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Organizational Knowledge as a Basis for the Management of Development Projects

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Abstract: *This paper presents conclusions from longitudinal case studies on the industrial development of complex systems. The approach is to investigate whether the traditional document based development model can be replaced by on model built upon shared understanding in teams. The need for and use of supporting tools are also discussed*

1 Background

Product development companies, in particular in the IT area, are facing a tremendous challenge today. The environment is changing dramatically: information is exploding in a true global world, the world is becoming more complex, the workforce is becoming more volatile, the speed in product development is steadily increasing, and innovation is becoming a major marketing weapon. In response to these environmental changes, new strategies for project management have to be coined, and these strategies have to be reflected in engineering education as well.

Traditionally, in industrial product development, the total project is decomposed into phases. The result from one phase, a deliverable, normally a document of some kind or a system component or a prototype is passed to the phase(s) to follow. The contents of the "phases" and the format of the documents are often prescribed in standards or corporate guidelines. This metaphor, where knowledge or understanding is packaged into documents, has been a cornerstone for our educational systems as well as for organizing engineering or social development projects. It is assumed that the understanding once achieved by the author(s) of the document will be transferred to its reader(s).

Due to requirements on increased flexibility and reduced lead-times, focus has shifted from the static or "canned" type of knowledge, towards an emphasis on capability and understanding. General complexity and globalization imply a shift in paradigm from the skills of the individual designers or "inventors" to shared understanding in teams. This understanding must also become part of the organization's persistent capability. We will refer to this combined organizational capability as organizational knowledge, which must evolve as the circumstances impacting the company change.

In a research project we have performed longitudinal studies on the generation and management of new understanding in industrial development projects [1]. We will present our findings and describe strategies for the management of development projects based on organizational knowledge evolution aspects. Two arenas will be discussed the development of microwave ovens at the Whirlpool company [2], and the development of telecommunication systems at the Ericsson company [3]. In the Whirlpool case the development organization is small enough, even if distributed over four continents, to enable a study of how new development methods and new approaches in management are propagated in the organization. It has been possible to focus on what happens at the individual and at the small group level in the very early phases of a development project. At Ericsson the systems developed and the development organization are so big that the major problem is the coordination of the development in the different groups, the management of the understanding achieved, and how to make this understanding globally available, and merged with and adjusted to findings in other groups. Hence, in the Ericsson study we have been focusing on the management of the artifacts of the organization. The original approach of our research effort was based on the findings in a long-term case study at CelsiusTech Systems [4].

Our conclusions on how to organize the development of complex systems are quite different from what can be found in textbooks and standards. Hence we will regard our campus as a third arena, where we are trying to prepare our engineering students for the new problems in the real world [5].

2 The Whirlpool Arena: Impact on Industrial Projects in the Microwave Oven Business Unit

2.1 The Whirlpool Context

The product development groups at Whirlpool, Microwave Oven Business Unit, are distributed. The core and the management are located in Norrköping, Sweden, but there are also units in China, U.S., and Brazil. In our project we have been working with the Norrköping unit. We have been observing meetings, reviewing documents, and interviewed persons at different levels. However, the effort has also been action-oriented. At four lunch-to-lunch workshops we have brought attention to some new aspects:

- *Organizational Learning as a Strategy to Support Advanced Industrial Development. Sept. 1998.*
- *Creative Design and Development in a Team. Knowledge, understanding, and learning – motivation, involvement, and cooperation from an industrial perspective. April 1999.*
- *Creativity and Motivation. From Synapses and Neurons to Microwave Ovens and Telecom Systems. Nov. 1999.*
- *Enabling Flexibility and Creativity by Means of Distributed Learning. April 2000.*

The focus on creativity and understanding comes from the observation that the difficulties and problems in the development were related mainly to the early phases, the ideation and conceptualization. The major problem was to understand what to do and why. That's where time was lost.

Another observation was that in particular the development engineers were not very comfortable with the uncertainty in the early phases. They expected somebody else to state the problems precisely, as they were used to in their education, and when they had found a solution, they wanted to proceed to the next problem rather than to motivate their design and have the solution questioned. As the understanding needed in the early phases is of a holistic character rather than a narrow restricted one, there was a clear conflict between the real situation and the expectations of the engineers. They had to improve on team understanding and teamwork in general.

