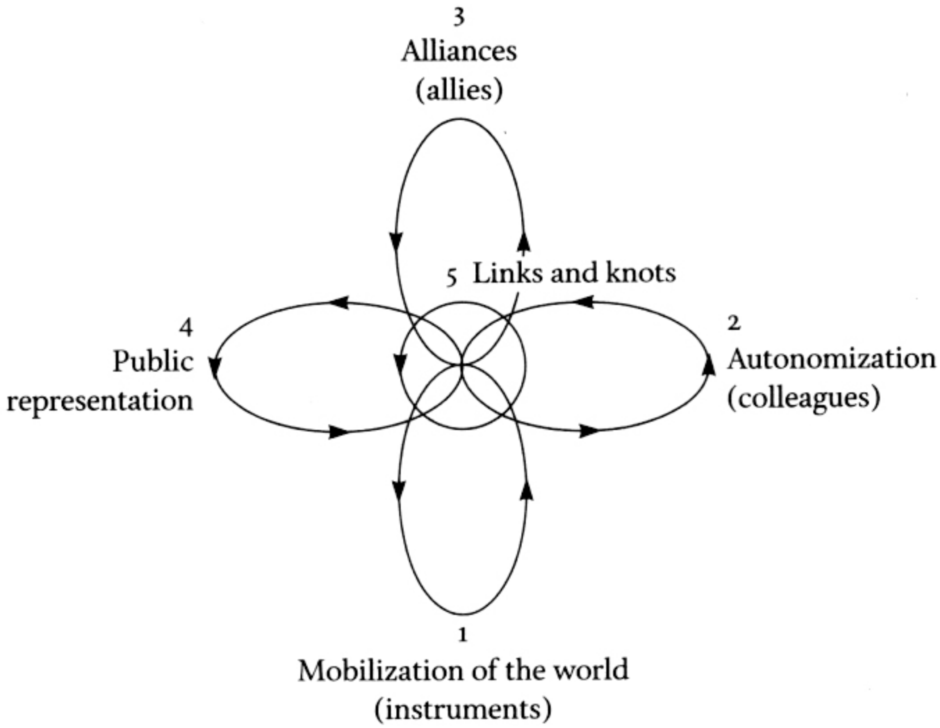

Figure 4. The mapping of the five circulations. Source: Latour, 1999: 100

Figure 5 illustrates the mapping of the five different loops that science studies needs to consider in order to reconstruct the circulation of scientific facts. “Five loops have to be taken into account simultaneously for any realistic rendering of science; in this model, the conceptual element (links and knots) is still in the middle, but it is situated more like a central knot tying the four other loops than like a stone surrounded by a context (1999:100). In other words, “each of these five activities is as important as the others, and each feeds back into itself and into the other four“ (1999:99).

2.2 Standards, strategy and policy

Prior to this subchapter we have looked into actor-network theory and how it can be used to understand the creation of an invention such as a standard. What we have not looked at yet is theory specifically discussing standardisation itself, the strategy and policy that go into standards creation, and finally, what problems have been identified in standardisation and classification systems. Important for this thesis is the theory considering compatibility standard and open standard. However, there are additionally several interesting aspects that should be considered in order to understand the nature of standards that I will describe in more detail.

Grindley (1995: 21) helps us classify standard by discussing two common categories of *what* standards are: quality standards, concerned with the features of the products itself, and compatibility standards, concerned with the links with other products and services. He further point out that these categories define the interface requirements to allow different core products to use common complementary goods and services or be connected together in networks. As explained above, compatibility standards are interesting for the purpose of this thesis because (Grindley 1995:23) they involve strong economic effects, acting through the demand side by making the core product easier and cheaper to use, with more complements available. In addition, open standards, which I later explain is essential for interoperability and integration, are interesting because they encourage imitation (in contrast to proprietary standards which restrict imitations). Furthermore, Grindley states that even for an open standard there may be an effective leader, or for the sake of this thesis – a group of leaders, who defines the standard in the first place and trying to lead a technological change. A good example for explaining the vitality of *openness* is the battle of the VCR standard between JVC and Sony, where JVC made the specifications of its VHS format *openly* available to other manufacturers and defeated Sony's Betamax.

Regardless of what a standard is called, proprietary or open, compatibility or quality, Grindley (1995:20) outlines that the aim of strategy is to use standards for competitive advantages. He mentions three objectives that any given company wants to achieve: it wants to ensure that whichever standard it chooses wins a standards contest, it wants to maximize its individual returns from the standards, and it must be able to compete effectively in the market once a standard is established.

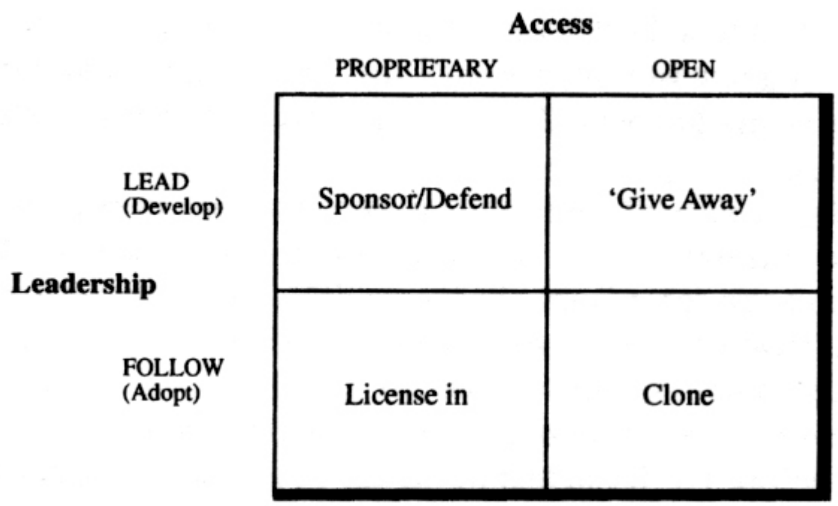

Figure 5. Strategic positioning decisions. Source: Grindley, 1995:30

After getting into *what* standards are it is now time to clarify *how* they evolve, where three traditional ways are outlined (Grindley, 1995): *formal* standards - proposed by standardisation bodies; *de facto* standards - technology standardized through market forces; and *de jure* standards - imposed by law. The dividing line between formal and de facto standards is not precise, and the two approaches are often combined. Like the WITSML standard, which I will explain in detail later, it is not unusual that one, or several, actors in an industry initiate standards and later hand them over to standard bodies for custodianship once they have gained substantial acceptance in the market. This strategy might have a vital impact on the success of an emerging standard. The reason for this, as I will debate later, is that formal and de facto approaches are very different in nature, which have a great influence on the standardisation process in rapidly changing technologies or industries.

2.2.1 Economics of standards

The logic of using a standard in a network is simply to reduce duplicated one-to-one connections for transmitting data between actors. Let us imagine that the cylinders in figure XX are actors in the O&G industry, and the links represent the need of different data transmission standards to achieve data transfer among the different actors. In illustration *A,* there exist only a world with proprietary standards, and in *B* the world have adapted to one uniform standard of data transmission. Thus, the number of links is reduced to the equivalent of the number of actors, and each actor's communication options are reduced to the standardised data transmission schemas. If we, again, imagine that there is a considerable amount of time and money spent on creating those links in *A*, that cost will be reduced to the one of applying the standard in *B* for each actor, regardless of the number of nodes in the network.

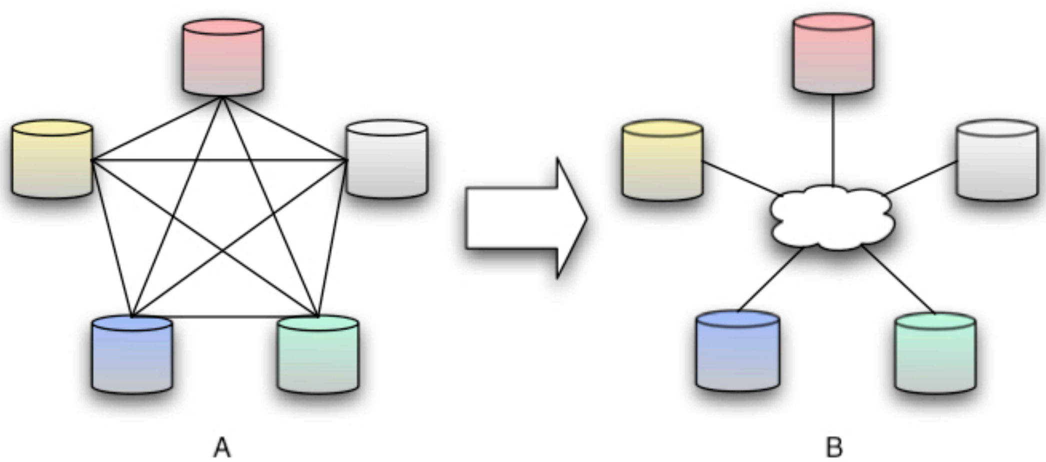

Figure 6. The number of different links as a function of the number of nodes.

From this simple economical model we understand that standards not only reduces the complexity duplicated one-to-one connections, but add value by making it cheaper to buy complements. Grindley (1995:25) make clear that for a user of the standard it will be easier to switch from product to product, and easier to use products in combinations. These are called *network externalities* because each adoption benefits all users and not just the individual, thus giving compatibility standards three main benefits: (I) builds a market for complements: enlarges goods and services, greater availability for people trained to use the standard and perform maintenance, (II) supports portability: users are less locked into a particular vendor and can shop around for the best price, (III) increases connectivity: joining core products in networks, mix and match low-price components from different vendors.

In consideration of the difficulties of changing standards once they are set there are a number of potential problems you would like to avoid. Some addressed to the unpredictability of the standardisation process are (Grindley, 1995: 28-29):

a) *Fragmentation:* market split into several small poorly supported standards. Each may have just enough of a niche to survive but not enough installed base to achieve full network benefits.
b) Stranding: orphaned - poorly supported standards, but locked in by their investments.
c) Premature standardisation: established around a design before the basic technologies development of the product has reached its full potential. Hold back development – restrict market growth.
d) Obsolescence: become technical obsolete.
e) Over-standardisation: The trade-offs between fragmentation and loss of variety are rarely clear.

2.2.2 Preconditions of standards

There may be a number of reasons why standards succeed where others fail, and there is no natural law that the best standard wins. Often cited examples are *de facto* standards such as QWERT, Lotus 123, MS DOS and VHS. Some favourable preconditions may be that standards build on an installed base; they have good marketing at the outset, and finally have a community of gatekeepers who favours their use (Bowker and Star, 1999). “A standard that builds on an installed base ahead of it competitors becomes cumulatively more attractive, making the choice of standards ′path dependent′ and highly influenced by a small advantage gained in the early stage” (Grindley 1995:2). Examples of technologies taking the lead and becoming more valuable for the user are MS Windows and IP.

However, standards are dependent on mechanism of enforcement or a grassroots movement, such as e.g. communities of practice within professional organisations of the oil industry that can adequately adopt the standard (Bowker and Star, 1999, page 11). Without such support - standards will face resistance in early phases, making it difficult to achieve the necessary trust. “A communication standard’s value is to a large extent determined by the number of users, that is, the number of users you can communicate with if you adopt the standard” (Hanseth, 2000). Explicit examples are the dominance of the Microsoft Windows operating systems, and the rapid diffusion of the Internet in recent years.

Monteiro & Hanseth (1999) argues that formal standardisation processes may benefit from de facto standardisation by emphasizing the evolutionary character as well as constraining the ambition of uniformity. Further explanation of how standards evolve through mechanisms of enforcement is given by Grindleys model. “The basic mechanism is that the large installed base attracts complimentary products and make the standard cumulative more attractive. A large base with more complementary products also increases the credibility of the standard. Together these make a standard more attractive to new users. This brings in more adoptions, which further increases the size of the installed base, and so on, as illustrated by Figure 8" (Grindley 1995: 27).

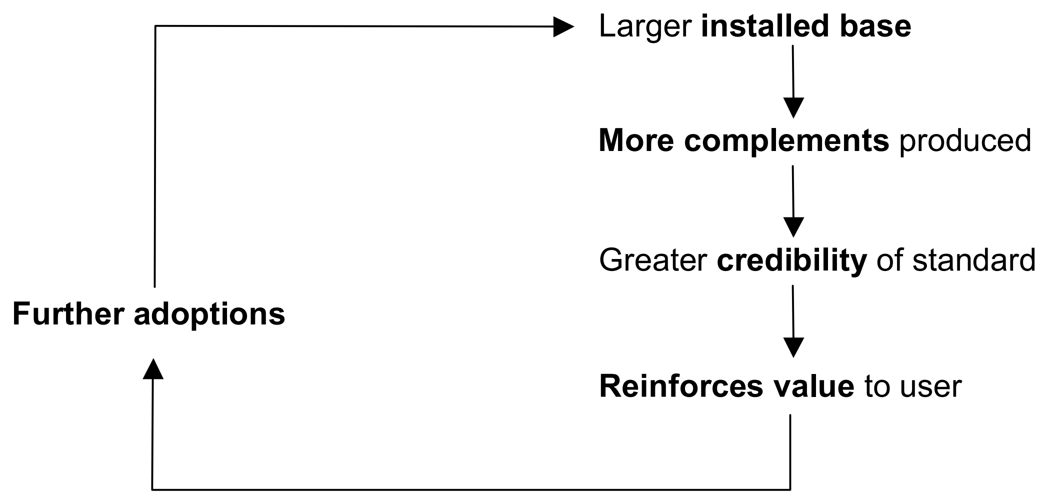

Figure 7. Standards reinforcements mechanism

2.2.3 Heterogeneity, autonomy and distribution

Hanseth (2000: 56-57) states that an information infrastructure is a sub structure or underlying foundation to any standard, and that infrastructure is such matter have a supporting or enabling function. "It is enabling in the sense that it is a technology intended to open up a field of new activities, not just to improve or automate something that already exist". The different elements of an infrastructure are integrated through standardized interfaces. Further, he stats that standards are not only economically important but also a necessary constituting element.

