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Hierarchical Model of Problems in Implementing Information Systems

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Abstract

There is a lot of literature about implementing information systems and numbers of papers describe failures and successes in implementations. Problems impede successful outcomes of information system projects, influencing e.g. on the interaction between project parties or on the learning process, slowing it down and killing time. Problems in implementing information systems are connected with risks and accident models can be used to describe causes of failure. This paper describes how a hierarchical accident model is a suitable framework when modeling information system failures. This study presents findings in literature and empirical experiences concerning problems. The empiric case comes from the university world where several universities acted as one client, taking into pilot use a common information system to support student mobility between the universities.

Keywords: Obstacles, Risks, Accident models, Information system, Implementation

1. Introduction

The implementation of an information system (IS) is a process that very likely leads to failure instead of success (Lyytinen and Hirschheim 1987; Lyytinen and Lehtinen 1987; Sauer 1993; Kumar et al. 1998; Schmidt et al. 2001). This paper presents how using the hierarchical framework introduced by Leveson (2001) a new approach can be found. The obstacles or problems which are found in the empiric case are presented using a model which is not commonly known in the context of information systems.

This research pays attention to findings in literature and in a case where an IS was implemented (Halonen 2004a). It concentrates on the obstacles impeding the success of the implementation project and considers obstacles and risks being related to each other. Therefore the authors offer methods to help identifying obstacles and risks that are related to implementation projects. By using the Hierarchical Accident Model introduced by Leveson (2001) the problems are presented in three levels. This model was originally developed to analyses of accident causation. We suggest that the model can also be connected with problems and thus help in recognizing and managing them.

This paper proceeds as follows. The next chapter introduces literature related to implementing information systems. After that, the accident models are described. Then we describe the research methods and study material, following with the case description. Combined results come next, constituting the main results of the research. This paper ends with conclusion.

2. Related Literature

There is a lot of literature concerning implementing information systems. This paper considers implementing information systems as Laudon and Laudon (1988) defined it: "All

organizational activities working toward the adoption, management, and routinization of an innovation". Developing and implementing an IS are instances of organizational change (Davis and Olson 1985) and they often lead to changes in work processes and structures of the personnel (Eason 1988; Sahay and Robey 1996). As Lorenzi and Riley stated (2003), all shortcomings that impede successful outcome lead to stress and change-resistive behaviors. Literature recognizes success factors and measures that are useful when evaluating the success or failure of an IS project (Lucas 1981; Markus 1983; Lyytinen and Lehtinen 1987; Kumar et al. 1988; DeLone and McLean 1992). Therefore, we present here some issues which are seen as obstacles: conflicts, social dynamics, lack of knowledge or lack of sharing it, user participation, management problems, resistance to change and, commitment to an IS project.

Conflict literature discusses recognizing conflict and preconditions for managing conflicts (Bodtker and Jameson 2001). According to them, recognizing an increasing conflict in the relationships between project people demands that the emotions of the people involved are identified and thus the possibilities to manage the conflict are better. Barki and Hartwick (2001) deliberated how conflict management and the level of interpersonal conflict affect outcomes of IS projects. They proposed five models to manage conflicts: asserting, accommodating, compromising, problem solving and avoiding. These models seem natural to be used also in the current research. Newman and Robey (1992) represented a social process model to guide research in the social dynamics of system development. Their model described episodes and encounters involving both the users and the designers, and because of the altering situation interaction between the parties, the model proved to be dynamic. The experiences of the authors of this paper show that the encounters between project parties seem to act in the same way.

Mumford (2003) expounded on solving problems by understanding social dynamics of the problem and identifying pressure points. Mumford (2003) continued by clarifying that it is no use removing symptoms instead of causes. She added that lack of knowledge hinders the problem-solving process in the beginning, when clarification and description of the problem are important. Lack of knowledge is emphasized also in the article of Ljungström and Klefsjö (2002) who studied obstacles in implementing a strategy of a total quality management (TQM) system. They described obstacles as "barriers and hurdles obstructing the flow of activities and changes in behavior, which are ultimate aims in the quest for an organization's improvement". Ciborra and Andreu (2001) discussed knowledge related to organizational context. They believed that managing knowledge differs in different organizational contexts.

