Accepted to HSS'99, Falun, March 16-18

Organisational Knowledge Evolution

Lars Taxén
Ericsson Utvecklings AB
Department of Computer Science and Information Systems, The University of Linköping
E-mail: lars.taxen@uab.ericsson.se

Abstract

The main part of the Ericsson development work concerns software for controlling and supervising the telecommunication traffic. The way the software is developed is currently being changed from the traditional, so called waterfall development model to an incremental development model which will make it easier to manage a dynamic market, especially with respect to customer requirement changes during a project. The transition to incremental development means that the knowledge about how software is developed must evolve within Ericsson. This is complicated by the fact that Ericsson has many designers (more than 10 000) working at local design centres all over the world. In this paper, we will propose a method for knowledge evolution and describe how this method was applied in the transition to incremental development. The method is based on a action-oriented view on knowledge, and uses concrete instruments for iterating between reflection and action. The instruments for reflection are *conceptual models* and *information flow diagrams*, while the instrument for action is an *object oriented Product Data Management system*. A conclusion is that a method for knowledge evolution based on these instruments is a powerful way of quickly acquire, deploy and manifest new knowledge in an organisation[1].

1 Introduction

The telecommunication market is changing very rapidly mainly due to two forces: the deregulation with the entering of many new operators leading to more competition, and the proliferation of new technology, for example mobile communications, intelligent networks, Internet etc. This has put a demand on the suppliers to be more reactive and flexible to the market needs, which means shorter lead-times and more flexibility in handling late and changing requirements. It is a very challenging task to achieve this considering the size, complexity and in service performance (up-time) requirements of the telecommunication systems.

One example of this situation is shown in figure 1, which is from a software project developing cellular telephone features for the Japanese market. Less than 50% of the original set of

1. This work has ben sponsored by the Swedish National Board for Industrial and Technical Development, NUTEK, project P10518-1, and The Industry Research School in Applied Information Technology and Software Engineering at Linköping University, funded by the Foundation for Knowledge and Competence Development.

requirements remained unchanged during the project. The rest was either new, changed or removed requirements.

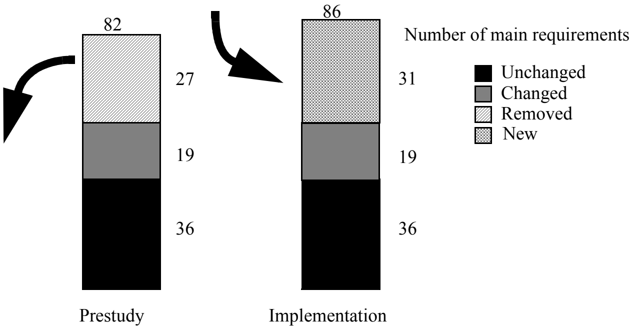


Figure 1. Typical requirement picture for development projects

Ericsson is trying to manage this situation by gradually replacing the traditional, phase oriented waterfall development model with an *incremental development* model. This means that the total development task is divided into steps (increments) that can be developed and tested as complete units. This makes the project less sensitive to requirement changes since, for example, late incoming requirements can be allocated to later increments. In the traditional waterfall model, all requirements are frozen early in the project, and any changes thereafter have to be treated as engineering change orders.

The transition to incremental development means that an extensive organisational knowledge evolution must take place. This is complicated by specific conditions in a company like Ericsson, some of which are

- a large number of designers (more than 10 000) which are used to the waterfall model,
- the development is distributed to different local design centres all over the world,
- different local traditions have evolved at the design centres.

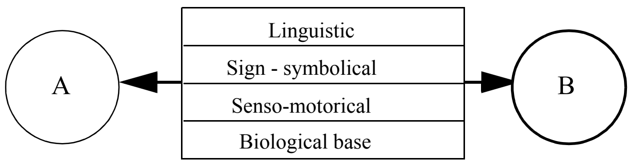
The knowledge evolution means that a new intersubjective understanding shall be achieved between the actors, and that the acquired knowledge somehow must be institutionalized within the organisation. The purpose of this paper is to describe a method for organisational knowledge evolution and to discuss the results from applying this method in the transition to incremental development at Ericsson. We will first give a theoretical view on knowledge where *interaction* is regarded as the basic knowledge category. From this we will define knowledge as patterns in contexts and appply that to individual and organisational knowledge. This action oriented view of knowledge is then used to define a method for organisational knowledge evolution which uses concrete instruments for iterating between reflection and action. The instruments for reflection are *conceptual models* and *information flow diagrams*, while the instrument for action is an *object oriented Product Data Management system*. The method and the instruments are described in chapter 4. In chapter 5 we will show how this method was applied to the transition to incremental development. The results are discussed in chapter 6. Since this paper is based on experiences from both industry and research, we will also include some observations regarding the co-operation between the industry and university.

2 The concept of knowledge - a theoretical frame of reference

What is knowledge? In Berger & Luckman (1966), knowledge is defined as "...*the certainty that phenomena are real and that they possess specific characteristics*". Molander (1966) speaks about "*knowledge as a form of attention*", while Rolf (1995, referring to Polyani) looks upon knowledge as "*a process where individual and culture interacts*". Goldkuhl (1993) defines knowledge as "*patterns of categories*". Often, knowledge is defined indirectly by aspects of knowledge like practical, tacit, living, personal etc. As with many similar multi-facet concepts, it is difficult to capture the essence of the concept of knowledge. In the following sections, we will describe a view of knowledge which we have found useful for purpose of supporting organisational knowledge evolution.