There must be a certain level of adjustments in every connection between an oil company and a service company in order to be able to optimize the specific oilfield and facilities. This is regardless of how the standard evolved in the future. Applying an ISO standard everywhere can be difficult due to diversity in vendors and physical conditions in where the operations are taking place. In a more practical sense - applications need to understand the data provided from others. Standardisation of message formats and message content plays an important role in this context. Hasselbring (2000) argues that XML is emerging as the standard for defining the syntax of data structures to be transferred over the Internet where definition of syntax and semantics for messages must be standardized. However, as the following model will explain, the notion of standardizing messages that in the end must be interpreted by end users is not trivial, due to the dimensions of distribution, heterogeneity and autonomy. I will discuss them subsequently:

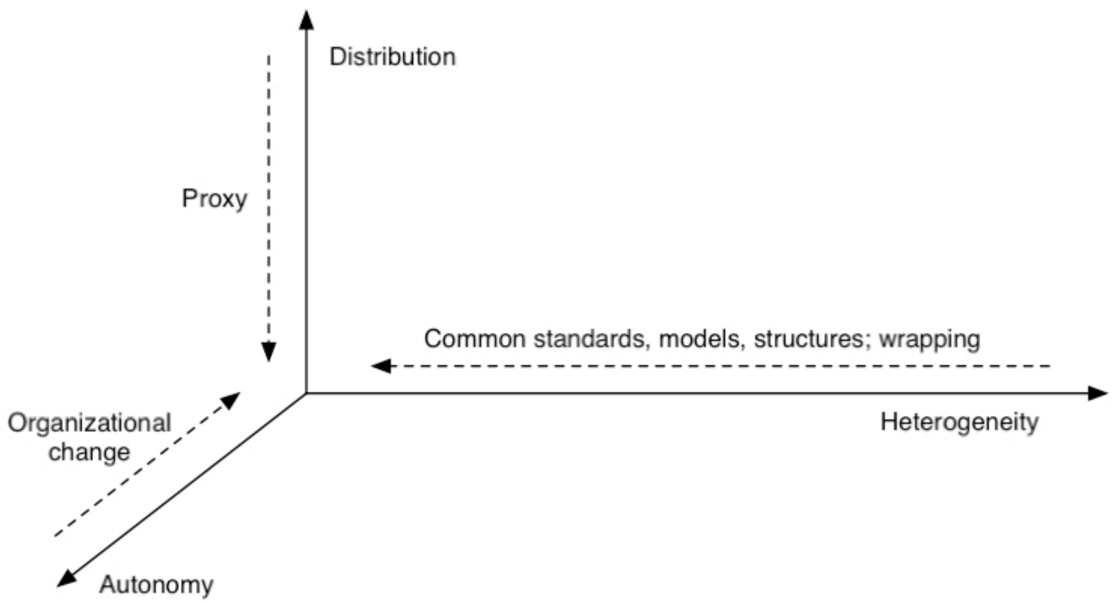

Figure 8. The dashed arrows indicate some general approaches to manage issues of distribution, heterogeneity and autonomy. Source: Hasselbring, 2000:36

Firstly, hiding technical complexity through proxy services are a well-known method for integrating geographically distributed assets. As the services become better and better (dashed arrows in Figure 9), the idea is that the disadvantages of being geographically distributed will disappear as assets appear as centralized, whereas organisations become more and more distributed.

Secondly, - standards, common data models and structures are implemented to make applications understand each other and to streamlining work processes that are adherent to their application portfolios. Hasselbring (2000) talks of to levels of heterogeneity: technical and conceptual. On a technical level there is difference in hardware platforms, operative systems, databases and programming languages. On a far more complex level is the difference in peoples understanding of the same real-world concepts, this being the use of the same name to denote different concepts (homonyms) and the use of different name for the same concept (synonym). Hasselbring (2000: 37) further denotes that "bridging heterogeneity" is one of the most difficult tasks of system integration, pointing at the notion of how partial overlap different organization and difference in term semantic should be understood.

Thirdly - and finally, is the notion of autonomy. Oil companies are constantly fighting their assets strive for autonomy. It is believed that autonomy poses a threat to organizational uniformity and that it "can only be reduced in connection with organizational change" (Hasselbring, 2000: 37). A general assumption describes uniformity as a way to achieve order and control, hence leading to better performances for the organisation as a whole. However, competitiveness and the need for being noticed support the suggestion that "autonomy allows for flexible architectures whereby individual assets or disciplines are able to adopt themselves to change in requirements. By allowing for heterogeneity organizational departments may choose the optimal systems for achieving their individual business goals" (Hasselbring, 2000: 37).

As an example, and with a slightly different perspective, we can look at the early stage of the Internet where a battle between two largely different protocol standards arose which had both politically and technically agendas. The battle stood between the TCP/IP protocol – with broad support in independent en diverse communities, and a protocol called Recommendation X.25, which was supported by strong financial and infrastructural stakeholders. The general opinion has always been, that standardisation is about uniformity – thus making operations more efficient by applying same rules and regulations for every activity in a domain. However - as pointed out earlier, heterogeneity and local circumstances makes uniformity mere impossible without seriously neglecting the complex accomplishment of coordinated and distributed work. Taking this into consideration – "the choice between having a uniform network or Internet protocol represents a trade-off between the simplicity and efficiency of having uniform networks and the flexibility of allowing diverse ones" (Abbate, 1994: 200).

2.2.4 Infrastructures

Information infrastructures are socio-technical networks, which includes heterogeneous constituencies such as technological components, humans, organizations, institutions, and so on. Furthermore, one infrastructure is composed of ecologies of (sub) infrastructures by building one infrastructure as a layer on top of another, linking logical related networks and integrating independent components that makes them interdependent (Hanseth, 2000). We can look at the World Wide Web upon the TCI/IP protocol as an example of such infrastructural layering. Infrastructures are never developed from scratch, but always integrated into or replaced part of an existing one, thus making them hard to change. As a consequence the installed base heavily influence design of new contributions, forcing them to be interlinked by extending and improving the installed base.

Considering standards in relation to the heterogeneous information infrastructures they try to sort out, Hanseth and Monteiro (1998) point out; "the problem of how to decide which areas should be covered by one standard, how different standards should relate to each other and how to change them as their environment change". Is there a way to pragmatically balance a standard against the (messy, heterogeneous and irreversible) character of an information infrastructure from what we have learned? The problem is more precisely not whether such a standard can be balanced or not, but accepting the fact that no standard can magically hide the heterogeneity of an information infrastructure on which it is built. The latter implies that standards are locally embedded, or as Hanseth and Monteiro (1998) proclaims, that standards are only universal as abstract constructions. When implemented, they are linked to, and integrated with local systems and practices, this being applications in the oil industry. The universality and homogeneity disappears as standards get implemented" (Monteiro & Hanseth, 1999).

2.2.5 Standards influence on knowledge work and information transfer

The purpose of this section is that it gives some explanations of how employees from different disciplines can work together, use same vocabulary, and understand the context under which their vocabulary is situated. Can this vocabulary be unified in a standard, and how will this affect knowledge work and information transfer?

The information provided in information systems is explicit and *encoded knowledge,* thus unreserved in respect to its physical representation of signs and symbols (Blackler, 1995). However, we as users must interpret the meaning of this information and make it metamorphose into "*tacit"* knowledge that can be used to solve the problem at hand (Nonaka & Takeushi, 1998). Empirically, research has proven that knowledge cannot be equalized just by adding information and communication technology (Walsham, 2001). Knowledge is not shared between users, simply by making information available to a broad part of the organization.

Blackler (1995) talks of five images of knowledge that is categorized into embrained, embodied, encultured, embedded and encoded knowledge. He argues that embrained knowledge is knowledge that is dependent on conceptual skills and cognitive abilities. This type of knowledge can be referred to as the ability to make complex rules out of routine behaviour and understand complex causations. Embodied knowledge is described to be the "know-how" of people's actions, and is rooted in people's physical presence and the situational context. Encultured knowledge refers to the process of achieving shared understandings. Cultural meaning systems are intimately related to the processes of socialization and acculturation; such understandings are likely to depend heavily on language, hence being socially constructed and open to negotiation. Embedded knowledge is knowledge that resides in systemic routines. The notion of embedded knowledge explores the significance of relationships and material resources. This knowledge is found in the relationship between technologies, roles, formal procedures, and emergent routines. Encoded knowledge is information conveyed by signs and symbols (books, manuals, electronically transmitted information).

3 Methodology

The purpose of this chapter is to give a description of my research method of choice. First, I clarify the applied qualitative research method, more precisely the interpretative case study conducted for the empirical data collection used to present my findings in this report. Further, I go into the different types of data collection techniques where I answer *why* and *how* I got hold of the empirical material. Finally, I will use Klein & Myers (1999) principles for interpretive field studies as a theoretical framework for evaluating my research. This report is produced on the basis of a longitudinal interpretative case study where I have collected and used real world examples to explain my findings in the discussion. I have used Actor-Network Theory for analytical purposes only.

3.1 An qualitative approach to IT research

The choice of research method is not at all accidental. On the contrary it is carefully chosen because of its nature and opportunities for human sense making that suites my case study. It is also endorsed and used by a large group within the IT research community (e.g. Suchman, 1987; Walsham 1993). The following statement by Klein & Myers sums: "IS research can be classified as interpretive if it is assumed that our knowledge of reality is gained only through social constructions such as language, consciousness, shared meaning, documents, tools, and other artefacts. Interpretive research does not predefine dependent and independent variables, but focuses on the complexity of human sense making as the situation emerges" (Klein & Myers, 1999, pp

69). Galliers & Land (1979) argues that research methodology must be chosen on the basis of the nature of the case and the complexity of the real world. Limitations in time and money encouraged for an interpretive approach, as human sense making is both cheap and efficient in exploring complex fields. In this case, the interpretative approach is expedient due to the complex and heterogeneous context of the O&G industry, where the research takes place. It is useful for IS research in general with similar complex conditions.

3.2 Development of research question

The theme for this report and the research question evolved along with my knowledge of standardisation and organisational use of ICT. Being introduced to Statoil via the AKSIO (Active Knowledge System for Integrated Operations) project, I learned to know some of the challenges facing the organisation. Later, I became interested in the PRODML initiative as it was following the footsteps of WITSML, which Statoil initiated. The final choice of themes developed in an iterative process of reading relevant IS research literature and discussing with my advisors for empirically adjustment. During the period of data collection I tried to keep a multiple perspective. Walsham emphasises that; “it is desirable […] to preserve a considerable degree of openness to the field data, and a willingness to modify initial assumptions and theories” (1995: 76). By taking different viewpoint (Oil companies, service companies, other standards) new and interesting details stared turning up that changed the course of my further work. This process strengthened my investigation and helped me to develop a research question that is of current interest for IS research on organisational use of ICT.

3.3 Data collection / Collection of empirical material

Throughout my case study I made use of the data collection techniques described below. Two decisive factors accelerated the data collection; access to Statoil offices and IT systems and membership in the “Production Optimisation Tools” project involving Statoil, Schlumberger and TietoEnator. These events will be discussed later.

In January 2006 I got access to Statoil’s offices and IT systems. This changed my working day and gave my research new opportunities. Suddenly, I was able make contact with people within the organisation that had the competence and knowledge I sought. Getting hold of e-mail addresses, IM (Instant Messaging) accounts and access to people’s calendars made it easy to make appointments, and plan and reschedule interviews. Having direct access to people via e-mail, collaboration web sites and IM made it easier to get quick feedback and comments on my work. In addition, getting access to internal contact lists, libraries and databases helped me understand the use of ICT in large organisations. In late March 2006, I was offered a position as a corporate trainee within the IT department in Statoil. This incident caused, yet another, big change of role for me as a researcher. Several factors can be identified to my change of role. Firstly, when approaching people in the organisation it was easier to present myself as a future corporate trainee than as a student. The “title” gave me credibility within the Statoil organisation and an increased helpfulness could be noticed in people’s behaviour. Secondly, during interviews I noticed that respondents loosened up and gave much richer information than I previously had experienced. As I was considered as “one of us” by the Statoil personnel, I became more confident and reckless in interview settings. I could as direct and hypothetical question, giving me multiple viewpoints from the participant, that otherwise would be considered inappropriate.