The role of user participation in IS developments and implementations has been under discussion (Markus 1983; Markus and Benjamin 1996; Sahay and Robey 1996; Kumar et al. 1998; Cairns and Beech 1999; Dewulf and van Meel 2002; Jiang et al. 2002; Mumford 2003). Newman and Noble (1990) described in a case study that the contribution is not always evident and that the user participation is only weakly associated with the success of implementation. User participation can be also seen as a security threat and therefore user participation may be rejected in IS projects (c.f. Siponen 2002). On the other hand, user participation can bring expertise and know-how to the project and it may be essential in cases when the designer is not familiar with the branch (e.g. Halonen 2004b).

Benamati and Lederer (2000) discussed the management problems in information technology changes. They raised the challenges in front and point to information technology acquisitions and implementation processes. Lyytinen and Lehtinen (1987) concluded that basically all

problems in information systems development can be blamed to derive from technical problems. This can be seen as level one or three problem in the hierarchical accident model. On the other hand, Griffith and Northcraft (1996) found that less than 10 percent of implementation failures stemmed from technical problems and most of them occurred because of human and organizational reasons, including users' misunderstanding of the technology.

Macri et al. (2002) presented a grounded theory for resistance to change and express that resistance to change can lead to reduced co-operation in an organization. According to them resistance to change is linked with organizational and shared learning. By hindering shared learning the members in the organization guard their personal knowledge and gained experience. Lorenzi and Riley (2003) emphasized the need of effective management of resistance to change and to turn resistance into commitment.

Commitment to an IS project work has been recognized as a success factor (e.g. Lucas 1981). Newman and Sabherwal (1996) studied commitment in their longitudinal study and they found that the level and changes in commitment are significant factors in the project. According to them, erratic commitment can increase the loss in the IS project e.g. when management level does not want to get rid of a project that is failing.

According to Lorenzi and Riley (2003) shortcomings in project management, technology and organizational issues turn to be main causes for problems, added with information explosion. They raise three sets of skills that are needed in order to avoid problems: 1) technical skills, 2) project management skills, and 3) people and organizational skills.

According to Effron (2004) there is no incentive to share knowledge, meaning that people are busy with their tasks even without the need to write their knowledge to any databases. Effron (2004) continued that learning to share knowledge needs overcoming cultural obstacles. Culture and social background has its impact on changes in organizations and implementing new technology (e.g. Noble 1986; Walsham 1993; Halonen 2004c).

In addition, it is not always self-explanatory if an IS project is a success or failure. According to Sauer (1993) an IS development project is a failure when the management terminates it. Larsen and Myers (1999) discussed what if an information system turns to be a failure even if it was already evaluated to be successful. Halonen (2004b) described an implementation project that seemed to be a failure but instead it might have been a step forward in the technological progress in that environment.

3. Framework

This research was carried out in order to find out how the obstacles in implementing information systems could be assessed. Furthermore, the study expresses how the means of risk management and accident investigation can be used in managing obstacles. Accidents models are used to explain how and why accidents occur and what events or circumstances are behind accidents.

A well known accident model is the domino model where Heinrich (1931) proposed that accidents are caused by people, not matters. In his model, there are five dominoes: 1) An ancestry or a social environment which leads to 2) the fault of a person, and is a proximate reason for 3) an unsafe act or a condition and it causes 4) an accident that leads to 5) an injury or losses. When the first domino falls, all other dominoes will fall down too. If any of the

dominoes will be removed, it will break the sequence and prevent injury or losses. The first falling domino is treated as an initiative event and it is a stopping point in tracing back what has happened. In Heinrich's model this event was considered to be some kind of human error or a component failure. Even no failure happens also number of "it-was-close" situations can be meaningful. These indicate exposure to risk even no loss has occurred. By analyzing these events we can be more aware of risks exposure.

Civil Aeronautical Board (1962) introduced "multi-linear-events sequence" model where several parallel chains of events are created based on data from a flight data recorder. This was one of the first methods that used several parallel event chains to explain causes of accident. Implicitly this means that there might be several obstacles or event sequences, which can not cause harm by them selves but all together can cause significant failure. In US National Safety Council Model (in Leveson 1995, 191) was one important discovery. Its basic is close to the domino model but just after immediate factors of accident there is a "Point of No Return". McClay (2003) used a term "Point of Irreversibility". When this point has been reached some measurable losses or failures will come up. Before that there is a way to prevent losses and go back to the normal action.