2.1 Interaction based knowledge

One possible view of knowledge is that knowledge is created when *someone is doing something in relation to something*. The *interaction* is where the knowledge is born and sustained, and without interaction, the concept of knowledge has no meaning[1]. This applies to every organism that has the ability to interact with its environment and from made experiences build up a persistent set of rules. The set of rules will guide the organisms' way of reacting in similar and new situations. In this sense, there is no difference between a human, a plant or a virus[2]. All of them will learn from the interaction with their environments in different ways. While a virus only relates to nature, a person also relates to other persons and to society.[3] Furthermore, it is possible to structure the interactions in strata, where an underlying stratum is a prerequisite for the strata above.[4] This kind of stratification could be described with the following interaction model:



All the prerequisites that are needed for an organism's interaction with its environment are found in the biological base. The interaction in this stratum could for example be the cells' responses to different chemical reactions, where the set of rules may concerns the geometric structures of the proteins. In the senso-motorical stratum, the interaction takes place through the sensory organs and their ability to orient in and comprehend the surrounding environment. In this case, the set of rules is compromised of different sensory memories such as muscle, hearing, touching and seeing memories. In the sign-symbolical stratum, the interaction takes place through signs or symbols carrying meaning, and in the linguistic stratum, through syntactic and semantic terms and through language.

Knowledge can be generated in all strata. Knowledge that originates from interaction in the two top strata can, in principle, be articulated and subjected to reflection and reconstruction. Knowledge within the two bottom strata cannot be articulated. The conception *tacit knowledge* is sometimes referred to as knowledge that cannot be articulated (Rolf, 1995), and would therefore belong to these two bottom strata.

---

1. The argument in this section is inspired by, amongst others, Volosinov (1986) and Kosik (1978).
2. Even artefacts like a neural network could be regarded in this way.
3. Rolf (1995, p 116) differs between three forms of practical knowledge: Skill, know-how and competence. All three forms can be traced back to the interaction as the essential category.
4. A good analogy is the so-called Open System Interconnect (OSI), which describes a stratified architecture for the communication between nodes in a network.

2.2 Patterns in contexts

An organism is learning something when something gets in focus in it's interaction with the environment. What is in focus in a certain situation, is governed by the internal driving forces of the organism and by events in the environment. The knowledge, which is being perceived in a given focal situation, is called *focal knowledge* (Rolf, 1995). Besides the focal knowledge, another kind of knowledge is needed to complement and direct the focal knowledge. This knowledge is called *background knowledge*.[1]

Together, the focal knowledge and the background knowledge can be described as knowledge in a *context* that is defined by a *focal horizon*. Knowledge above the focal horizon is active in a given focal situation, while other parts of knowledge are latent or resting in the very same situation, no matter what stratum is concerned. Necessarily, the limiting of a context through the focal horizon is blurred and vague. Furthermore, following Goldkuhl's definition, the knowledge in a context has to be structured in some pattern where categories of knowledge are associated with each other. An example of a context is found in figure 2:

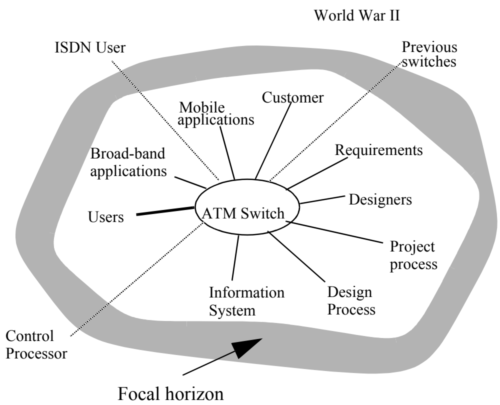


Figure 2. Example of a context

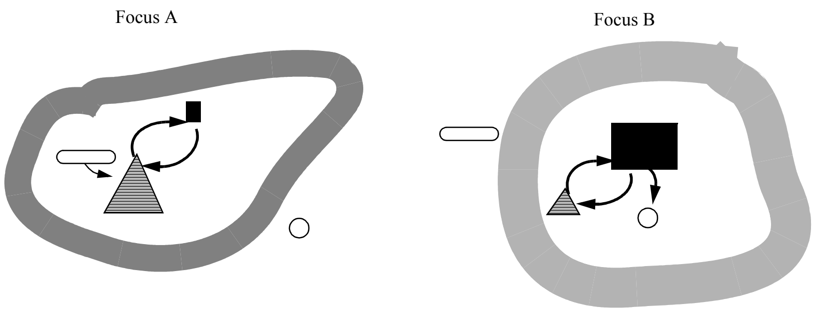
When a context has been learned by an organism, it can be used in corresponding focal situations. The pattern in the context is used to draw conclusions about the situation and to act in accordance with the information that results from the interaction between the focal situation and the context[2]. From this it can be seen that a context has both a static and a dynamic aspect. The static aspect is the pattern, i.e. how knowledge categories are related to each other. The dynamic aspect is the order in which the information is created and used according to the pattern. Thus, knowledge in a context is defined by:

1. In a given focal situation, Rolf (1995, p 63), equates background knowledge with tacit or silent knowledge. This is not in accordance with the definition of silent knowledge as not possible to articulate. In principle, background knowledge in the two top strata of the interaction model can be articulated.
2. Note that the same focal situation in general brings different kinds of information to different individuals, depending on the fact that their fields of meaning are different.

- a focus,
- a scope delimited by the focal horizon,
- categories organised in patterns,
- the order in which the information is being created and used.