3.3.1 Observation and participation

Considering my role as an interpretive researcher it has changed from being that of the outside observer to the one of the involved researcher, through participant observation (Walsham, 1995). I started off by analysing documents and literature that would explain the different problems facing the O&G industry in near future with respect to utilisation of IT (information technology). After acquiring some important information on the current situation I started approaching personnel in Statoil, vendors and OLF to find more information on my research topic. At the same time, as previously mentioned, I was accepted as a project member of the production optimization tools project involving Statoil, TietoEnator and Schlumberger, which gave me totally new possibilities in my data collection activities. The membership gave me access to workshops where the parties openly discussed the notion of optimising production on "Snorre B" (oilfield in the North Sea). Here I also got to hear debates dealing with the PRODML standard with viewpoints from both vendors and operators. Basically, I feel that the following statement quoted from Hepsø & Montero (1998) gives an accurate description of how my role changed after getting the proper access as previously mentioned:

> *"The fact that the authors were free to wander about and make appointments – symbolically gestured by the existence of a Statoil based e-mail address – has greatly facilitated our ability to select and identify interesting sources of data rather than being closely steered" (Hepsø and Monteiro, 1998: 259).*

3.3.2 Interviews

The primary data sources for interpretive studies are interviews. This is also the case in this report, although getting hold of the right people has been a problem since people have been spread throughout organisation and geographically distributed location. The data collection from the interviews consists of in all 12 semi-structured and in-depth interviews lasting up to 2 hours. They have been conducted of a total of 10 informants during autumn 2005 to spring 2006 (see Table 1, not all are enlisted). The key informant have been interviewed 2 times, and later been asked follow up questions either by e-mail or in informal on-the-fly discussions. Most interviews were tape-recorded, such that I could go through them subsequently picking up details that might have been lost if I had written everything by hand. The disadvantages with this method are that respondents might be seriously inhibited by the presence of the machine (Walsham, 1995). However, in my case, I took time to explain the purpose of recording the interview and made it clear that the tape would be deleted as soon as the transcription was done. In all cases this comforting explanation made the atmosphere of the interview setting much better. Furthermore I experienced, in most cases, that the respondents forgot all about the tape recorder as soon as the interview started.

Informant	Type of information	Volume	Coding
Operator Onshore Support Centre, Manager 1	Interview	1	O-OSC manager #1
Operator Onshore Support Centre, Manager 2	Interview	1	O-OSC manager #2
Operator Onshore Support Centre, Production Engineer	Interview	1	O-OSC engineer #1
Operator IT Centre, Department manager	Interview/E-mail	2/3	OC DEP manager #1
PRODML project manager	E-mail	1	PRODML project manager
Vendor Business Development manager	Interview/E-mail	1/1	V-BD manager #1
Vendor Real-time data manager	Interview	1	V-BD manager #1

Table 1. Collected empirical data and information

An interviewing technique often used was to cross check quotations between interviews. Confronted the respondents with quotations from other interviews such that they where tested from within different viewpoints. These statement where sometimes presented without notification of who had said them, but mere as a supplement to the ongoing discussion. This technique worked well in most interviews and often confirmed my anticipations.

3.3.3 Informal conversations and small talk

My presence at Statoil offices has lead to a lot of informal contact with informants knowing a lot about my field of research. This has been of great importance and inspiration for my work as it has bundled my otherwise theoretical aspects with real world objects and episodes. The key event that triggered this was, the previously mentioned, my participation in the "Production Optimisation Tools" project. Knowledge on the role of PRODML in practice would have been difficult without this access. Getting outside of the predefined framework of a formal interview and into the informal setting of a coffee break, or a lunch, to talk about standardisation has enriched my knowledge. Actually, one informant approached me during lunch and asked me if I wanted to do an interview for my thesis on matters of standardisation work. The informant had heard about my research, an in addition heard that I was accepted as a corporate trainee, and wanted to contribute with what he/she thought should be taken into consideration. In my opinion, there is no doubt that my "inside" role in Statoil made such an incident happen.

As my contact network grew I learned how to get hold of relevant informal information such as informal documents and presentations. Mostly, they were presentations from conferences and meetings, summing up projects and initiatives. My informal discussions and interviews with members of the "Production Optimisation Tools" project helped me relate somewhat sketchy presentations from Statoil's internal networks and on external web sites to real world examples of standardisation work.

During the summer of 2005, I was fortunate to participate in Statoil's "Summer Project 2005". First of all, this job gave me the opportunity to learn to know the organisation from the inside by observing situated organisational work, learning to know routines and best practice work processes and not at least the organisational milieu and culture. In this project I worked with two other students, creating a prototype for knowledge management within interdisciplinary teams. During this 2-month period I made a lot of important contacts with employees, which I could contact for follow-up questions later on in my research. Making contacts within various disciplines also became crucial for "Summer Project", as the prototype we made had to support all knowledge areas in every discipline.

3.3.4 Document analysis

The area of my research is of international interests and empirical data should therefore be collected from a broad range of internationally operating oil companies and service companies. Unfortunately, that is not the case due to limitations in recourses and abilities to make contact with other players in the industry. However, I have been well aware of the limitations in my empirical material and tried to make compensations by supplementing with formal and informal documentation written by international standardisation committees and publication from other operators. This document analysis has strengthened my research approach and adjusted my empirical findings to support the organisation of investigation as well as other globally operating oil companies. Such documents have been: PRODML scope statement, standardisation conference presentations, papers from the Society of Petroleum Engineers (SPE), steering documentation from Statoil and web sites for project teams.

3.4 Evaluation of methodological approach

As a framework for evaluation of my methodological approach I use Klein & Myers's (1999) principles for conducting and evaluating interpretive field studies in information systems. For the purpose of this evaluation, I have used principle 1 to 4, and in addition, principle 6, as they are the most relevant for evaluating how my research was performed.

The first principle is of the hermeneutic circle and suggests: "all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form" (Klein & Myers, 1999:72). In other words, iteratively conducting interviews (chapter 3.3.2) and making observations through participation in meeting and workshops (chapter 3.3.1), and in addition, reading literature that would explain what I had observed and heard in interviews helped my knowledge. This interpretive cycle made me understand the bits that I had observed in relation to the industry as a whole. From this I was able to generalise on how ICT was used, and how standardisation work is done, within and between large organisations. Eventually, I started using my improved vocabulary and contextual understanding in interaction with my informants, which in return gave me better and more precise information.

The second principle discusses the contextualisation by underlining the importance of critical reflection of the social and historical background of the research setting. Contextualising the empirical data has been of high priority for my research as the fundamental understanding of standardisation of data transmission within the O&G industry is based on historical and social events. In my document analysis (chapter 3.3.4), interviews and observations (chapter 3.3.2, 3.3.1) I tried to investigate why there was a need for standardisation in the E&P industry. The result I found is presented in chapter 5.1, and supports the present principle. My explanations of this complex industry domain will hopefully help, as Klein & Myers state, "the intended audience to see how the current situation under investigation emerged" (1999:72).

The third principle debates the importance of critical reflection on socially construction of research materials. Central here is the interaction between the researcher and the participants. Social relationships can influence the research process in itself, and it was important for me to be self-conscious and to question my own assumptions. As previously mentioned, my role as a researcher changed quite a bit after I was accepted as a corporate trainee. It gave me better access to information and people to interview, but at the same time it was a challenge to maintain my research focus and not get too tightly engaged in Statoil's subjective problems and reality. Another aspect that influenced my work was my many friends and contacts within the Statoil organisation, which may have influenced my selection of persons to interview. This implications is emphasized by Rolland stating that "it is unlikely that the same informants would have been selected for interviewing if I had not had any knowledge about the case on beforehand" (2003:17).

The fourth principle looks at how empirical data is related to theoretical, general concepts that describes the nature of human understanding and social action. When generalising the essence of my findings I draw from "specific implications" in standardisation work for the O&G industry (Walsham, 1995:80). To my comfort the company of investigation is a globally operating oil company where "specific implications" might be generalised due to implications spanning a broad range of scenarios and involving a large number of other companies. Statoil, as an organisation, was a good place to show human actions within a context and relate those to theoretical, general concepts. Cornford and Smithson (1996:41) argue: "The qualitative researcher, in seeking out the individuals experience and awarding it its own value, must accept a more subjective view of reality". Proper to the interpretive approach, the generalised assumptions I have stated in this thesis tries to use verbs as 'can' rather than 'will' (Walsham, 1995).

The sixth principle considers the implication of multiple interpretations. Takes up the possibility that participants may have differences in their interpretations of the same events under study. In my findings, I experienced that interpretations of what the standard should be (the PRODML) standard was strongly related to who they came from. My goal as a researcher was, therefore, to seek out the reasons for this disparate and mutiple interpretations. What I found is presented in chapter 6, but in general the interpretations of the standard was multiple due to the economical factor of market control and future competitiveness.

4 Background and technology

To be able to give reasonable elaboration of challenges faced by the O&G industry we need some background information that explains the increased focus on technology and work processes, and in addition, enabling technologies that have emerged in recent years making integration on a technical level much easier. First, we take a look at the initiatives that seeks to be the future for O&G companies that want to utilise both new technology and human resources for increased efficiency in operations. Second, some enabling technologies are explained that is regarded important in the technological aspect of integration work within organisations.

4.1 Integrated Operations

All major operators have begun to exploit the benefits of highly instrumented fields for optimal operations of their assets. Depending on the operator such initiatives have all different names such as; Integrated Operations, e-field, smart field etc. Even though the scope varies among actors in the industry most of the initiatives evolve around planning and implementation of new work processes enabled by the latest real-time information and communication technologies.

> *"A typical definition of an e-field is an instrumented and automated field that utilize people and technology to remotely monitor, model and control processes in*

a safe and environmental friendly way in order to maximize the life value of the field" (Hepsø, SPE100712, 2006).

The technology referred to in the definition by Hepsø is, among others, the automated production and operations monitoring systems. Typically, these systems gather well or facilities data through electronic meters or gauges. This data is transmitted via satellite, microwave or optical fibre to remote servers and "data historians", which are subsequently linked via standard wide area networks (WAN) to users with advanced analysis, visualization and process control tools (Gregovic, et al., 2005). An illustration is shown in Figure 10.

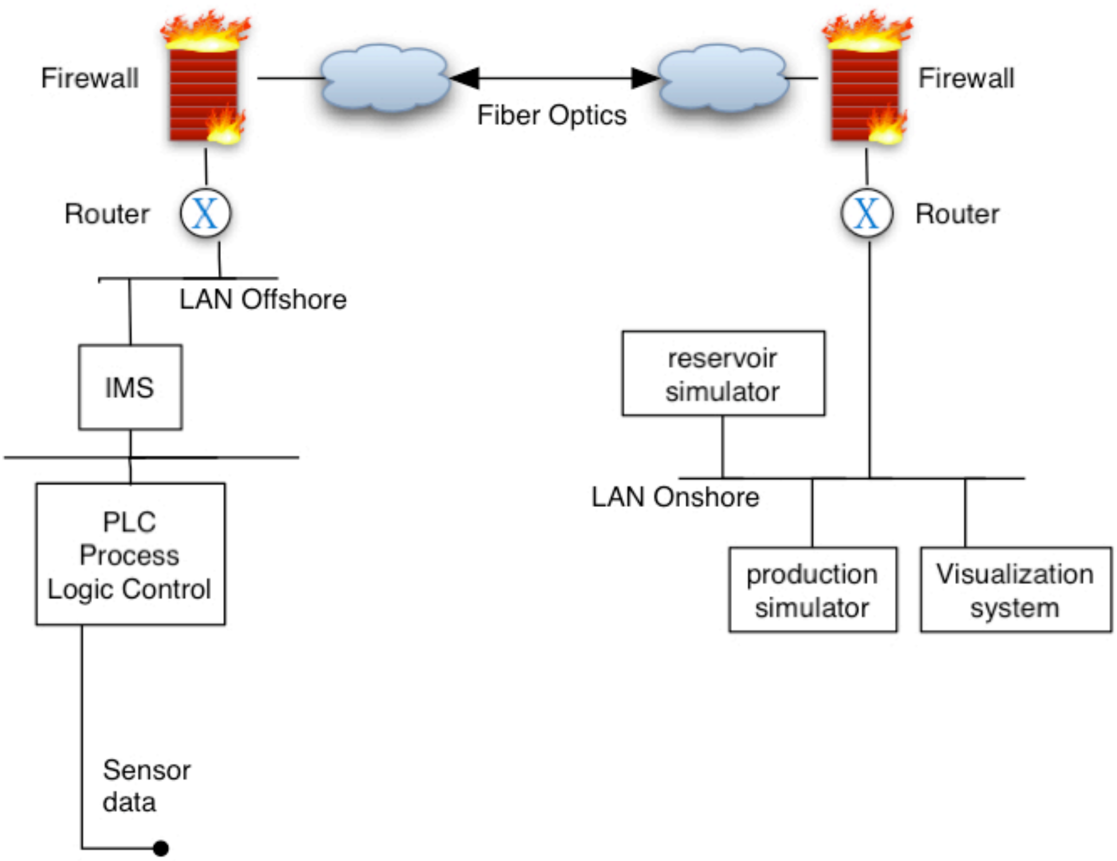

Figure 9. The illustration shows transmission of data from reservoir sensor to desktop applications.