The Domino and some related process models have been criticized because most accidents involve variety of events and conditions. Identifying only a single factor as a root reason for accident is misleading and can be a hindrance in preventing future accidents. E.g. Lewycky (1987, 6-8) criticizes that we often isolate one condition and call it "the cause" and other conditions that are "contributory" to the basis for these distinctions are not found. Also Leveson (1995, 56) argued that most accidents in well-designed systems involve two or more low-probability events occurring in the worst possible combination and major accident often stems to flaws in security culture or society and organization Leveson (1995, 53). Especially overconfidence and complacency (which is common element in major accidents) are typical. This means that a single event seldom is a real cause to an accident or there simply is not such a single event which can start a chain of accidents - there might be several parallel or nonparallel events which might start a chain of accidents.

Sometimes accidents may be prevented most effectively not by eliminating direct causes identified by the chain of events, but by indirectly manipulating other factors. The hierarchical accident model (Lewycky 1987, Leveson 1995, Leveson 2001) provides multiple models of accident causation at different levels of abstraction. In the three-level model (Figure 1) the lower level describes the accident mechanism (the chain of events). The second level includes conditions or lack of conditions that affect to the occurrence of events at the first time. Factors in the third and the highest level, sometimes called root causes or systematic factors, affect general classes of accidents. They are weaknesses of technical, human, organizational, managerial, or social nature that not only contribute to the accident being investigated but are likely to affect classes of accidents in the future. Often responses to accidents involve fixing only a specific condition while leaving the general systemic factors untouched. Countermeasures aimed at preventing accidents described by hierarchical models require making changes at all levels, particularly the systematic factors in the level three.

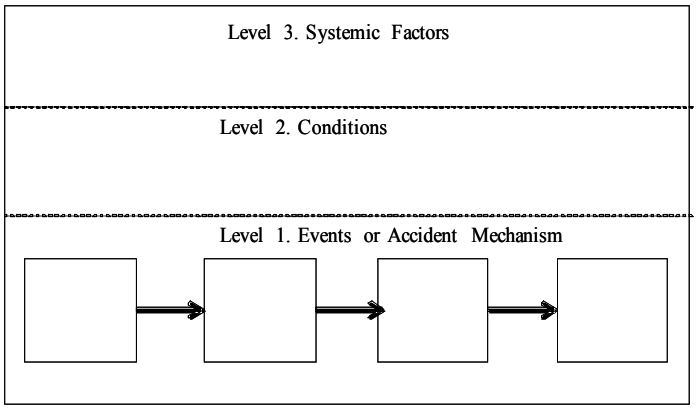

Figure 1. The Hierarchical Accident model (Leveson, 2001, 9).

According to Leveson (1995, 47), large scale engineering systems are more than just a collection of technological artifacts: They are reflections of the structure, management, procedures and a culture of an engineering organization that created them and they are usually a reflection of a society where they were created and used. Causes of accidents are frequently, if not almost always, rooted in the organizations - their culture, management, and structures. Also Rasmussen (1997) emphasized this. An IS implementation success has several analogies to accidents that happen in large and complex systems. In both cases usually no single cause of failure can be named as a cause but rather a sequence of several events which together finally cause losses or failure.

4. Research Method and Study Material

Action research is argued to be ideal for studying information systems in practice (Baskerville and Wood-Harper 1998). A combination of action research (Schön 1983; Ayas and Zeniuk 2001) and public reflection-in-action (Heiskanen 1995; Raelin 2001; Mason 2002; Coghlan and Brannick 2003) has been chosen as the research method because of the strong involvement of the first author and the participants in the empiric case. There has been discussion about action research having several different forms (e.g. Baskerville and Wood-Harper 1998) and this study at hand performs action research without recognizable cyclical process.