2.3 Field of Meaning

When the focus changes, so does the context. Certain categories will disappear below the horizon, while others will remain visible:



An organism's knowledge can be interpreted as its capability to acquire, sustain and activate patterns of categories for focal situations that concern the organism. These patterns will make it possible to recognise the situation and act accordingly. However, if the organism encounters a new focal situation, a learning must be accomplished by acquiring a new pattern corresponding to that situation. This pattern is based on former patterns which may be considered as *pre-understanding* to the new learning.

The entire pattern of categories, which are institutionalised in the organism, can be described as it's *field of meaning* (Goldkuhl, 1993). Thus, when the organism faces a certain focal situation, a context is formed which activates the relevant parts of the field of meaning. This applies to all the strata in the interaction model, including the senso-motoric. In the two top strata of the interaction model, the field of meaning can be articulated and explicitly described, which is utilized in the modeling technique described in chapter 4.1.

3 Organisational knowledge - managing artefacts

So far, we have been discussing knowledge from an individual point of view. In order for several organisms to interact, it is necessary that some intersubjective understanding takes place. Intersubjective understanding means that the interacting organisms have some parts of their field of meaning in common. The common parts are shaped in the dialectical process taken place between the individual's subjective reality and the socially constructed objective reality (Berger & Luckman, 1966). This applies also to the individuals belonging to an organisation such as a company. If the organisation is to appear as an organism, a common field of meaning must exist amongst its members. Also, objective realities such as rules, norms, formalized organisational structures etc. must be institutionalized in the organisation.

Obviously, the common field of meaning cannot include every aspect of the individual fields of meaning. In order to analyse organisational knowledge, we need to define what categories can be associated with this kind of knowledge. The approach taken in this paper is to define organisational knowledge as knowledge which concerns the *managing of the organisations' artefacts*. Artefacts may be products developed, services provided etc., in short the artefacts which motivates the existence of organisation. The focus on management means that organisational knowledge concerns the relationships between artefacts rather than knowledge about each individual artefact. Some aspects of management are:

- The scope of management, what artefacts are managed?
- Characterisation of the management aspects of artefacts.
- The relationships between artefacts.
- The status of the artefacts.
- The order in which the artefacts are processed.
- Guidelines, rules and norms associated with artefacts.
- Architecture of information management systems.

The organisational knowledge will change when new focal situations, such as for example changed market conditions, appear. This means that the organisational knowledge must evolve with new focal situations. An organisation's ability to achieve this will depend on how quickly a new intersubjective understanding and new institutions can evolve in the organisation. A too detailed and commanding set of rules will make the organisation react slowly. On the other hand, a loose or non-existent set of rules means that the intersubjectivity is low, and the organisation will then not be able to act as a unit. Thus, there is an optimal balance between "plan economy and anarchy" (see for example Nilsson, 1976). We will return to this in chapter 5.3.

4 A method for organisational knowledge evolution

If the evolution of organisational knowledge shall not be ad hoc and driven from external circumstances only, the evolution has to be articulated and somehow objectified as a method for organisational knowledge evolution. In this chapter we will present such a method, which is based on the theoretical view of knowledge described in the previous chapter. We will assume that the knowledge concerned is knowledge about artefacts being managed in the organisation. Furthermore we assume that the organisational knowledge can be represented as a filed of meaning in the sense described above.

The starting point is that the organisation is facing a new phenomena which it cannot interact with properly with its current organisational knowledge. Thus a new context for managing the new focal situation must emerge within the organisation. This is achieved in the following way:

- A group of actors is provided with concrete instruments for reflection and action, which they use in a dialectical interplay to achieve intersubjectivity on the pattern of categories the new context.
- The instruments for reflection are *models* of the static and the dynamic aspects of the context. The static view is modelled by *conceptual models in the OMT-notation*. The dynamic aspect is modelled by *information flow diagrams*. These models are further described in sections 4.1.
- The instrument for action is an *object oriented PDM-system*, Matrix from Matrix-One Inc. By action we mean that "real" managed items are being created and managed based on the type definitions in the reflection models. The experiences gained from this will in turn affect the models for reflection. In order to maintain the dialectical interaction between reflection and action, it must be very simple and straightforward to implement the reflection models in the system. How this is done in Matrix is described in section 4.2.
- Intersubjectivity is achieved when the actors agree that the models and the implementation

in the PDM-system sufficiently well describe the new context.

- The new knowledge is institutionalized and manifested by the models and the implemented system which will be part of the organisation's objective reality. To make the objectification easier within large, distributed organisation like Ericsson, the models and support is made adaptable to local circumstances. This is described in section 5.3.

4.1 Instruments for Reflection

The instrument for reflection of the static aspect of a context is the Object Modelling Technique (OMT) notation. The most important concepts of OMT are described in figure 3:

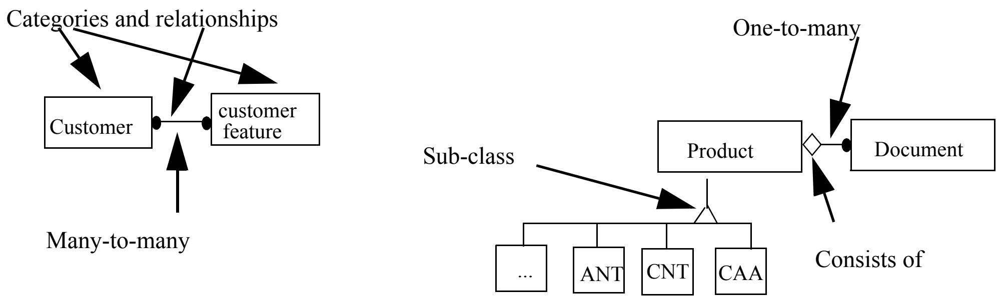


Figure 3. OMT-notation

The categories are described as "boxes" in the OMT, while "lines" between the boxes indicate an association between categories. The complete OMT-model describes the pattern of categories for a particular focal situation.