Real-time data volumes can be enormous. For example, a typical production platform with 25 to 30 wells could generate tens of thousands of real-time data points of interests; wellhead pressure, temperatures, well test information, choke valve settings, compressor readings, flare meters, tank depth levels, and so on. Some asset update real-time information every 15 seconds, other every 15 minutes, depending on the need. Those lacking real-time access have to rely on information that may be up to 24 hours old, which hinders efficient asset surveillance and timely intervention when problems arise (Gregovic et al., 2005).

The work that is done in the oil and gas industry is distributed in more than one dimension. It is distributed geographically, in control centres offshore and in operation centres onshore. It is distributed in time, by interdependent phases in operations, and it is distributed in different disciplines, which have key knowledge in their respective fields. *Integrated Operations* (IO) is the generic term for improving drilling operations and oil and gas production, using ICT solutions together with real time data to support decision-making in interdisciplinary teams. These projects all depend on an extended usage of data streaming from the oil filed to the office. Two essential elements: Infrastructural improvements, and a common data exchange format as a lingua franca between applications. The industry is presently pursuing a number of efforts to reach a quantum improvement in overall efficiency by applying digital and communications technology to a refined, simplified E&P process.

4.1.1 Enabling technologies: Web Services

> *"When the appropriate time comes to do so, having a Web service interface will streamline that change as well, without any negative impact on whatever applications are currently in use." (Gregovic et al., 2005)*

The expression *Web Services* refers to a specific set of code that uses widely adopted Internet protocols to create common, robust connections between diverse components within a new or existing IT infrastructure. Consequently, this technology is highly flexible when interfacing heterogeneous sources of data or information due to its simplicity and low-tech solutions. However, Web Services are not necessarily the highest performing option available but it makes it possible to interlink E&P technical applications and directly access critical information without any need to know how underlying data sources are structured, hence allowing E&P companies to mix and match their new applications with their existing legacy applications and database systems so that they will fit rapidly changing needs (Gregovic et al., 2005:2-3).

I will try to explain the connections and structures behind the Web Services technology by using the analogy of mailing a *letter* (Gregovic et al., 2005:4). The Web Service technology is platform and operative system independent, but what does this mean? Try to imagine that you are writing a letter and the language in which the letter is written in is XML. To write something that is understandable for others in one particular language you will have to write in correct grammar, which is WSDL (Web Services Definition Language) in this case. This includes how and where accessing a particular Web Service. When the letter is ready to be sent you need an envelope that is SOAP (simple object Access Protocol) which include both routing and security information. The SOAP – like any good envelope, is independent of either the content of the letter or the transportation mechanism. In the end you will need a "Courier service" – the HTTPS (Hyper Text Transfer Protocol Secure) protocol that will deliver your letter safely to the receiver.

Now that all the phrases and technologies are put in place I will further explain some of the components of which this technology is built on. First up is XML or the Extensible Markup Language, which is a document processing standard that is an official recommendation of the World Wide Web Consortium (W3C), the same group responsible for overseeing the HTML standard. XML is actually a simplified form of the Standard Generalized Markup Language (SGML), an international documentation standard that has existed since 1980s. However, SGML is extremely complex, especially for the Web, thus W3C scaled down the SGML to a form more suitable for the Internet.

XML is a Meta language that allows you to create and form your document mark-ups. We know from HTML that mark-ups are static and tightly integrated into the standard, like e.g. <HEAD> and <BODY>, which cannot be changed. XML, on the other hand, allows the users to create their own mark-ups tags and configure each to their specific purpose, for example: <WellheadPressure>, <WellheadTemperature>. Each of these elements can be defines through your own document type definition (DTD). A DTD specifies the rules for how the XML elements, attributes, and other data are defines and logically related in the document (Eckstein & Casabianca, 2001: 1-5).

5 Case: PRODML - standardising transmission of production data

The domain of E&P is extremely complex. To give a throughout explanation would be an insuperable task for the purpose of this thesis. Moreover, it is doubtful that a complete understanding and mapping of the industry even exist. As I mentioned in the theory chapter actor-network theory provides us with a language that helps us identify and understand the stakeholders, human as non-human, and the actions they inflict or perform. Launching a standardisation initiative within the production industry would seems to be difficult with respect to the complex setting in where it is meant to play its role. However, there are several distinct actions and actors that drive the development of the standardisation initiative, which is discussed in this thesis. These are, among others, the operators, the vendors, standardisation bodies, governments, technology, oil and gas prices and industrial competition. What is important to clarify is that standardisation within such industry domains are not – and cannot be controlled or owned by one single force of power, but by multiple actors putting their interests into what becomes a compromised and generic solution.

In the following chapter I start with an explanation of the E&P industry in general. Further, I take a look at the different actors influencing, and being influenced, by the PRODML project. First, the current participants of the PRODML project are introduced. Second, I look into the scope of PRODML. Third, I look at the predecessor and inspiration for the PRODML project, namely WITSML. And finally, a rival to PRODML is introduced (the OPC UA initiative). Although PRODML, for the initial scope, is strictly a data transmission standard, there are a lot more to this project than technical implications and agreeing on its content. These actors will hopefully give an overview of different stakeholders and forces in the production industry that influence the outcome of the development of the PRODML standard.

5.1 Current status of the E&P industry

Operators are the ones that are responsible for – and are carrying out operations to produce oil and gas. This involves exploration activities where new reservoirs are allocated, test drilling to see if the allocated reservoir holds the anticipated values of oil and gas, drilling operations to ensure secure and efficient production, and at last production and maintenance activities that brings oil and gas to the market. However, operators are not able to do these tasks by their own and are dependent on vendors to deliver facilities, tools and expertise in every phase of almost any of the previously described operations. This means that tight integration and collaboration between operator and vendors are crucial for the success of their operations. Operators may have numerous alliances with vendors all over the world, in various geological and physical conditions - and involving various local governments imposing their laws and regulations on exploration and production activities.

The O&G industry is facing huge challenges in near future. Operators are trying to produce more oil and gas, and they are finding less. In addition, the oil and gas they find - and already are producing, are getting more and more difficult to produce. This means that the source of income is decreasing while the cost of production is increasing, hence making the oil business less profitable. Taking this into consideration, the operators wants to reduce cost of the supply chain by utilizing new ways of getting the oil and gas to the market. Operators are competing intensively to succeed with their efforts to operate and produce more efficiently. As a result of this, vendors are competing intensively to be the preferred partner for future operations, thus forcing a strong focus on technological development and willingness to cooperate with operators to fulfil their requests.

5.1.1 Optimising the production of oil and gas

Operators are continually exploring for new oil and gas reserves. For the last 10-20 years this have been *the* key factor for future prospects, and important both to future operations and the current value of the companies. Although exploration is still important, operators are more than ever preoccupied with their aging reservoirs that have been in production for some time. The reason is that new technology has made possible to drain more and more oil and gas out of the reservoir than old technology would allow, thus giving operators more available reserves than previously expected. Furthermore, as the reservoir gets older production gets more complicated due to pressure drop and changes in the formation that occur when oil and gas is pumped out of the reservoir. Simply put, when oil is pumped out of the reservoir it gets replaced by water, sand or gas, which causes a pressure drop in the reservoir. This makes it harder to produce the remaining oil, as the water cut and sand production increases. Water or gas is injected into the reservoir to maintain the desired pressure in the reservoir, such that production can continue. Going further into details on production optimisation are out of scope of this thesis.

5.1.2 Data transmission: from reservoir sensors to desktop applications

Although most vendors have a complete set of applications and services that can deliver data all the way from the reservoir sensors to the desktop applications, this is usually not the case – in fact, it is very rare. All operators have their own standard set of tools and application that they use. They have bought these over the years from different vendors and investing enormous amounts of time and money to integrate them into their assets. As an example, one operator might have the reservoir simulator Eclipse from Schlumberger, the production simulators Prosper and Gap from Petroleum Experts, the process simulator High Sys from Aspen Tech and the visualisation systems ProcessNet from Matrikon. The problems caused by the fragmented application selection hinder integration because every coupling has to be hard-wired (customized) by the vendors. This is both costly and time consuming, and is taking up a lot of resources on matters that do not concern the production of oil and gas itself. On the other hand, because of the large amounts of money and time already spent on these applications no one is willing to replace them. The goal is to integrate them together with a data transmission standard specifically designed for the production industry.

Photo: Håvard Gustad

The picture shows one of Statoil's onshore operation rooms where collaboration and decision-making with offshore facility personnel are tacking place. These rooms are equipped with the newest of CSCW-systems where people can observe the current status supported by shared vision of data and applications.

5.1.3 Why standardise?

At this moment of writing the production business is very lucrative for a number of reasons. Firstly, there has been a sustained high oil and gas price. At the time of writing every barrel off oil that is produced is worth approximately 65$, encouraging a drive to escalate production to ensure large income. Secondly, the E&P industry is struggling to find new reserves and the ones they find are difficult to produce because of technical and geological challenges. Some examples may be problems related to deep-water production, long tie-backs, heavy oil that is difficult to bring to surface and hydrate problems which blocks the transportation lines. The production of oil and gas is getting more and more complicated because the fluids that are produced are getting more and more complex. As the reservoir gets older it becomes more difficult to produce high value fluids like oil and gas because the ratio of waste products like water and sand increases. All of these problems cause large investment and production costs.

The production industry has been characterized by building systems specifically for the need at hand (ad-hoc) rather than building solutions that can work in various settings. This has lead to costly efforts in building local, one-off solutions by custom coding point-to-point connections between data and application. The next time the same data source is linked to a different application, that hard-wired connection has to be rebuilt from scratch. A vendor manager states:

> *"Approximately one third of the total investment costs are consumed by these efforts". (V-BD manager #1)*

Due to the fragmented selection of IT solutions and applications in the production industry, every asset within an operator has its unique combination of systems and data formats that requires custom interfacing. However, production technologies have matured the last 10-15 years making them ready to be integrated through standardised interfaces. Reservoir simulations and process simulators have developed for many years, but production simulations and production applications have continued to be a *cottage industry* (small company/in-house industry) throughout this period. As the production technologies have matured and developed the big service companies like Schlumberger, TietoEnator and Halliburton have bought it up, providing them with a full set of integrated production tools and applications. This – again, provides the industry with real requirements to how production tools and applications communicate, such that an open standardized industry solution can be developed. Because of competitive reason, there is no way the industry will standardize on an Schlumberger set - or a Halliburton set. Furthermore, because many vendors can provide a full set of tools and services but few operators are buying the whole set from just one vendor, there is a much greater request on the vendors to link their tools and applications together, thus a data transmission standard is needed.

Some operators maintain the current IT situation because they believe that change is too difficult. More generally, there are no indications that operators are going to replace their existing systems and incorporated infrastructures, which is why PRODML is considered important: it is believed to take the costs and politics out for the vendors to be able to integrate their systems together. "Whatever approach is adopted must accommodate both emerging and heterogeneous legacy systems, which can never be replaced all at once. […] Also, introducing new or standard technology into an existing architecture can be a slow, frustrating and needlessly expensive process" (Gregovic et al., 2005: 2).

5.2 Participants and interests

A very important foundation for any standardisation process, and cooperative work, is to attract the right initial actors that are genuinely interested and willing to make an investment into the project. The PRODML project, initiated by British Petroleum, Chevron and Shell, were focused on a pragmatic approach to the innovation idea. The following strategies were applied for the initial scope:

1. *"To expedite the development of the PRODML specifications, the group will be kept as small as practical". Source: press announcements, PRODML official web site (www.prodml.org)*

The project group scheduled a 1-year time frame for the first iteration, that is, the time spent agreeing on content, make adjustments to software and initiate and perform pilots that would be feasible within a 1-year period. Hence, the list of contributors had to be short in order to keep the tight time schedule planned. A long list would have resulted in a forum of time-consuming discussion.

2. *"After the first version is completed, the results will be handed over to an appropriate standards organisation for further development and custodianship". Source: press announcements, PRODML official web site (www.prodml.org)*

This strategy, which is adopted from WITSML, was applied to ensure openness to the industry, telling everyone interested what is currently happening and what will happened in the future. Most of the enlisted companies have large contracts with outside companies. If PRODML is put into these contracts a large number of these companies will be interested in implementing these solutions.

3. *"The strategy for enlisting vendors was to make sure we had all niches of applications and services covered. We were satisfied with one or two actors within each niche as long as they were of adequate size in the industry". (OC DEP manager #1, PRODML group member)*

Let us take a look at the stakeholders, the oil companies and service companies, that have agreed to participate in the PRODML project. From the operators perspective the main motivations for this project were two-sided. For one, it was to apply a plug-and-play strategy for the best available tools in a workflow (potentially from different vendors), such that these tools could be easily coupled. Traditionally, a majority of tools and applications would have been bought from one vendor, which would take care of the integration work. In addition, standardisation could give the operators a unique opportunity to test and evaluate new workflows that could be automated or made "smarter" than those currently used. Second, the fact that WITSML, which is based on the same concept, seemed to gain ground in the drilling domain was a good reason for giving it a chance in the production domain.