According to Mason (2002), at the heart of all practice lies noticing: noticing an opportunity to act appropriately. To notice an opportunity to act requires three things: being present and sensitive in the moment, having a reason to act, and having a different act come to mind. Furthermore, an academic actor-researcher (Lallé 2003) as a concept belongs to this study by meaning researcher working in an organization and generating new scientific knowledge. Ayas and Zeniuk (2001) emphasized "effective collaboration between academics and managers, thus benefiting both practice and theory, enhancing the significance of research, informing both practitioners' and academics' views and actions".

The research presents findings from literature and from a case study. It is essential that the case offers possibilities for learning and getting better understanding about implementations in different environments (Stake 2000) and therefore it is a pertinent choice in this paper. According to Yin (2003) "using case studies for research purposes remains one of the most challenging of all social science endeavors". The case is reported by bearing the idea of van der Blonk (2003) when he stated that cases are written with a purpose that heads to the goal

of the research project. He continued that the researcher is interpreting the case when writing it down. The case is described in detail enough in order to give a good understanding of the environment and to help the reader to get a view of actions that were performed.

The case comes from the university world where several universities were involved as one client and designing and implementing one IS to support the management of student mobility. This case is an intrinsic case (Stake 2000) offering diversified environment with several interest groups and project parties. The empirical material is gathered from the memos and memorandums from meetings and encounters, and from the personal observations made by the first author. Van Maanen (1988) remarks that field data are constructed from talk and action and thus they are interpretations of other interpretations and that they are mediated many times. Van Maanen continues that case studies are presented with differing styles. This paper presents the case realistic, pointing critically out some issues that behave like obstacles.

Like Coghlan and Brannick (2002) suggest, the researcher has written a personal diary during her working in the case. In qualitative research studies the benefit of diaries is realized when writing out the cases (Newbury 2001). The purpose of personal notes is to facilitate the research process through recording observations, thoughts and questions when they happen to be used by the researcher (Newbury 2001). The approach is subjective and reflecting on the past of the researcher, relying on the remarks of Frankl (1963) when he states how our experiences and past have made us what we are. In this sense the approach is also interpretative (Walsham 1993) because the approach is very subjective, the observations and findings reflecting strongly on our personal presence. Mason (2002) states: "Writing autobiographical and other notes, keeping a journal, and mentally re-entering salient moments can assist professional development and be integral to research".

5. Empirical Findings

The case comes from the university world where several universities were involved as one client and designing and implementing one IS to support the management of student mobility between Finnish universities. It is expected that the movement increases multiply during the following years. The first author was working as a project manager in a project that produced an IS project called MoSu. It was based on a previous effort when specifications and a demonstration model of the user interface for the new IS were made by other actors during preceding years. In the first phase MoSu was to be piloted by three universities in the Helsinki metropolitan area but the use will be extended to be nationwide in the following years. In addition to the universities, the Finnish Virtual University (FVU) participated into the project. Other main stakeholders were two vendors and the Ministry of Education that funded the project. The vendors began their work on the basis that MoSu will cover the whole process of student mobility between universities.

The MoSu project had started in very versatile circumstances where the specifications and plans had changed along the time and some specifications were not completed because of the lack of resources in previous years. Changes in the personnel necessitated knowledge sharing between the former project personnel and the current personnel. Because the administration of the mobility differed in every university, the three universities pointed out the importance of piloting while the FVU emphasized the importance of getting a nationwide IS. Discussion continued when the FVU announced its new project FlexStu that was to serve students nationwide in applying for rights to study in other universities. This project seemed like a competitive project for MoSu and it surprised all other participants in the meeting. Steps were never discussed openly and the competition between these projects had reverberated to all

encounters and meetings of the MoSu project. The changes in the requirements had given extra difficulties to the vendors (and the project manager) to understand the scope of MoSu because FlexStu was to implement the first steps in the mobility support.

The user authentication and user administration will be one of the crucial tasks to be catered before MoSu would have access to the information systems in different universities. The knowledge sharing between FlexStu and MoSu appeared to be problematic; one vendor owning the information concerning FlexStu and the other vendor having main responsibility of carrying out the new IS. Holding knowledge has been evident, slowing down the co-operation between vendors and inflicting on discussions and meetings. Then again the role of FlexStu was changed to implement a uniform application and to give extensive information about studies in other universities.