The situation in the white-goods sector is highly dynamic, even if not to the same degree as in the IT area. The environment is changing dramatically: information is exploding in a true global world, the world is becoming more complex, the workforce is becoming more volatile, the speed in product development is steadily increasing, and innovation is becoming a major marketing weapon.

Early on we stated that the new models and strategies should be based on shared understanding with little support from documents. We wanted to force the development teams to sharpen the shared understanding, and steer them away from documents. The documents should support the understanding process but not be the heart of it. The documents should have the same catalytic effect as has the written exam for the undergraduate student or the thesis for the graduate. The main result is the understanding in the head of the person, and not the mere text on the paper.

2.2 Inspiration from Philosophy and Psychology

Our approach has been to use basic concepts from philosophy and psychology and apply strategies and methods in the real environment in an experimental fashion. In search for the key elements of the knowledge creating system we stated that, most likely, the most fundamental way to look at knowledge would be to consider the *basic aspects* of a human being:

- The *feeling human being* (no fear, no shame)
- The *thinking human being* (logical and with insights),
- The *believing human being* (truth, false)
- *Human action* (behaving)

and to consider the fundamental, and relevant, *needs* of the human beings, Maslow [6]:

- *Safety Needs* (protection from elements, security, order, law, limits, stability)
- *Belongingness Needs* (work group, family, affection, relationship)
- *Esteem Needs* (self-esteem, achievement, mastery, independence, status, dominance, prestige, managerial responsibility)

- *Cognitive Needs* (knowledge, meaning)
- *Self-actualization* (realizing personal potential, self-fulfillment, seeking personal growth and peak experience)
- *Transcendence* (help others find self-fulfillment and realize their potential)

The philosophers whose thinking have guided the work are:

- *Plato* - Powerful questions in dialogues
- *Wittgenstein* – Language sets the limit for our thinking
- *Popper* – Critical rationalism

The growth of organizational knowledge can be summarized in the following way, Senge [7]:

- *Mental Models:*
  New ways of thinking on design as a guessing and correcting process
  I am not my job; ideas and solutions can be criticized without simultaneous critique of the individual
- *Shared Visions:*
  Strategic Intent
  Goals which initially can not be planned for
- *Personal Mastery:*
  Methodologies
  ”The problem is…”
- *Systems Thinking:*
  Weekly build (from Microsoft’s Daily Build [8])
- *Team Learning*
  Dialogues
  Different team composition during the product creation process

2.3 Description of New Knowledge

Popper based his *critical rationalism* on his conviction that we can never be completely sure about a certain hypothesis. We can never find arguments, which guarantee that it is true. For this reason, we have to challenge the hypothesis as brutally as we can, and the more challenge it withstands, the more we can be sure it is valid. The more tests it can withstand, the more we can trust it.

Assume we have invented a new feature in a new product, can we use our existing knowledge about the customer to predict satisfaction? We can, to a certain degree, but we can never be completely sure, unless what we thought was a new feature, in reality was an old one, from which we had real experience. So what do we do? Our only possibility is actually to go to a *customer focus* group and observe the reactions to our hypothesis.

Plato means that knowledge is gained through understanding, which would mean that understanding is a means to an end, not the end. And understanding is facilitated when the connection between the new and the known is clear. And this connection can best be made in a dialogue.

Wittgenstein argues that our language restricts our thinking, and that many problems are problems because the language deceives us.

2.4 Results Achieved at Whirlpool

New skills and capabilities ithin the group of development engineers within Whirlpool are difficult to measure or quantify. *However, it is quite clear that* the ability to handle uncertainty has been improved considerably: “We focus quickly on the real problem at hand”.

New management strategies has been developed and successfully used:

- *Socratic Leadership*
- *It is OK to be creative*

The establishment of a *creative and innovative culture* has been part of the effort

- *Yes, and...*
- *Creative sessions with problem based methodology*

A team based *planet organization* has been introduced [1].

The work has been recursive, *i.e.* the approach to developing the new model mimics the approach the new strategies will be based on, and both are evolving from the new knowledge created. And the entire

Development department was involved in the creation of the new knowledge, through ”lunch-dialogues” and mini seminars, with groups of 8 to 10 people.