Table 2 describes the project members and *probable* reasons why they joined the project:

Oil companies:	**Program:**
BP	*Initiator:* See the above description. This operator, along with Statoil, was also an initiator for the WITSML project.
Chevron	*Initiator:* See the above description.
Shell	*Initiator:* See the above description.
ExxonMobile	*Ally:* This operator was invited because of its size and substantial role as a major actor in every part of the O&G industry. Hence, this actor is always a good ally in standardisation work. Empirically, they have rarely made contributions towards standards development.
Statoil	*Ally:* They were invited because of their technological experience and reputation, both as an initiator and key contributor to the WITSML project and as an operator coming a long way in the IO initiative. Another reason is their current efforts in standardising production reporting in cooperation with OLF.

Service companies:	Program:
Halliburton *	*Invited*. To see the development of production data standard for Halliburton DSS application.
Invensys	*Invited*. To bring process control application into O&G market
OsiSoft	Invited. Might have joined both because of new business opportunities as well as making sure that their PI Process Book application can understand the production data standard.
Petroleum Experts*	*Invited*. Might also have joined both because of new business opportunities as well as making sure that their existing business is in alignment with the new standard, and visa versa. E.g. to ensure that the applications PROSPER and GAP can integrate with other production applications and data management systems via a defined standard.
Schlumberger*	*Invited*. Joined early to continue developing a production standard. Having seen the success and power of WITSML for uniting vendor applications and databases they are eager to see the success of a standard that can help integrate 3rd party applications and databases into their platform.
Sense Intellifield*	*Invited*. Eager to se new business opportunities and also ensure that Sense real-time systems can use PRODML.
TietoEnator*	*Invited*. To ensure the Energy Components Database can integrate with PRODML standard within applications.
Weatherford	*Invited*. To ensure that the applications Reo and Wellflo can integrate with production data management sources that use PRODML.

Standard organisations:	Program:
POSC	*Invited as custodian*: An obvious contributor. This organisation lives from standardisation and are continuously developing and maintaining standards for the industry. In this case the industry wants to develop a standards based on their greatest success to date - WITSML, thus it would be hard to understand why they should not be interested. In other words, POSC would undermine its own existence in the industry by turning down this initiative.

Table 2. Participants of the PRODML project.
*POSC Work Group Agreement – In Process.
Sources: Participants taken from PRODML web site (www.prodml.org), Program information: PRODML project members from both vendors and operators.

Considering the enrolled service companies (some are mainly software companies) they all are involved with strategies, in one way or another, on the ongoing IO initiative in the industry. Standardisation is an important part of IO, thus lies within their field of interest. The motives might vary among the participating vendors; some are searching for new business strategies were others are eager to be in advance of new changes that might influence their existing business.

There are several reasons why actors in the industry would like to be a part of the PRODML initiative. When a project group, existing of a considerable part of the industry, invites a limited number of companies to join a standardisation initiative they cannot simply be ignored. Here are the reasons why:

a. *Reputation: ignoring initiatives like this would give a negative signal effect to other actor in the industry.*
b. *Technological advantage: if the standard becomes a success the participant will already have a head start in adapting the new technology.*
c. *Protecting existing business models: the easiest way for an actor to prevent the standard from disrupting its business strategies is by joining the group that develops the standard. (PRODML Project member #1).*

5.3 PRODML – the standardisation initiative

Major oil companies have recently been working together to establish an open industry-standard method to facilitate the exchange of information between applications in the domain of oil and gas production based on IT industry Web Services standards. This project is referred to as PRODML (PRODML scope statement, 2005). Currently, all production software developed by various vendors has their own data structure and content. This means, as previously discussed, that connections between them have to be hard-wired for each unique setting. With this background the PRODML project group have announced

> *"The PRODML standard will address information flows among software that enhance production workflow from the reservoir/wellbore boundaries to the custody transfer points, where the workflow have decision time cycles that range from minutes to months. The standard will address all well types and all production operations including high and low business operational interdependencies" (PRODML Scope Statement, 2005).*

In other words, the main problem that PRODML is going to solve is to define a data transmission standard between point A - and point B, such that point A and point B can be different oil companies, vendors, software, and also different time frames. The latter means that this might be low frequency data from a well test, or it might be a high frequency real-time data infrastructure. An abstraction layer is needed, such that data structure can be exposed, and vendors can effectively interface their products into a customer's optimization loop and associated architecture.

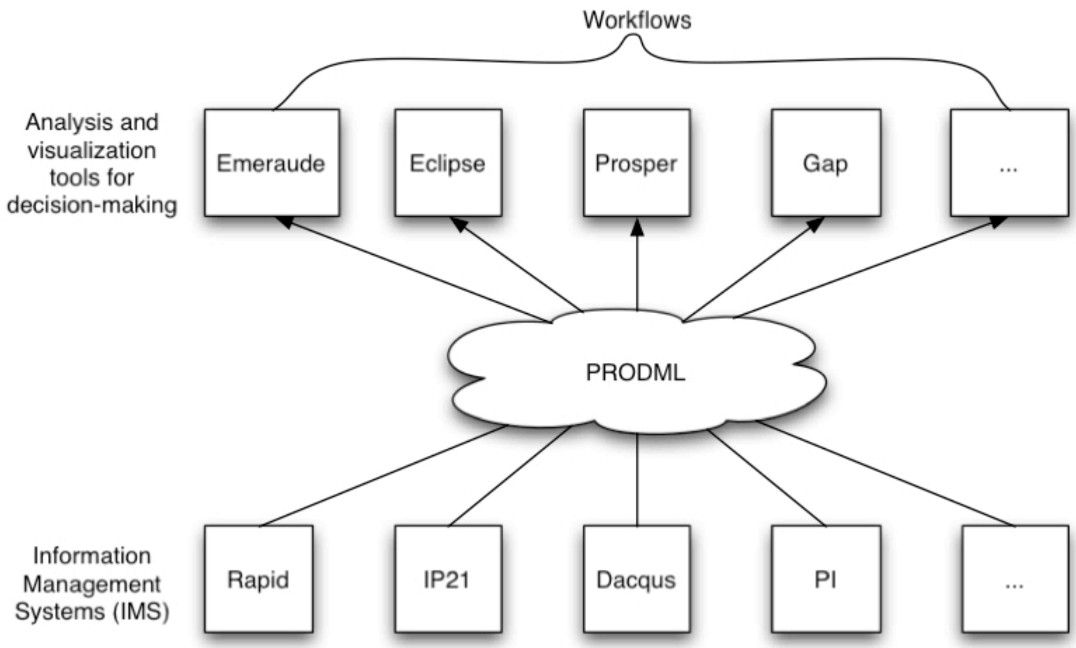

Figure 10. The figure illustrates how PRODML can integrate applications and IMS-systems.

So far, the project has concentrated on how such a standard could be efficiently defined, and the types of work processes that would be of the highest value from such a data exchange mechanism. These focus areas have been identified for the PRODML project:

- Industry standard data exchange for the production domain
- Eventually the PRODML standard will cover all data exchange, ranging from well completion - to point of sale.
- Current focus is a subset of "production optimization"
- Reservoir Management, injection (water, steam, CO_2), gathering separation and distribution.

5.3.1 Relationship to WITSML

In developing such standards there is a lot of risk involved, due to large investments and uncertainty if these investments eventually will lead to increased returns. The PRODML project team have therefore looked at WITSML, which was considered a success, for guidance on how such a project could be executed. They adopted the following principles for the further execution of the project:

- The standard must be an open standard, which can be readily implemented by all players in the field of hydrocarbon production.
- The standard will be developed by a representative team of oil companies, vendors of application software and hardware, and IT companies. This team will be kept as small as possible but large enough to have adequate access to essential resources.
- The scope of the project will be determined by what can comfortably be delivered within a one-year period.
- The standards should build on WITSML, and should *not* be incompatible with WITSML. If the PRODML standard would exposes a deficiency in WITSML, the project group must work with WITSML special interest group to achieve a solution both groups can agree with.
- POSC has been member of PRODML since kick-off to ensure alignment with WITSML, and to share learning's from WITSML experience.
- When PRODML's first version emerges, it will be handed over to POSC for ownership and stewardship. (Source: PRODML scope statement, www.prodml.org)

5.4 The success story of WITSML

The WITSML project begun in October 2000, and is currently a largely adopted standard in the E&P industry. This was an “oil industry initiative sponsored by BP and Statoil, and later by Shell, as a new standard for drilling information transfer. Initial participation is from the major service companies Baker Hughes, GeoQuest, Halliburton, Landmark and Schlumberger” (WITSML web site, www.witsml.org). The aim of the project was to provide an improved E&P standard, such that data exchange between different operators and vendors, and their software systems, could be enabled during wellbore construction, planning and execution phases (Holt, et al., 2002). In the initial period of the project the scope was restricted to drilling, as that was deemed to be the highest priority. This project was ultimately the notion of getting the ´right-time´ seamless flow of well-site data between operators and vendors, which would lead to faster and enhanced decision-making. One of the inventors and initiator of the WITSML project explain:

> *“The idea behind WITSML started off as a note written down on a napkin during lunch. [..] We started searching for partners that were interested in our idea and eager to keep a pragmatic approach.” (O-OSC manager #1)*

But why did this standardisation initiative become a “success”. The answer given by Holt (2002), et al is found in several reasons: Firstly, the project hosted the right initial players that had a clear focus of where to go and what to do. These companies, as central and influential players in the E&P industry, had a strong commitment to the project, an also contributed with initial founding. This commitment lasted throughout the initial delivery of the project.

Secondly, and merely technical, there was a practical incremental approach and clear focus on target outcomes throughout the implementation. Building on established Internet standards such as XML and SOAP, the choice of technology gave the project a leap over many infrastructural difficulties that occur in early evolution of standards. The participants frequently communicated through steering and technical teams to secure progress and maintain focus. In addition, there was a comprehensive output and documentation off the project along the development, such as XML schemes, server API and sample implementation.

Thirdly, and most importantly, there was openness throughout the whole evolution of the standard, which included public seminars, presentations, publications, and promotions. Finally, the standard was transfer to POSC (Petrotechnical Open Standards Consortium), which is a commercially neutral custody, in early 2003. Making this non-profit project a POSC standard was an important step in the recognition and further development of the standard.

5.5 PRODML versus OPC UA

There is currently a very important discussion within the PRODML project group on how they are going to behave according to another standardisation initiative, namely OPC UA. This initiative, based on the already existing OPC standard, is trying to change a widespread standard used in the process industry into a standard that makes use of Web Services and XML technology and its architecture. This is, more or less, the same technological focus as for the PRODML initiative. In addition, it basically covers the same scope; it has come further in the development and documentation process and it has a considerably large group of supporters.

5.5.1 History: from OPC to Unified Architecture

The OPC standard is an old data method for sending and receiving data between systems and is in widespread use in the process industry, although it is not a standard specifically designed for the O&G industry. The standard is further explained in more detail: “OPC is open connectivity in industrial automation and the enterprise systems that support industry. [...] There are currently seven standards specifications completed or in development. The first standard (originally called simply the OPC Specification and now called the *Data Access Specification*) resulted from the collaboration of a number of leading worldwide automation suppliers working in cooperation with Microsoft. The standard was originally based on Microsoft's OLE COM (component object model) and DCOM (distributed component object model) technologies. The specification defined a standard set of objects, interfaces and methods for use in process control and manufacturing automation applications to facilitate interoperability. The COM/DCOM technologies provided the framework for software products to be developed” (Source: OPC Foundation, www.opcfoundation.org).

The OPC standard has been, and still is, extensively used in the process industry, but it is also mainly *for* the process industry. “The OPC Unified Architecture (UA) is the next generation of OPC, and has developed in recognition of the following factors: (I) Microsoft’s COM and DCOM, the foundations of earlier OPC specifications, are now officially legacy technologies, (II) Web Services now offer the primary mechanism for data transport between computers (and also provide a better option for communications with plant-floor devices), (III) earlier OPC specifications failed to provide a single coherent data model - e.g. the Data Access item hierarchy was totally disjoint from that offered by Alarms & Events, (IV) backward compatibility with earlier OPC specifications is key to acceptance of any new standard” (Source: OPC Programmers’ connection, www.opcconnect.com).

5.5.2 Strategies of alignment

An important question arises: to what degree is the OPC UA initiative going to support standardised Web Services technologies (e.g. WS-* stack), in contrast to building its own special version of the Web Services technologies – only supported by WS-*. In other words, which out of the three following strategies should be applied: (I) should PRODML build on the OPC UA framework from the beginning, (II) should it develop along its own path and then be aligned with the OPC UA framework, (III) should it develop separately and only interface the OPC UA standard?

The answer to these questions could be crucial for the success of the PRODML initiative. Some information that would help us along the way is whether the OPC UA initiative is on the same stage in development and time scale as PRODML. A problem could be if OPC UA develops faster than PRODML and are able to show pragmatic testing. So far, the scope and ideas (also called *foil ware*) are made for both initiatives, but the pragmatic implementation and testing is yet to come. Another important aspect is that the scale of PRODML is much broader than that of the OPC UA due to the fact that it does not include contextual data. In consideration of an plausible alignment of the two initiatives one project member state:

> *"If both the PRODML and the OPC UA standards are advancing in the market they should most certainly be aligned, such that a standards war where both initiatives will suffer is avoided." (V-RT manager #1, PRODML project member)*

Though OPC UA is still in the foil-ware stadium, they have done a lot of work in documenting the initial scope for their upcoming tests. PRODML is also in the foil-ware stadium but have less documentation a far broader initial scope. The question raised then is how the PRODML group believes they will succeed?