The nature and amount of information that were discussed in the project meetings seemed to appear problematic. The representatives of student affairs offices were not interested in technical details but the technique was important when e.g. the processing rules of applications had to be specified and decisions made. The vendor tried to explain everything in depth in order to help the officials from student affairs offices to understand the functions. There were problems with the information in two ways: there were too much technical information addressed to wrong people and there were insufficient information delivered between the experts.

Culture and social background as well as economical competition may also be an obstacle when they appear like impeding the implementation process. The case has shown that working in a university world has been free and there is not much power of commands. This means that things will be done when somebody feels them important – not because someone else tells to do them. In this sense freedom can be seen as an obstacle when it is preventing the performance of work and commitment to common goals.

In February 2004 the financier arranged an information seminar that was addressed to the directors of EDP offices in universities and polytechnics. The aim of the seminar was to introduce MoSu and FlexStu as being a common intent in supporting the student mobility. This seminar made visible the overlapping role of the two projects. These actions proved the problem with overlapping in projects and their influence on each other. The overlapping was not preventing the whole implementation of MoSu but it was really hindering the designing of it. At the beginning of the collaboration between the FVU and the MoSu project there appeared to be competition about the tool to be used.

The implementation has proceeded to the piloting phase and so far the case expresses four interesting obstacles: several parties involved, disputes over focus, overlapping projects, power game between project members. In this case the obstacles were related to each other, affecting on the implementation and impeding the progress.

6. Combined Results

This paper introduces a model to be used when managing obstacles that may appear in implementing information systems. The model is developed for analyzing accident causation at different levels of abstraction. However, the authors believe that also IS implementations will gain from the hierarchical accident model introduced by Leveson (2001).

When using hierarchical accident model, findings from previous IS literature (Table 1) mostly seem to belong to levels two and three. This supports assumptions made by Leveson (2001), Lewycky (1987) and Rasmussen (1997) that failures are not primarily caused because of direct event sequence but because of poor conditions and systematic factors and obstacles in social, cultural, organizational and technological level.

	Authors(s)	Found obstacles
Level 3 Systemic factors	Noble 1986, Walsham 1993, Halonen 2004c Newman and Robey (1992), Griffith and Northcraft (1996) Macri et al. (2002), Lyytinen and Lehtinen (1987) Lorenzi and Riley (2003)	Inappropriate culture and social background, Social process episodes Users' misunderstanding of the technology, Technology itself Resistance to change and structural inertia, Poor change management
Level 2 Conditions	Bodtker & Jameson (2001), Barki and Hartwick (2001), Ljungström and Klefsjö (2002), Mumford (2003), Ciborra and Andreu (2001), Effron (2004) Markus (1983), Markus & Benjamin 1996, Sahay & Robey (1996), Kumar et al. (1998), Cairns & Beech (19999, Dewulf & van Meel (2002), Jiang et al. (2002), Mumford (2003). Newman and Noble (1990), Siponen 2002 Benamati and Lederer (2000) Newman and Sabherwal (1996), Lorenzi and Riley (2003), Lucas 1981).	Conflict with emotion Lack of knowledge, Poor knowledge sharing Inactiveness Poor user participation User participation as a manipulative tool Poor user contribution, User participation as a security threat Unsuitable technology Erratic commitment Poor decision making process
Level 1 Event chain	Benamati and Lederer (2000)	Outdated technology

Table 1. Summary of review of IS success literature categorized to hierarchical model.

In case there is no understanding between different parties the interaction can severely be aggravated. It may lead to difficult problems in continuing the implementation but at least it will impede the interaction and discussion in the project.

From the experience gained in this case, the authors believe that the impeding problem in collaboration may lie in the role of the different parties. E.g. the character of the FVU differs from the roles of the universities. The FVU is not a "real" university but a virtual one and its main task is to promote and develop networking among universities. MoSu is very much networking and it might be that the main reason for discomfort in collaboration roots into power game about owning the networking and mobility between universities. The case highlighted holding knowledge as an obstacle, preventing the building of collaboration between vendors and slowing down the requirement specifications that were dependent on the lacking knowledge. Holding knowledge can be related to working culture – if the working

culture does not support writing memos from meetings, a lot of knowledge remains undistributed.