The instrument for reflection of the dynamic aspect of the context is information flow diagrams. These belong to a category of process models usually called "Entity Based Process Models" (Humphrey & Kellner, 1989). The focus in these models is put on data status rather than on activity status. The principles of the information flow diagrams are illustrated in figure 4. A downward pointing arrow shows that the category is used in an activity. An upward pointing arrow from an activity changes the status of the category. The categories are same as in the conceptual model. The information flow diagrams describe in what order the information associated with the categories is processed.

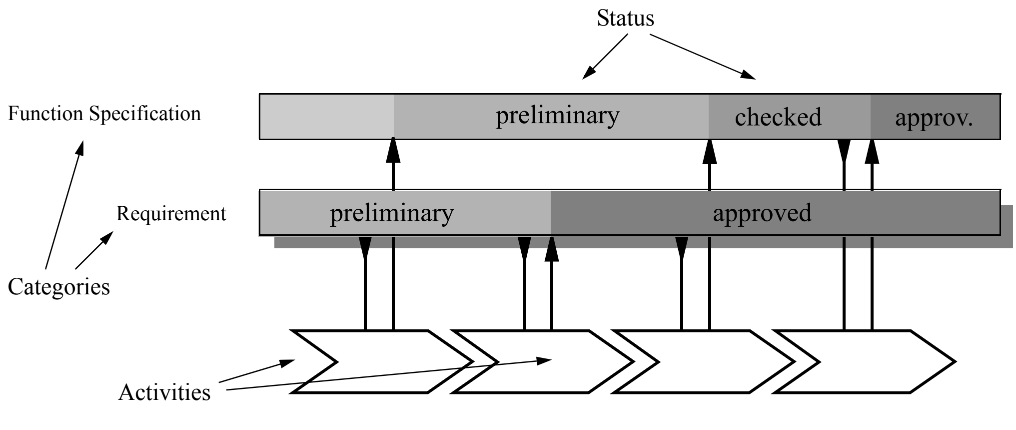


Figure 4. Information Flow Diagrams

The OMT models and information flow diagrams are being used alternatively during the reflection phase. These models were chosen because they are easily understood by the actors and model the context on an appropriate abstraction level.

4.2 Instrument for action

In order to maintain the dialectical interaction between reflection and action, the OMT-models and the information flow diagrams must be directly tried out in the action phase. Thus it is very important that the reflection models can be implemented straight on and easily recognized in the instrument for action. A system with these qualities is Matrix. The OMT notation is implemented in the business modelling part of Matrix where object- and relation types are defined. Patterns are formed by stating what types of objects that can be connected to a relation, see the example in figure 5:

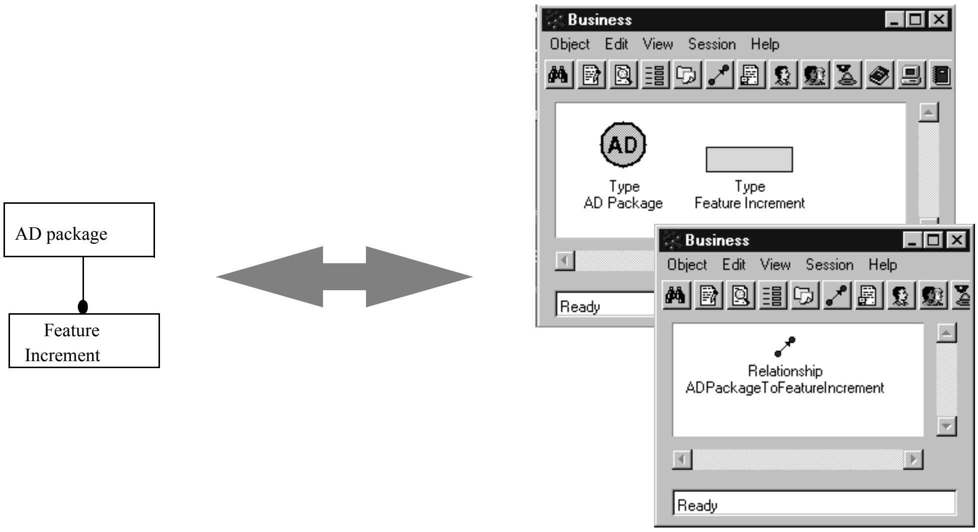


Figure 5. Definition of object types and relations

Information flow diagrams are implemented by defining the different values of status that an object can assume during its life cycle, see the example in figure 6:

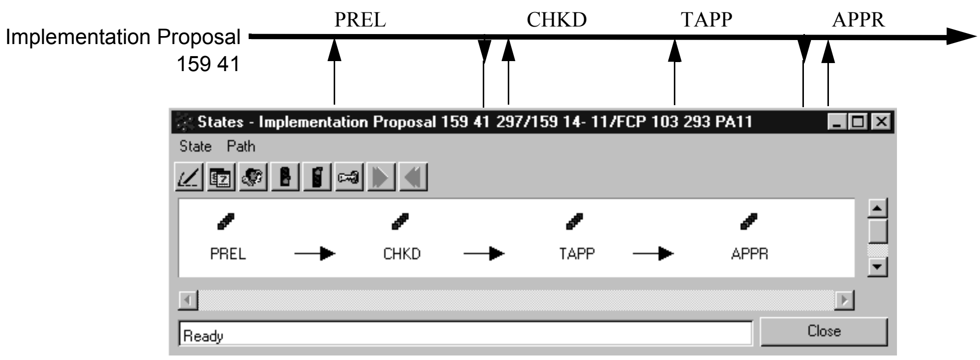


Figure 6. Definition of information flow

A context can be viewed upon from optional perspectives, starting from a category and following the specified relations throughout the context. In this way, different views of the pattern in a context can be studied separately. One example of this is shown in figure 7, which shows the relation between a customer and those documents implementing the requirement specification of the customer.