5.5.3 Differences between the PRODML and OPC UA initiative

It is important to notify that there is quite a difference between the two initiatives. As I initially described, the cope of the two initiatives were more or less the same. However, they do not cover the exact same areas: the OPC UA, with origin in the process industry, is trying to apply the Web Services technology to the existing OPC standard, whereas PRODML, whit origin in the production industry, is trying to build a standard influenced and compliant with WITSML. A member of the PRODML project describes the problem with this difference in more detail:

> *"OPC is traditionally developed within a controlled environment, which implies the actions of setting up networks in an organised environment where you have a good overview of all parts of the environment. The other thing is that the process industry is very static, so it is easy to predict and control".*
> *(V-RT manager #1, PRODML project member).*

In other words, a difference between the process industry (topside) and the production industry (subsea) is that production has considerable uncertainties to consider when transporting data from one place to another, whereas process industry has fixed and predictable environments. Production is everywhere, that is, onshore, offshore, arctic or desert environment, and need expertise on different conditions in where the production takes place. This involves e.g. setting up links through public networks and building advanced and reliable firewalls and services. As mentioned, the OPC standard uses the DCOM protocol for transportation of data. However, this protocol has poorly support for firewalls, thus implementation and data transfer gets complicated outside the controlled environment of the process industry.

Recently, a dialogue between the two camps has been established. The documentations have been exchanged and the first meting has taken place.

6 Discussion on a standards development

Having been through theoretical concepts, such as Actor-Network Theory, and the nature and implications facing the O&G industry presented in the case study, we now have the necessary background for discussing standardisation within complex, distributed and heterogeneous domains. This discussion consists of two parts:

First, I will look at the findings in my field research from a theoretical perspective. By using Latour's "Circulatory System of Scientific Facts" I try to achieve the understanding of how standards evolve from a vaguely defines concept to a materialized and durable standard (Latour, 1999: 98-108). By using this circulatory system I hope to identify some of the critical success factors of open standards development. These iterations, or loops as Latour states, are common for standardisation processes in any domain, and thus, should be interesting for such initiatives in general. Each loop connects findings from the research with theoretical aspects and implications found elsewhere in standardisation and integration processes, providing a framework for analysing the implications and critical success factors facing the PRODML standardisation project.

Second, I look at standardisation from a mere practical perspective, where I focus on the different forces that drive the standardisation process forward, and the forces that are holding it back. For this purpose I use Latour's program and anti-program (1991:104-107), which can show us some of the difficulties of aligning interests. This shows how opposing actions transform the initial concept into something else then the initial idea hold by the inventors. These actions of others are crucial in order to understand how the standard becomes an abstract construction of negotiated agreement between different interests.

6.1 Implications on theory: Circulations of PRODML

I have in the beginning of this thesis introduced Actor-Network Theory as a way of understanding the role of humans and non-humans in innovation and design processes. In the following discussion it is calcified how these actants influence and are being influenced by the standard such that we can understand the implications of standardisation on a general level. As I said, will use Latour's circulatory system for scientific facts. In addition, and more directly coupled with standardisation in general, I draw attention to Grindleys theory on establishing standard and maximizing profits.

However, before we get into the discussion, let us take a look at the following sketch in Figure 12. As a visual supplement to the circulatory system I have sketched a figure to illustrate how the PRODML concepts travels in time (from top to bottom) and enrols existing actor-networks through its materialization process. It shows how the idea of the PRODML is progressively loaded with humans and non-humans, building robustness and finally evolving into a utilized standard. Since the PRODML project is yet to reach its pragmatic testing, the figure envisions plausible outcomes of the standardisation process.

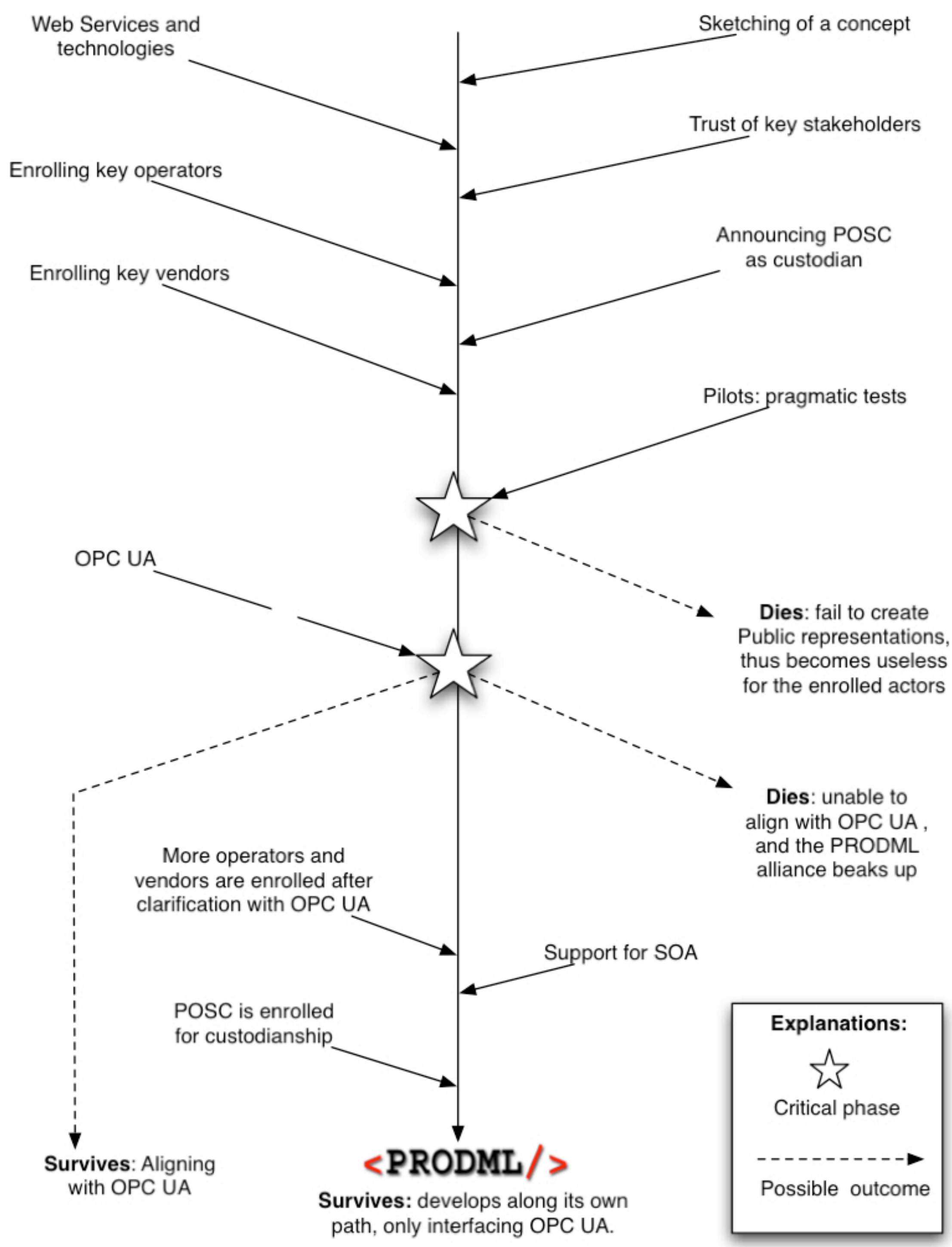

Figure 11. The materialisation of PRODML.

6.1.1 Mobilization (instruments)

As described earlier (chapter 2), there is a need to understand where the idea of PRODML came from and how it transformed into the setting where it is meant to deal with the problems currently facing the O&G industry. In other words, three important questions need answering: why has PRODML advanced as an initiative in current time (chapter 5.1.3), who came up with the idea (chapter 5.2), and finally, what is PRODML going to solve (chapter 5.3)? The answer to all these questions has to do with the *mobilization of the world*. I would now like to draw attention to these three important aspects, which was found during the field research:

For one, it is interesting to witness that such an initiative takes place in current time. It is important to remember, as previously discussed (see chapter 5.1.3), that PRODML could not have happened 10 years ago. Two reasons are recognised: first, the maturity of the production industry in general did not allow for standardized solutions because no one had the ability to put together requirements for such a standard, and second, technological incompatibility made it very difficult to standardize on solutions (the premature nature of the Internet did not contain enabling technologies and services necessary for the standardisation process, e.g. Web Services, SOA, XML). The standardisation process would then suffer from prematurity by "establishing around a design before the basic technologies development of the standard had reached its full potential" (Grindley, 1995). The Internet has now matured in the sense that it provides the enabling technologies, that is, the "sub structure or underlying foundation" for the standard (Hanseth, 2000:56), such that a field of new activities is opened. This field is now used as an argument for evolving the idea of PRODML. This is what Latour presents as "non-humans progressively loaded into discourse" (1999:99).

Second, the initiators who first came up with the idea are recognised as operators coming a long way in IO and e-field operations, constituting a "community of practice" that gives the idea enforced power through a "grass-root movement" (Bowker & Star, 1999). They may have an improved vocabulary for articulating the difficulties facing the production industry in general, thus presenting credible arguments for their idea. In other words, they may have the ability to communicate in an easy way *what* is relevant for the business. This credibility is important for the idea because it helps others transform it into their local setting, that is, the setting of the production industry where it was meant to deal with the problem of proprietary systems and standards. As discussed earlier, even though this is an *open* industry standard the initiators lead this initiative exclusively as a strategy for "competitive advantages" (Grindley, 1995: 20). If PRODML succeeds they will be able to maximise their individual returns as well as compete effectively in the market where the standard is established.

Finally, in the discussion of the mobilisation process is the recognition of a common problem, where local activities such as IO/e-field create attention to the concept and help it to attain a life on its own. Without these activities PRODML, as a concept, have no financing and thus is unable to mobilize humans to gain momentum. One of these common problems is, as previously discussed (chapter 5.1), the proprietary ICT solutions. Currently, ICT infrastructures existing within and between actors in the O&G industry is based on proprietary standards and solutions interlinked by customized interfaces for the problems at hand. The utilization of new solutions, discussed above, is not happening because of the inconvenience of different ways of transmitting data. Yet again, the ability to identify and articulate these difficulties is an important skill for the creation of arguments. One SC manager puts his emotions into the argumentations to identify the problem, characterising the current situation as a *mess*:

> *"The E&P industry is such a mess – there has never been a common data standard. You got one service company trying to impose its standard, our company trying to impose ours, and a third trying to do the exact same thing - but no one is succeeding! It's like a complete disaster". (V-BD manager #1, PRODML project member)*

In addition, the success of WITSML played an inspirational role on the mobilisation of the PRODML initiative. The people enrolled and the finances spent on the WITSML project within organisations might have helped the PRODML initiative gain its momentum. It became the “installed base” on which the PRODML idea built its credibility, and its pragmatic approach (Grindley, 1995; Bowker & Star, 1999). Key actants, initiators and early phase participants, observed a successful standardisation initiative with quite similar precondition to that of PRODML. Even though the scope varied between the two because of difference in domain, the negotiations of technology and business might have caught a rare attention to how practical solution should be approached.

6.1.2 Autonomization (colleagues)

The key to understand the concept of autonomization is to understand how independent elements, that otherwise would have no connection, are reconfigured to play a role in each local setting. Consequently, connections between the IO and e-field initiatives within organisation and the PRODML initiative have to be made. There is no given or natural link of such kind without people reconfiguring their initiatives and make PRODML a part of their daily work. The concept has to be linked to their strategic agenda, and since there are no natural connection the stakeholders uses legitimising narratives to bundle the PRODML concept with existing corporate initiatives. These narratives help building robustness around the concept as they breaks away from the initiators (BP, Chevron and Shell) and into each organisation, where founding infrastructures of humans and non-humans can be enrolled (Latour, 1999; Hepsø 2004).

As we remember from the case, there seems to be a big similarity between WITSML and PRODML. However, the latter need stories of its own “that can connect the idea with the real world” (Hepsø, 2004). An example of this is how the PRODML concept was bundled with the already existing project called Integrated Information Platform (IIP) initiative in Statoil, providing it with people and resources necessary to transfer its claims into meaningful discussions among colleagues.