The role of interaction rises in this study. The case showed that with sufficient interaction overlapping in work could be decreased. It seemed that there were intentional lacks of knowledge sharing and removing them appeared difficult to manage. The interorganizational "learning ladders" introduced by Ciborra and Andreu (2001) were not taken into use. The authors believe that the responsibility of sufficient interaction belongs to the project manager and she should be able to perceive the lack and insufficiency of interaction. The lack on perceiving can hinder the implementation process but when handled in time it probably will not torpedo the implementation.

Some of the recognized obstacles can be classified as organizational obstacles. One obstacle appeared bigger that any other – overlapping projects – and it can be managed only by organizational maneuver. Managing two overlapping projects so that overlapping will disappear, demands organizational skills and ability. In a sense choosing project manager is also an organizational issue but possible shortcomings may be cured by increasing social capabilities.

Misunderstanding and lacks of interaction are phenomena of deficiencies in social capabilities among project participants. Wrong sort of information can affect as an obstacle. The officials were not interested in what technical way the application form is managed in the IS. The most important issue appears to be lack of noticing. Without noticing it is not possible to increase interaction or discussions between project parties. Noticing is needed also in order to change own attitudes or feelings in encounters. Without noticing misunderstanding it is not possible to increase understanding or build collaboration between project parties.

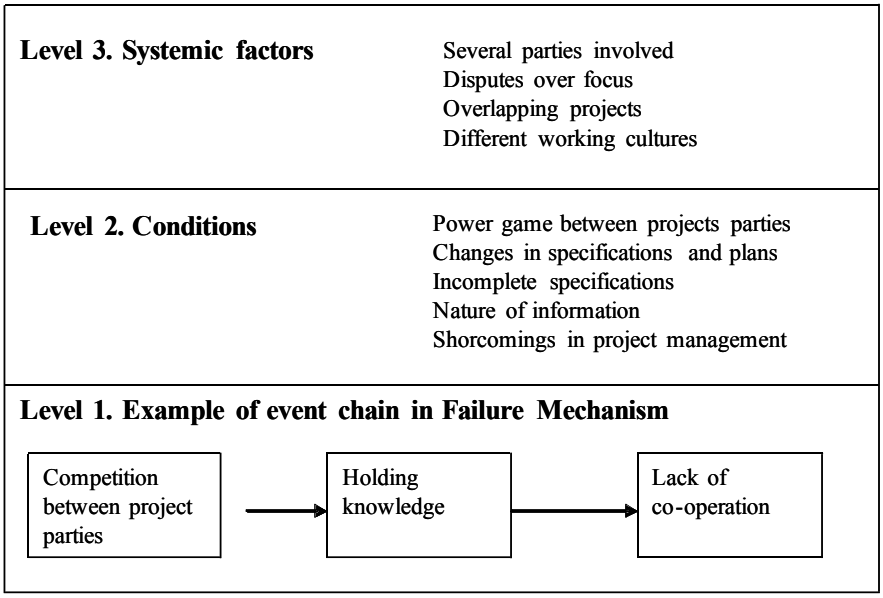

Figure 2. Hierarchical Model to define obstacles in information system implementation. Adapted from Leveson (2001).

Figure 2 presents the obstacles from the case categorized in three levels: systemic factors, conditions and events. This model gives understanding to the relations between obstacles

placing them into their contexts. It offers a direct, quite well identified process (people, technique, etc.) which had lead to negative situations. This process is depending on circumstances and conditions (e.g. poor management, resources, decision making process, and poor information) where it acts. Circumstances depend on society (or any other large system where it acts) with poor education, general technology failures, inadequate laws, instructions, human behavior etc. The authors have shown that a model designed for risk management can be used also when managing obstacles in information system implementation. Like analyzing risks it is useful to use models when analyzing obstacles. Managing problems and obstacles will benefit from the model introduced by Leveson (2001).

7. Conclusion

The hierarchical framework introduced by Leveson (2001) gives a new approach that is not used in information systems field. When using it in IS success research, categorization of obstacles and risk factors comes clearer. The tree-tiered hierarchical model is near to Bateson's communicative system and its use as framework in the study by Star and Ruhleder (1996), although point of view differs. This model has also benefits in IS implementation risk management when selecting suitable methods and controls. Anyway, this demonstrates that the model needs some improvements.

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