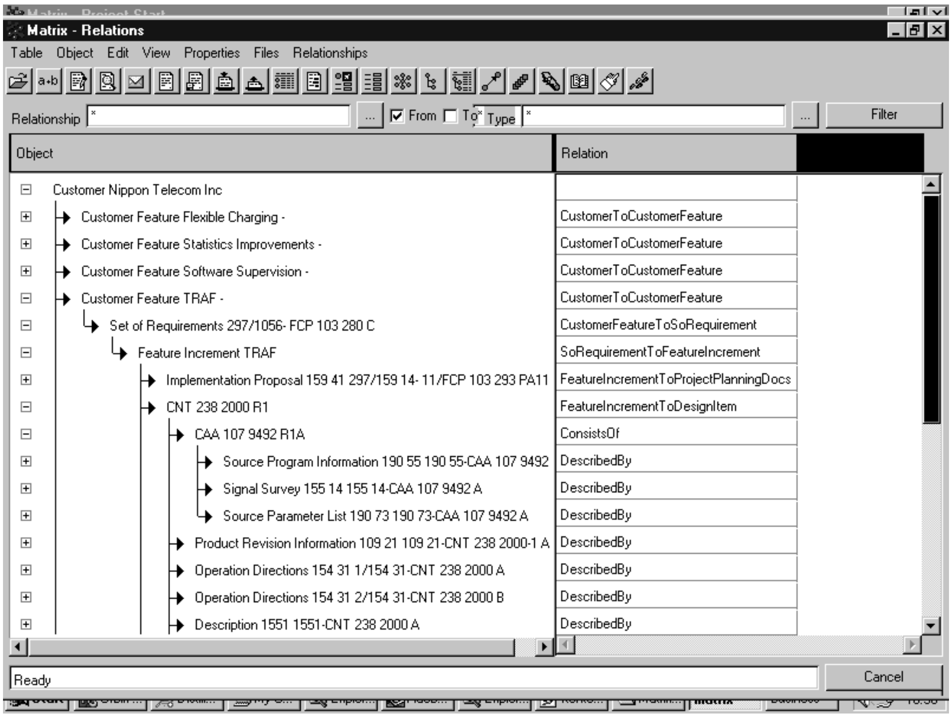


Figure 7. Traversing the context

Since the reflection models and action support evolve together in a dialectical process, a new organisational knowledge and a new objectified support will both be the outcome of that process. This means that the new social construction is established very quickly within the organisation.

5 Transition to an incremental development model - a case study

This chapter will describe the knowledge evolution transition from the traditional waterfall oriented model to the incremental development model at Ericsson.

Within Ericsson, the development of software for the telecom services has for a long time been done according to the waterfall model. This means that the development is done in sequential phases, where a certain result is accomplished and fixed after each phase. For example, the requirements are analysed and frozen very early in the development as is illustrated in figure 8:

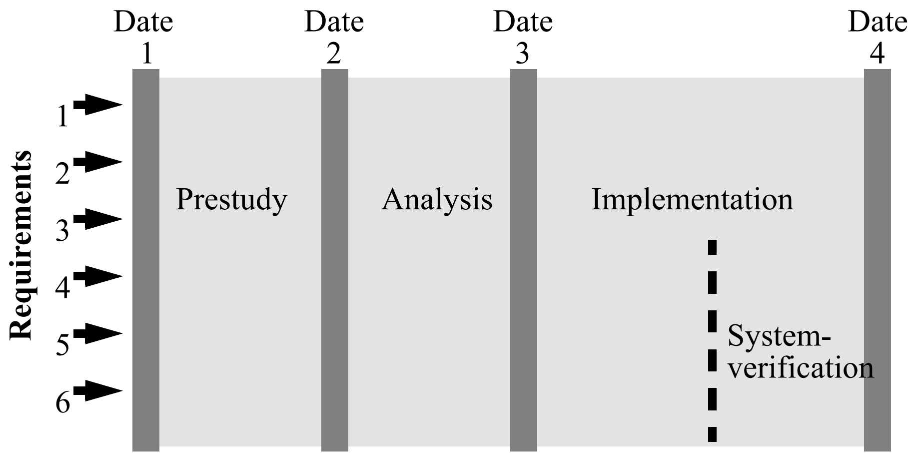


Figure 8. The waterfall development model

This model is objectified in the method product MEDAX, which more than 10 000 designers at local design centres all around the world work with. Some projects are very large (up till 500 000 man-hours) and employ several hundreds of designers at 15 to 20 design centres spread out in some ten countries. Often, adaptations of MEDAX are made due to local conditions, but the basic foundation remains the same. This means that MEDAX is a manifestation of inter-subjective understanding among Ericsson employees throughout the world.