6.1.3 Alliances (allies)

The third circulation is that off building alliances, which can make materialized solutions that can be used by others. This crucial endeavour has some very interesting aspects, also highly relevant for standardisation processes within ICT and organisation in general. As I make clear, and as Actor-Network Theory supports, an idea or concept is *not* favoured by every actor within a certain domain. Why are some actors preferred and others are not? How do actors form “large and secure” alliances such that it “enables the work to exist and endure” (Latour, 1999)? As for the first question the initial alliance in a standardisation initiative is indeed not casual. Why not? It is because of the importance of establishing credibility. As for the second question, it is about aligning interests. The program of one actor’s interests is countered by another’s anti-program. I will discuss these implications in more detail:

In order to form alliances lobbying skills are necessary for navigating in existing institutions. It is crucial to enroll “gatekeepers that favor the idea” (Bowker & Star 1999), and increase its credibility and are willing to make a sacrifice, that is, spending time and money, for the standard to succeed. Being an open industry standard, PRODML need a certain degree of openness from actors, or else it will fail in integrating them. The PRODML project manager expresses his thoughts on openness and access to common data sets and infrastructures in the E&P industry:

> *“Corporations are becoming obsessive about protecting data, competitive advantage, methodology, and access to production and IT assets. These same corporations that are crying out for simplicity, interoperability, and plug-and-play, are doing their level best to make sure these productivity improvements do not happen. It's like a psychotic person with two personalities“ (PRODML project manager).*

A problem identified from the above statement is: how can PRODML succeed in its plug-and-play program if the alliance has an anti-program that disrupts it? If the anti-program is not abandoned PRODML dies because of lack of integration. Another part of the answer is that those actants abandoning the anti-program and becomes aligned with the program can have a better chance of success when the standard is deployed. In other words, in such standardisation processes there are always winners and losers - and the standard itself becomes the differentiator. The following statements explains in more detail:

> *"If a real-time data company (vendor) have designed their own real-time data transmission standard - then all of a sudden PRODML replaces it – that might be a significant part of their value possession gone." (V-BD manager #1, PRODML project manager)*

This statement is indeed true and recognizes that the standard could diminish competition. This is also true when a new standard imposes a market in general. As we remember from chapter 2, Sony's Betamax did not survive the competition from the openly available VHS format, although it had superior technology. VHS simply won because JVC made the standard open, thus attracting strong allies that built a large installed base, making the standard "cumulatively more attractive for users" (Grindley, 1995). Returning to our case, there is reason to believe that, as the alliance grows and credibility increases, the PRODML standard will cause problems for some actors as they are forced to rearticulate their value add. As stated by the PRODML project manager:

> *"In many cases, some of a vendor's competitive advantage is based on making disparate workflows, data sources and organizational components work together. Interoperability bypasses or minimizes these advantages and makes true value statements much more challenging".*
>
> […]
>
> *"As long as no outside agency can dictate or communize internal functionality, schema, etc, some players can protect their perceived value add. Once the momentum of a standard is such that they are forced to look internally, they run into the problem of defining true value in what they sell. In my view some vendors*

are more "shell" and less "substance" then others. These are the threatened ones.” (PRODML project manager)

Initially in this chapter I asked why some actors are preferred allies in standardisation initiatives? As for the initial alliance of PRODML, described in chapter 5.2, we can identify both credibility and alignment in interests as criterions for enrolling actors. For one, actors sufficient in size and major actors of the industry were selected, and second, those providing the right applications and tools for initial scope of the standard were desired allies.

The enrolling of initial alliances also had a pragmatic aspect. The group needed to be small in order to keep the tight time schedule planned – a strategy adapted from WITSML. Considering the “installed base” discussed earlier (Grindley, 1995), the PRODML project group collected a god mixture of operators and vendors for the initial scope of the standard. The project committee seemed well aware that they needed a large group of actors able to communicate the standard to the rest of the industry, making them able to deliver credible requirements covering all areas of the standard. The pragmatic approach of the committee wished for the actors to make their deliveries in accordance with the time schedule, such that they made sure the reference architecture carries all the data used by the applications. In that way expectations from the outside world would be met.

“Everyone has to fulfil their commitments and get the job done, and all vendors and oil companies must be involved in test pilots of the architecture”. (V-BD manager #1, PRODML project member)

As for the deployment of the standard it is important that the ones that are not directly in the project are able to get the information they need, to be able to do their own test, prepare their own budgets, such that they can start using PRODML for their applications on long term. One way of succeeding in communicating the standard throughout the industry is for the involved partners to build on already existing relations and alliances with other companies. This is what we know from ANT as enrolling existing actor-networks. Requirements and specifications can then be communicated in future business relation where both sides will earn the benefit of implementing the standard. This might not be easy to do because they are all in competition with each other, but if the operators are able to get PRODML as a part of their contracts, insisting that the solutions they use will apply PRODML as a standard, it can lead to a quick diffusion of the standard.

6.1.4 Public representation

The concept needs public representations mapped with people's everyday activities. A key aspect of the PRODML initiative is not only reduction of complex and proprietary one-to-one connections, "but added value by making it cheaper to buy complements" (Grindley, 1995: 25). What is crucial for the circulation of public representation is to conduct pragmatic tests that will prove the plug-and play strategy feasible, that is, "for users of the standard it will be easier to switch from product to product, and easier to use products in combination". These network externalities are the key argument for the standards success. Actors need to se that there is a market for complements where improved goods and services are available. Thus, a requirement for the pragmatic tests is that they are showing the world sufficient support for "portability" and "connectivity". Failing in this area means a reality where customization is a necessity. The question is, why is customization a necessity in the first place?

As pointed out by Hanseth & Monteiro (1998) standards are locally embedded and only universal as abstract constructions. Thus, the pragmatic tests in this cycle are not a unilateral technical endeavour but also require socio-technical negotiation and understanding of the social nature of work. This cycle requires new skills, both in handling specific situated knowledge in particular knowledge domains as well as technological integration competence. As the abstract construction of the PRODML standard breaks down, and becomes locally embedded, implications of scalability emerges. The following statements illustrates the difference between small-scale mapping and universal interoperability:

> *"It is one thing for two vendors to get together and map their internal variables and data schema to a common interface model and make it work. This is not much more then good old integration work. In our current pilots, most of the vendor-to-vendor work is being conceptualized and executed in this fashion. This is not, strictly speaking, "Interoperability Plug and Play". In the first instance, two*

> *vendors agree on what to call data and variables based on their internal schema. To take it to a true "Plug and Play", all vendor need to agree on a common set of interface characteristics data schema, and variables. This second effort requires something the first does not... some or all of the vendors might need to modify internal schema, functionality, and services to accommodate a more Holistic interface." (PRODML project manager)*

In consideration of the above statement actors are, on a conceptual level as well as technological, forced to change their internal way of performing work to accommodate with the forthcoming standard. As emphasized by Hasselbring (2000) the implications of unifying peoples understanding of the same real-world concepts is on a far more complex level then that of technological incompatibility. Some questions should be asked: will the pragmatic tests prove the concepts plug-and-play interoperability model? If not, does this mean that customization, doe to heterogeneity, is necessary? The answer given by the PRODML project manager indicate that these implications are recognized and should be handled as soon as possible:

> *"PRODML in the Pilots are dealing primarily with the first level of "mapping". The true efforts will be applied over time to develop high-level common interface that guides vendors to provide common services, schema, and structure. Tracking and managing this is a daunting proposition but a very important one." (PRODML project manager)*

However, the task of "bridging heterogeneity" is the most difficult task of system integration (Hasselbring, 2000: 37). Therefore, the choice between having a uniform standard or a standard with some degree of customization represents the trade-off between the simplicity and efficiency of having uniformity and rigidness, and the flexibility of allowing diversity (Abbate, 1994).

An example of the complexity and heterogeneity PRODML has to deal with is the importance of selecting the right initial scope. An important question here is: how to gradually construct a pragmatic test? As already mentioned, without a pragmatic test the standard will lose its credibility. On the contrary, if the pragmatic testing succeeds it will increase the interest and credibility of the standard. That is why selecting the right initial scope is crucial for the success of the standard. Gas lift (injecting gas into the reservoir to increase production of oil) was selected as the initial scope for PRODML. Although some of the companies involved in the development of the standard had no interest in gas lift, like Statoil and TietoEnator, they complied to the scope simply because there is no way that the initial scope will be interesting for everyone.

> *"The problem is that production industry is such a wide range in area, it is difficult to choose one workflow that everybody, every vendor and every oil company can be interested in" (V-BD manager #1, PRODML project member).*

Because of the large numbers of operators and vendors facing problems with gas lift it was chosen for the initial scope. Still, the committee seems to be well aware that the testing needs to extend very quickly into the other areas of production, such that the relevance for other players can be demonstrated.

Another important aspect to the public representation of PRODML in general is how it will align with the OPC UA initiative. As previously discussed, both are open standards and compatibility standards. If the two are not aligned they could suffer from "fragmentation", where both initiatives survives but are unable to achieve full network benefits (Grindley, 1995:28). Inn addition, and with remembrance of the recent discussion on heterogeneity, they will have to deal with added complexity in the integration process. As stated by one PRODML project member:

> *"They (both standard initiatives) have a very similar scope, but have very different backgrounds and basis. If both standard initiatives follow the Web Services specifications (in accordance with W3C) they could be interoperable. The disadvantage would then be added complexity, which can further obstruct the integration process (V-RT manager #1, PRODML project member).*

By analyzing the above statement it is likely to believe that the choice of building a common business and context terminology, where a lot of effort is spent on talking through the definitions of words, is worse than living with fragmentation. It should be noticed that PRODML have not reached this phase yet, however for the PRODML standard to prove its usefulness it must survive the pragmatic testing.

6.1.5 Links and knots (the pumping heart)

In order to survive as a concept this loop is quite essential, it is “the conceptual core” (Latour, 1999: 106-108). What does this mean? How is this loop connected to the other four? The PRODML concept is the tight knot at the centre of the net that holds the many heterogeneous resources together. It is what strengthens the elements cohesion, and accelerates their circulation - holding a collective of humans and non-humans together. This is understood by a two-way dependency between the concept itself and the other four loops. The concept of PRODML cannot be observed in isolation, or at least it would make little sense. Without the concept the four other loops will die: mobilisation of the world would dissolve into unconnected fragments, colleagues would move to new projects, the allies enrolled would lose interest and the public would never gain much interest. Likewise, the fifth loop would deplete and die without any of the four other loops. It would make little sense having a concept that mobilised essential parts of the world, if there were no colleagues to develop it; no supporting institutions, no alliances and collective to put it into circulation, and no public everyday activities that could provide pragmatic tests in its applicability. In other words, it means that if PRODML should appear to be a concept without validity, a standardisation initiative that is not able to generate the benefits foreseen, it eventually will die, regardless of all other cycles. What needs to be clear is that the circulations is not a linear process, they are not followed successively, but are repeatedly reiterated.

What have the PRODML committee done to prepare for this fifth loop? They have planned for a strategy to, upon completion of the pragmatic tests, transfers the PRODML component to the standards organization POSC (Petrotechnical Open Standard Consortium) for custodianship and further development (PRODML official web site, www.prodml.org). This strategy was adopted from the WITSML project as it proved to be successful in keeping a pragmatic approach. In addition, a lesson learned form the WITSML project was to keep control of the standard at all times, preventing it from escalating, thus making it applicable and easy to integrate.

6.2 Implications on practice: Program vs. anti-program

As initially described, all actors have a program, that is, their interests, that drive their actions to achieve their goals (Latour, 1991). The program involves a strategy that aims to use the standard for competitive advantages (Grindley, 1995:20). In the following discussion I present the PRODML standardisation initiative as the operator's program, and the opposing interests to the standard as the vendor's anti-program. The key ting is that some vendors can join the operators program, and use the standard for their competitive advantages as well, while others fail to abandon their anti-program and loses once the standard is accepted in the market. Another outcome could be that the anti-program is never abandoned such that the standard fails to get accepted in the market.

6.2.1 Operators: program

The operators want a plug-and-play model where they can change vendor at the choice of their needs. As presented in the case (chapter 5), operators are eager to maximize production, which means that their statement is to produce more oil and gas. Their program is to apply a strategy that will lead to this goal. Operators strive to streamline work processes and software across disciplines and units such that best practice procedures and knowledge can be shared throughout the organisation. However, introducing the plug-and-play model opens the market for smaller vendors, hence leading to greater competition. The following statement illuminate this aspect:

> *"When this model was first introduced through the introduction of WITSML many large vendors quickly categorised it as disruptive for their business models". (O-OSC manager #1)*

This reaction is understandable in consideration of the fact that the model is removing an important control mechanism for continued product sales. Data flow is closely attached to the work processes, thus if the vendors lose control of the data flows they also lose control of the work processes and applications attached to those data flows. The notion of this aspect touches the core of the vendors *anti-program*, and is further exemplified my one OSC operator manager:

> *"If I were the owner of a Service Company my goal would be to earn as much money as possible. I would have strived for a monopoly control of the market. How do you earn as much money as possible? The answer is to get into the core of the work processes of the operators. And what is in the core of the work processes? The data flow and the applications that are attached to those data flows". (O-OSC manager #1)*

The overall goal for the operators is to have full control, in any case, of the work processes and the tools and data flows that go with them. This implies if operators succeed with their strategy vendors must let competitors take their place at the choice of the operators. Due to the plug-and-play strategy, small vendors, with small niche products

Example - Epsis

Epsis is a technology company targeting the real-time asset management *market niche*, focusing on data-to-information systems and services. Being a fairly new actor in the O&G industry (since 2003) and consisting of a very small group (currently 17 engineers engaged) they are offering applications and services for real-time data management as well as new work processes that support these systems. *(Source: Epsis web site, www.epsis.no)*

Similar solutions are provided by a large number of actors in the industry, due to operators increasing needs on such services. Larger vendors, with considerably more experience, more manpower and economical vigour, have currently an advantage in this lucrative market niche. Still, a minor player like Epsis is able to attract clients such as Chevron, Hydro, Shell, NFR, Statoil and ABB. If a new standard is deployed in this industry domain, opening new opportunities for quick and easy vendor selection, minor vendors might have a greater chance of becoming a preferred partner in operations. On the contrary, those failing to integrate with the standard will vanish.