A new product development system with a set of project management strategies has been created. These strategies have already been put in use with extraordinary results.

3 The Ericsson Arena: Impact on Global, Large Scale Product Development Projects

3.1 The Ericsson Context

For many years, Ericsson has developed its products according to the waterfall model. This model, which consists of sequential phases, prescribes that a number of documents are written and reviewed in each phase. This model worked well in the traditional telecommunication world since the market was stable and predictable. This is no longer so. Therefore, during the last four years, Ericsson has begun to turn this traditional model into some variant of an incremental development model where the total project is divided into smaller, controllable steps, which can each be individually tested and verified. Furthermore, the rapid advances in information system development has made it possible to manage information in new and innovative ways, where documents are complemented with more sophisticated and elaborated ways of capturing and maintaining information.

The transition towards the new way of working is not an easy task. The changes needed are so fundamental that it makes sense to talk about a new development *paradigm* for Ericsson. Some problems that must be considered are:

- *How do we formalize the incremental development model?* What components does it consist of and how are they related?
- *How is the model deployed in the organization?* Is the best way to do it as a central, corporate initiative, or should it first be tried out on a small scale? This problem is particularly relevant for Ericsson since this company consists of a number of highly independent, globally distributed development companies.
- *How is an understanding about the new model to be achieved among the members of the organization?* For example, many thousands of designers are acquainted with the traditional waterfall model. Somehow, these designers must evolve their current state of knowledge.
- *How will ongoing, traditional development tasks collaborate with the task run according to the new model?* Projects at Ericsson are mostly large (some span several years) and globally distributed. When deploying a new development model, there will be both new and traditional models involved in a project.
- *How is the new knowledge going to be institutionalized in the organization?*
- *How are the information management systems in the organization going to be restructured?*

As can be seen, these transition span many areas such as the development strategies, individual- and shared understanding, organizational capability persistence, information management policies, etc. This enterprise has to be undertaken in a situation where organizations, markets and technologies constantly change. Obviously, the risk of failure is imminent unless we have a clear strategy for how to solve these problems. Our approach is to base this strategy on a particular view on organizational knowledge evolution.

3.2 Organizational Knowledge - Definition and Strategy for Evolution

We consider organizational knowledge be shaped in the interaction of individual- and shared knowledge, as well as institutionalized, or objectified knowledge of form of methods, rules, information management systems, etc. [9]. This means that individual knowledge, shared knowledge, and objectified knowledge are different aspects or views of organizational knowledge, and any evolution of this knowledge must consider all these aspects.

Next, we need to define the precise nature and target of organizational knowledge. It is obvious that organizational knowledge is only meaningful in conjunction with a particular organization. Our definition is that organizational knowledge is knowledge associated with the *management of the organizations' artifacts*. The artifacts may be products developed, services provided, etc., which motivate the existence of the organization. It is obvious that knowledge about how to manage these must be considered the core knowledge of any organization. We will call these artifacts *managed items*.

We can now define a strategy for organizational knowledge evolution. The strategy, which is action oriented, provides of a group of actors with specific instruments to achieve individual and shared understanding about the development task. The instruments are reflection models and an information management system, which the actors use iteratively. The models describe the spatial and temporal aspects of managed items in the development context, and these models are directly implemented and tried out in the information management system. Thus, individual knowledge, shared knowledge, and objectified knowledge, in the form of models and information management system support, emerge simultaneously.

3.3 Ericsson Results

The suggested strategy, based on organizational knowledge evolution, has been applied in the transition towards a new development paradigm at Ericsson. We will describe the results from two perspectives, comparing traditional and new knowledge. The first perspective is the concrete application of the strategy in a particular, first pilot development project, where we will treat the issues:

- *the importance of coherent or isomorphic models*
- *the necessary properties of information management systems*
- *user understanding and acceptance on a global scale*
- *role distributions, team composition*
- *managing traditional versus new knowledge*
- *how to achieve a global, web based information management support*

The second perspective is the deployment of the strategy in a global organization like Ericsson, where we will treat issues such as