Recently, is has become obvious that the waterfall model is not suited for the dynamic market situation of today, especially not when it comes to requirement changes during a project. For some time now, different ways of incremental models have been tried at several local design centres. In the beginning of 1996, the time was ripe to consolidate these attempts into a productified method and tool support for incremental development.

In the incremental development model, the whole development assignment is divided up in steps (increments) which can be developed and tested as independent units. This means that there is no need to freeze all the requirements at the exact same time. Late incoming requirements can be directed towards late increments, and removed requirements will only affect single increments. This means greater flexibility with respect to requirement changes than the waterfall model can offer. Figure 9 shows a principal picture of an incremental development:

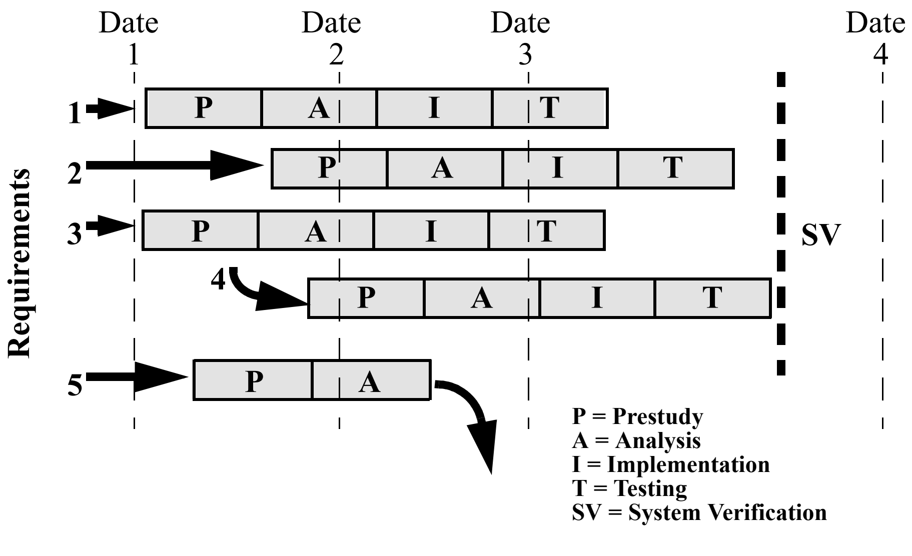


Figure 9. Incremental development

5.1 Incremental development -phase one

The transition to incremental development was done in two phases. The purpose of the first phase was to develop a method package for incremental development which should support identification, specification, planning and coordination of increments. The preconditions were that

- no support system were to be specifically developed for the incremental model,
- the management of the information was to be done in a traditional way, i.e. as documents.

To achieve this, the reflection models in the method was used. Since no particular support was to be developed, there was no action phase involved. The actors were a team consisting of method developers and a support group for projects developing cellular telecom systems for the Japanese market. Since several local development projects already had used some form of incremental development, a form of objectification had taken place at some parts of the organisation, but no intersubjective understanding of incremental development had been achieved within the entire Ericsson. The discussions on how to shape a common model were, in principal, leading nowhere until we started to work with conceptual models according to the OMT notation. After some thirty revisions of the model, there was a limited agreement about the model in figure 10:

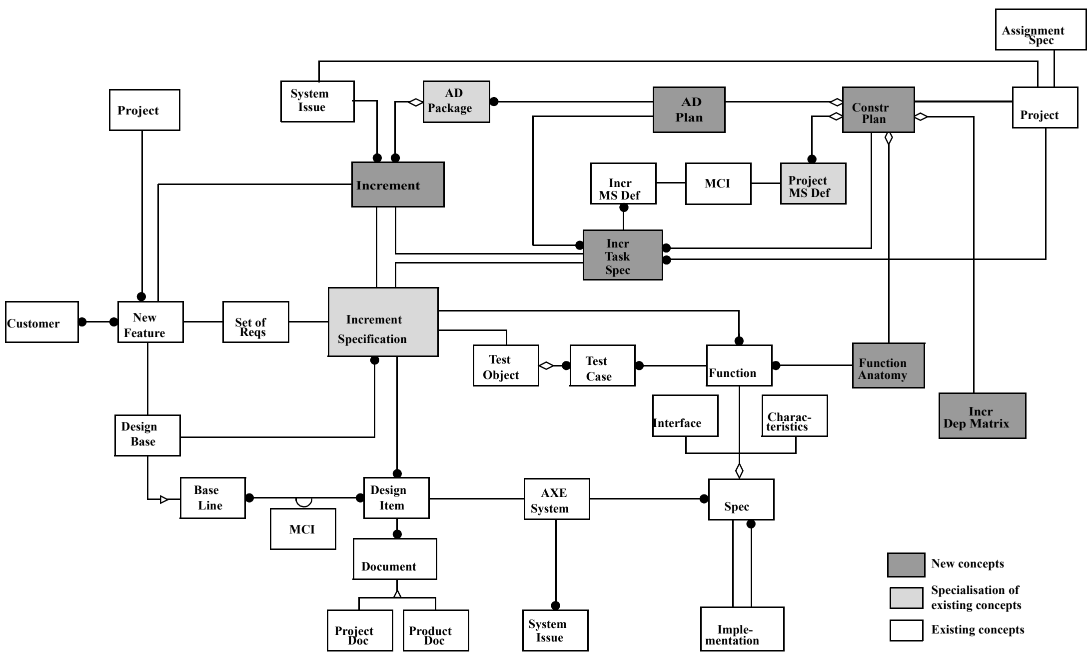


Figure 10. Conceptual model - phase one

Some interesting observations are:

- The traditional social construction is clearly marked (white boxes). This was not affected. The renewal of categories is of two kinds: completely new ones and already existing ones that were used in a new way.
- Both information categories (for example "Function") and documents used as configuration entities are represented in the model. This occurs because we were not, at the time, quite

aware of the differences between these categories.