Table 3. Example of Epsis

(See Table 3) and limited recourses, that otherwise never would have been able to compete with large and powerful vendors, will equalize their competitiveness with the leaders of the industry.

6.2.2 Vendors: anti-program

The overall goal for any vendor, or any other company for that matter, is to sell their products to as many operators as possible. When a new standard is imposed that suddenly prevents the fundamental way of making money, it meets resistance. In other words, one of the major problems covering the operators desired consensus is that their strategies may disturb the vendor's business models. While the standardisation initiative group encourage actors to see this as a long-term investment, and strategic decision that gives profit over time, vendors are more concerned with loosing their competitiveness:

> *"Vendors are only cooperating on the surface of these initiatives. There are only involved so that they can observe the progress and make sure they are not missing out on anything" (O-OSC manager #1)*

The large vendors are well aware of the downside of greater competition. The question is: why are they contributing in the effort to make them successful? There are several reason, some are listed in Table 2 (see chapter 5.2): looking for new business opportunities, observing and monitoring competitors and the projects in which they engage, and maybe the most important one – making sure there is nothing going on that they might miss out on.

From a different perspective, it means that the vendors can spend more time on what makes them competitive in the first place, namely the development of applications, tools and technology, rather than using large resources on the effort of data transportation. This argument is elaborated in this statement:

> *"When a standard is established we can rewrite the applications once instead of customising them each and every time we go into an relationship with a customer. This will make the whole relationship with the customer much easier". (V-RT manager #1, PRODML project member)*

With the deployment of a standard the vendors are believed to save time in the deployment phase. From the their perspective there is too much work spent on doing repetitive tasks, which do not help developing technology in itself. On the contrary, vendors are profiting on this extra work, hence removing this extra work represent removing both the income of doing the work as well as exclusively providing the skill and ability to help the operators integrate their solutions. With the PRODML standard, operators will be able to do it themselves. Vendors are intentionally avoiding this notion, since their goal is to show the industry that they want to profit on superior technology rather than maintain their strategic advantages of sticking to their proprietary solutions. When confronted with this implication, a vendors representative decisively counters the argument with the following statement:

> *"All sales must be done in accordance with our work capacity. We cannot sell our software without calculating a considerable amount of man-hours spent on installing and integrating the solutions with the operators existing infrastructure. Without a standard our capacity will be strained". (V-RT manager #1, PRODML project member)*

Therefore, the bottlenecks are the time spent on getting the products to work with the already existing infrastructure used by the operators. The information provided by the operator might change slightly in the time span between when the contract is signed and the implementation starts, such that adjustments must be made to the products in order to make them work in the current situation. Furthermore, one engineer argue that standardisation will lower the risk of future projects:

> *"It will lower the total risk in the projects because we will be able to calculate how much time all connections will take to establish". (V-RT manager #1, PRODML project member)*

Operators are putting a pressure on vendors to integrate their applications and services. Simply put, they require that each and every application that is used in their present and future information architecture shall be modified to send and receive data in the same way. Building in support for WITSML and PRODML into their applications is not the worst part. As these standards continue to develop and requirements changes problems are getting more complicated:

> *"There might be a future situation where a request from an application will not be answered because of too loosely defined interfaces. Then we are back to the starting point where connections need to be customized". (V-RT manager #1, PRODML project member)*

Considering the above statement the expectations is not very optimistic regarding the pragmatic success of the standard. The reason why is because developers have a great deal of experience with integrating different ICT solutions – and they do not believe that no customizing will be necessary when the standard is "implemented". The fact is that customisation in most cases will be necessary regardless off the rigidness or flexibility of the standard, but the amount of time spent on customisation may be drastically reduced in *some* cases. The question previously asked on why the vendors are supporting this standardisation-race is partly because they need to be *up to date* on the emerging technologies, business opportunities and strategies as well as developing and maintaining their existing product portfolios.

7 Conclusion

Throughout this thesis I have investigated the development of an open standard initiative for data communication between organisations. I have elaborated the different actors, humans as non-humans, who have influenced and been influenced by the standardisation initiative, and tried to give an understanding of how the need for such standards emerges. Further, this thesis has given insight into how the concept of the standard got mobilised, found colleagues, created an alliance, and how it for the future will be able to convince the public by conducting the pragmatic test that is crucial for its survival. Also, it has been discussed the implications of the difference in interests that needs to be aligned for the standard to be translated into something else than a concept.

Initially I described the purpose of this thesis as to articulate the difficulties and critical success factors of open standards development. So, within organisational use of ICT - what does it take for PRODML to succeed in the long run? As I did for the discussion in chapter 6, I will answer this question in two parts: As for the difficulties of open standards development the alignment of interests is the key factor for the standard to survive. The program of each actor that is brought into the negotiation of the standard may initially seem to be aligned. However, as the specifications of the standard force the actors to look internally they are forced to articulate true value in what they do. Interests are difficult to align because the interests of one can disrupt the interest of others. I believe that in standardisation initiatives, like the one investigated in this thesis, one can never expect that the interests of all actors in a domain will be aligned, thus the flexibility of the standard should allow for some degree of customisation.

Concerning the critical success factors of open standards development, can these be identified from the example presented in this case? From the basis of Latour's cycle system, I find special interest in the aspect of enrolling allies and create public representation. The allies constitute the installed base and create credibility for the standard (Grindley, 1995). If the right initial players are enrolled they represent gatekeepers that can help the diffusion of the standard (Bowker & Star, 1999).

Finally, in my contribution from the basis of this thesis I asked if ANT could help for a better understanding of standardisation work and design. From what I have experienced in my research, for applying ANT as an analytical frame work for understanding my empirical data, and with the support from a large community of IS researchers (e.g. Bygstad & Rolland, 2004; Walsham, 1997; Monteiro & Hanseth, 1995; Hepsø, 2004) my answer would be positive. In this case, where the complexity of the domain under study is a barrier of its own, ANT gives us a language that can make us better equipped to articulate implications in standards design. ANT can help us in understanding and identifying the uniqueness of each standardisation initiative by looking at the woven fabric of humans and non-humans (Latour, 1991). Regarding this, I want to emphasise, as ANT suggests, that the inspiration for the standard is no more than an actor, giving an idea to a solution, and not a solution per se. It can only be viewed as an actor influencing the standard by being enrolled in the actor-network that constitutes the standard.

There is no such thing as an easy way to standardise a solution. However, an important step along the way is to acquire knowledge of how these processes should be performed, who should participate so that the standard can build credibility, trust and robustness. Most important of all, it takes hard work to keep the standard alive, that is, the links and knots that tie the whole network of heterogeneous resources together (Latour, 1999).

For future work I suggest that the aspect of "formal versus de facto" standardisation is investigated. What happens when a standard body takes custodianship of the standard, and after? Moreover, the alignment with other open standard initiative should be investigated.

8 List of references

Abbate, J. (1994) *The Internet Challenge: Conflict and Compromise in Computer Networking,* J. Summerton(ed): *Changing Large Technical Systems*, Westview Press, pp. 193-210.

Blackler, F. (1995) *Knowledge, Knowledge work and organizations: an overview and interpretation*, Organization Studies, 7:2 pp. 277-300.

Bowker G. C. & Star S.L. (1999) *Sorting things out: classification and its consequences*. Inside technology, Cambridge, Mass. MIT Press.

Bygstad, B. & Rolland, K. H. (2004) *ANT og Information Systems: En epistemologisk forelskelse*, Sosiologi i dag, årgang 34, nr. 2, 69-86.

Callon, M. (1991) "Techno-economic networks and irreversibility", In Law, John (Ed.), *A sociology of monsters: Essays on power, technology and domination,* (pp. 132-161). London and New York: Routledge

Cornford, T. & Smithson, S. (1996) *Project Research In Information Systems - A Student's Guide*. Macmillan information systems series, *PALGRAVE*.

Eckstein, R. & Casabianca, M. (2001) "*XML Pocket Reference, Second Edition*", Printed in the U.S, O'Reilly & Associates, Inc., Sebastopol, CA 95472.

Galliers, R. D. & Land F. F. (1987) *Choosing Appropriate Information Systems Research Methodologies, Communication of the ACM*, Volume 30 Number 11, pp. 900-902.

Gregovic, R. M., Foreman R., Forrester, D. & Carroll, C. (2005) *A Common Approach to Accessing Real-Time Operations Data: Introducing Service Oriented Architecture to E&P*. SPE Annual Technical Conference and Exhibition, Dallas, Texas, USA, 9-12 October. SPE 96441, Society of Petroleum Engineers.

Grindley, P. (1995) *Standards, strategy, and policy: Cases and stories*, Oxford: Oxford University Press.

Hanseth, O. (2000) *The Economics of Standards*, In: C. Ciborra (ed.), from control to drift, Oxford Univ. Press, pp. 56-70.

Hepsø, V. (2004) *On the role of Human and Non-Human Stakeholders in Design and Innovation – Socio-technical negotiation processes and paradoxes*. Presented at "European Academy of Management" St. Andrews Scotland, May.

Hepsø, V. (2006) *When are we going to address organizational robustness and collaboration as something else than a residual factor?* Intelligent Energy Conference and Exhibition, Amsterdam, Netherlands, SPE 100712, Society of Petroleum Engineers, 11-13 April.

Holt, J. Haarstad, I. Shields, J.A. James, J.P. & Seiler D. (2002) "WITSML: Technology to Business (T2B) for the Oilfield." IADC/SPE Drilling Conference – February.

Klein, H.K. and Myers, M.D. (1999) *A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems*, MIS Quarterly, vol. 23, no.1, pp.67-93.

Latour, B. (1987) *Science in Action*, Cambridge: Harvard University Press.

Latour, B. (1991) "Technology is Society Made Durable", In Law, John (Ed.), *A sociology of monsters: Essays on power, technology and domination* (pp. 103-131). London and New York: Routledge

Latour, B. (1999) *Pandora's Hope: Essays on the Reality of Science Studies,* Cambridge: Harvard University Press.

Monteiro, E & Hanseth, O. (1995) "Social shaping of information infrastructure: on being specific about the technology". In Orlikowski, Wanda J., Geoff Walsham, Matthew R. Jones and Janice I DeGross. *Information Technology and Changes in Organizational Work.* Chapman & Hall, p.325 - 343.

Monteiro, E. & Hanseth, O. (1999) *Developing corporate infrastructure: implications for international standardisation.* In: Kai Jakobs and Robin Williams (eds.). *Proc. from Standardisation and innovation in information technology (SIIT '99),* pp. 75 – 79.

Monteiro, E. & Hanseth, O. (1998) *Understanding information infrastructure*. (forthcoming manuscript for book, Manuscript 27. Aug.)

Monteiro, E. & Hepsø, V. (1998) Diffusion of information infrastructure: mobilization and improvisation, In Information systems: current issues and future challenges, TJ Larsen, L Livine and JI DeGross (eds.), IFIP, pp. 255-273.

Nonaka, I. & Takeuchi, H. (1998) "A theory of the firm's knowledge-creating dynamics", in A.D. Chandler jr, P. Hagstrøm and Ø. Sølvell (eds): The dynamic firm, The role of technology , strategy, organisation and regions, Oxford University Press, pp. 214-241.

Rolland K. H. R. (2003), Re-inventing information infrastructure in situated practices of use. An Interpretive Case Study of Information Technology and Work Transformation in a Global Company. http://www.idi.ntnu.no/emner/it3010/.

Suchman, L. A. (1987) “Plans and Situated Action – The problem of human machine communication. Cambridge: Cambridge University Press.

Tatnall, A. & Gilding, A. (1999) *Actor-Network Theory and Information Systems Research*, Proc. 10th Australian Conference on Information Systems. http://www.vuw.ac.nz/acis99/Papers/PaperTatnall-069.pdf

Walsham, G. (1995) *Interpretive case studies in IS research: nature and method*. Eur.J. Inf.Systs., Vol. 4, pp 74-81.

Walsham, G. (2001) “Knowledge management: The benefits and limitations of computer systems”. *European Management Journal*, 19(6), 599-608.

Walsham, G. (1997) "Actor-Network Theory and IS Research: Current Status and Future Prospects," in: *Information systems and qualitative research,* A.S. Lee, J. Liebenau and J.I. DeGross (eds.), Chapman and Hall, London, 1997, pp. 466-480.

OLF – Work Group Quality Information. “Quality Information Strategy for Integrated Operations on The Norwegian Continental Shelf”. Oljeindustriens Landsforening, http://www.olf.no/io/digitalinfrastruktur/?29218.pdf, Last visited, 01.06.2006

Ward, R. (2005) “Can E&P Standards Success be Predicted?” (Draft) November, CERA, http://www.cera.com.

Blaker, J. (2005) “PRODML scope statement version 2.0”, Content Team, ed. J. Blaker 2.0, October. PRODML web site, http://www.prodml.org (guest account, required)