- *the role of initiators (pathfinders, pioneers?*
- *knowledge emergence: from bottom or top?*
- *knowledge evolution speed, punctuated equilibrium model*
- *global aspects of deployment*
- *adaptations, balancing control and freedom*
- *information politics, conflicting interests*
- *information system development, new paradigm*

4 The Campus Norrköping Arena: Impacts on Engineering Education

4.1 General Implications on Engineering Education

Our findings, with immediate implications on engineering education, in the industrial case studies can be summarized as follows. For the development engineer:

- *Ability to learn new things is more important than to memorize and repeat static knowledge*
- *Ability to communicate and to co-operate is more important than individual brilliance*
- *Ability to understand totality is more important than having deep narrow knowledge*
- *Ability to act and ask questions is more important than ability to follow detailed instructions.*

A few specific examples: When the design review meetings were introduced at Whirlpool, the electronics design engineers were initially not comfortable with having to motivate their design decisions. They were not trained to do so, and they did not understand why they should do it. Also, they expected to be given answers rather than questions. They expected somebody else to be able to supply all objectives, requirements, and constraints.

4.2 A Course Experiment

In a second-year course in computer networking we have tried introduce components designed to train the new capabilities. For a group of about 70 students we presented a global task:

> *Develop a distributed system simulating the public transport in a city in a computer-game like fashion, such that there are train clients and station clients operating on different lines in different cities. In the system there must be special clients for monitoring the traffic. There must be simulated passengers, such that the train moves and such that there are (simulated) people in the*

train and at the stations even if no one is "playing" at a station or train client at the moment. A web page is available for information about existing cities and also for the creation of new cities.

The project should be organized so that the system consists of eleven subsystems, each developed by a group of 6-7 students. To give a set of reasonable subsystems, there are two public transport companies in the city. One is running its train according to timetable, and the other runs traffic on demand. The definition of the total functionality of the system and the interfaces between the subsystem is part of the task, just like the organization of the subprojects and their coordination. At the end of the course, there should exist an integrated and tested operational system. Each group of students has responsibility for the understanding and capability of each individual group member at the end of the course. The examination is of an oral nature and aims at testing that each member of the group has the capability to organize a project like this and the technical skill to implement the functions by means of Java software on PCs connected to Internet.

Three teachers and one third-year student were involved. The teachers had responsibility for the teaching and examination of different areas, one for the technical content, one for the communication between the students and the groups, and one for the group dynamics and project management aspects. So, the task was designed with the four new capabilities in Section 4.1 in mind. However, it is not possible to sacrifice the traditional requirements on knowledge and skills. The traditional skills are needed even more today than before. Hence, the task was also designed to include client-server architectures, basic Internet communication via sockets and URLs, as well as object-oriented design and programming in general.

4.3 Student Reactions

Our students, just as the design engineers in industry, didn't like the approach at the beginning. They wanted detailed instructions what to do, when, and by whom. The project ran from the beginning of November until mid-March. At the end of the course most of the students appreciated the course. They had implemented a system they hadn't believed they were able to build. They appreciated that they had been given the responsibility to organize the project into subprojects. A very common comment is "we didn't really understand what kind of system we had to build until we had built it". Our conclusion is that we have gained a lot in terms of training the new capabilities without losing very much, if anything, in terms of traditional technical content.

However, the immediate reaction from students and teachers who have not been involved is negative to our ideas, as were the design engineers in industry to the new approaches at Whirlpool and Ericsson.

5 Conclusions and Future Work

Our main conclusion, so far, is that our basic approach is still relevant. As a matter of fact, it is more relevant now that it was when we started. The conversion towards flexible and dynamic development models is more widespread now than it was a few years ago. The organizations we have studied, CelsiusTech Systems, Whirlpool, and Ericsson are operating in very different sectors: military, white-ware, and telecommunication, and the have very different traditions. However, the basic issues, problems, and approaches are the same. Observations at one arena have in general in the discussions directly been identified as relevant also at the other two. Hence, we have reason to believe that our findings may have some generality.

In the future we will study in particular tool support for the organizational learning in a distributed organization. The tools will support and keep track of the understanding once achieved, but can never replace the team understanding capability. This capability means ability to answer *new* questions and solve *new* problems on the fly, as they occur. That's why the old static documents, the specifications, are of little use.

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