- Both focus ("Increment Specification"), focal horizon and patterns of categories are represented in the figure. This corresponds to the definition of knowledge according to chapter 2.

This first version of the incremental development model was used in a cellular project for the Japanese market. The experiences from this project showed that the model did work, but that a support system was necessary to manage all the information during the project.

5.2 Incremental development - phase two

The purpose of phase two was to develop a support system for managing incremental development. In this phase the method described in chapter 4 was fully utilized. It was anticipated that the development model would be affected when the support system was brought into focus, which is also confirmed by the conceptual model achieved after this phase (see in figure 11):

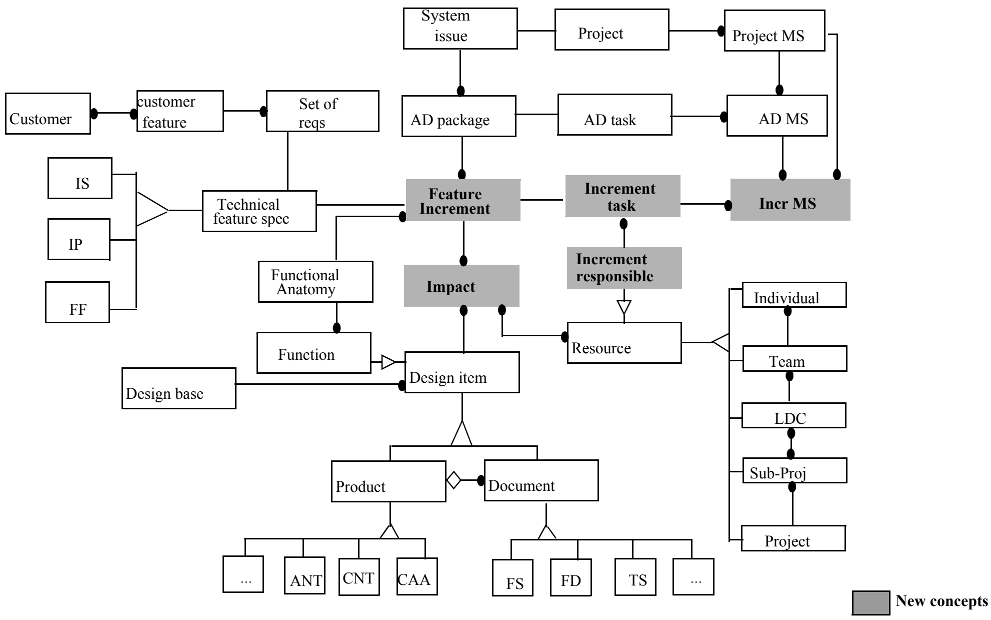


Figure 11. Conceptual model - phase two

Compared to the preceding model, it can be noted that:

- The model has become less complex, and is therefore gaining a broader acceptance much easier.
- Some categories have disappeared, and others have been added, for example those involving the resources of the project.
- Documents as management categories have disappeared, and the model has become more focused on pure information categories. This is a consequence of the support system (Matrix), which makes it possible to extract information from different perspectives, and, if necessary, account for it in a traditional way, i.e. as documents. This means that information elements rather than documents are managed, which is a significant change within Ericsson.

However, the most striking observation is that the model contains so few categories that are specific to incremental development. The total work effort of developing and gaining acceptance of the model accounted to several thousands of man-hours. A comment often heard was "that's obvious, we are already working like that". One conclusion drawn from this is that articulating a becoming knowledge in a large organisation is difficult. Once it is established, it is easier to convey it to a larger group. The corresponding information flow diagram is shown in figure 12:

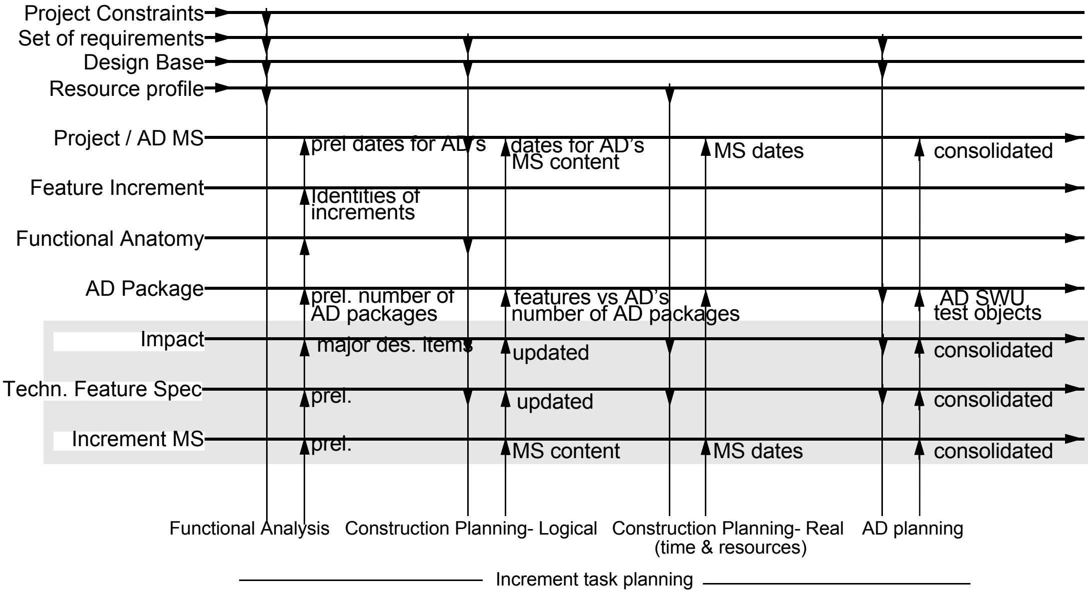


Figure 12. Information flow diagram - phase two

5.3 Adaptations of standard products

In a large and distributed organisation like Ericsson, it is impossible to achieve a common field of meaning across the entire organisation. There will (and should) always be local deviations. At the same time, there must exist a common set of rules for enterprise common tasks, for example how to identify products and documents. There has to be a balance between total order and chaos which maximizes the organisations ability to adapt to new focal situations. This relationship is illustrated in the principle outline in figure 13:

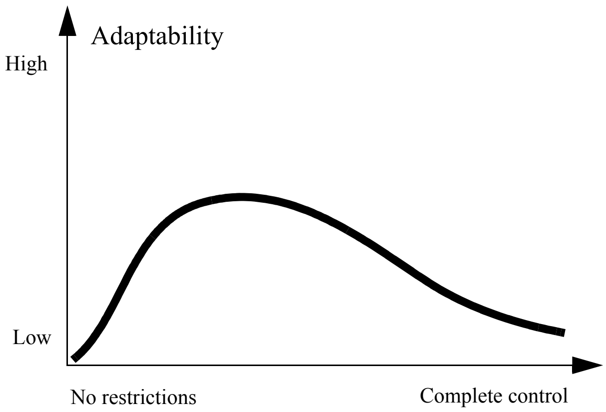


Figure 13. Adaptabilibility vs. control

One solution to this problem is to use models and support systems which *shall* be adapted before they are put into use, in other words, a sort of semi-manufactures. Both the model and the support system for the incremental development are based on this assumption. This will accomplish several things:

- The acceptance of the change will be very effective, since the intersubjectivity is achieved in interaction with those that shall use the new development model. The difficulty to gain acceptance of new ways of working and of new support systems in an organisation is gravely underestimated. By making the actors part of the final design, the model and the support will quickly be established in the organisation.

- Intersubjectivity across the company is achieved quickly since consensus only has to be achieved on the development model from which the local context can be specialised. One example of this is the concept “Increment” which at some parts of Ericsson is called “Data Definition Package”. However, the development model is the same.
- The possibility of adaptation makes it easier to find the optimal balance between total order and chaos. The common set of rules should be implemented in the semi-manufactures.
- The local knowledge evolution will progress very fast, since no coordination throughout the entire company is needed. In principle, each local organisation will get tailor made models and support systems adapted to their needs. It is however desirable that those local adaptions, which are of general interest, can be incorporated in the semi-manufactures.

To accomplish this way of working, intersubjectivity about the reflection and action principles and instruments must have been achieved throughout the entire organisation. On top of this, the models and the support systems must be easily adaptable to the local organisation’s needs.

6 Discussion

Many companies are today experiencing a large pressure to change due to the market and technology evolution. In order to make the companies successful in changing their business, they need to manage the evolution of knowledge associated with the change. In this paper we have presented a method for organisational knowledge evolution, which is based on an action oriented theory of knowledge and which uses concrete instruments for reflection and action. The method has been used in the transition from a traditional waterfall way of developing software to an incremental development model.

The first experiences from applying this method are very good. In a rather short time (a couple of years), and with a relatively small staff (less than 10 persons), an intersubjective understanding of the incremental development and a corresponding support has been objectified within several parts of Ericsson. We are now using the method in the transition from document based to a computer based engineering change order process, and the results are equally positive. In just three weeks we have a achieved a fully operational computer based process as well as an intersubjective understanding among configuration managers, project leaders and support staff. However, more cases have to be studies before the claimed qualities of the proposed method can be fully established.

Whether the achieved organisational knowledge and objectified models and support will be institutionalized in permanent changes, is too early to say. The huge pressure of change that the companies experience today makes it very hard to establish new, stable social constructions within large organisations of Ericsson’s kind.

6.1 Some reflections on Industry - University co-operation

The results reported in this paper emanates from both the industry and the university. A challenging task in the society today is to get industries and universities to co-operate in a way that is beneficial for both parties. In this chapter, I will try to give a personal view on this matter.

My background is some thirty years of working with support and processes within Ericsson as developer, project leader, line manager, system expert etc. Recently, I decided to try to consolidate my experiences from industry into a Ph.D. degree at the University of Linköping. I'm doing this by dividing my time equally between Ericsson and the university.

Usually, when working on projects with demanding requirements on delivery time and cost, there is no room for reflecting about the work. Nevertheless, during the practical work, a lot of ideas and suggestions for improvements are generated. Since there is no arena for reflection within the industry, these ideas seldom reach the stage where they are institutionalized in the company. Thus a lot of potential improvements are lost.

If a company is very action oriented, the university is more reflection oriented. On the other hand, ideas generated at the university are difficult to try out in industrial work since there is no natural way of introducing them to the company.

The problem from the knowledge-in-action point of view suggested in this paper, is that the actors are separated in an action group (the company) and a reflection group (the university) but the interaction between them is vague. The solutions tried so far do not capture the essence of the problem. One way is that the company orders a certain job from the university and receives the result after the job is finished. Thus, during the assignment, there is little interaction between the company and university. Another way is that a researcher from the university participates in a project in the industry. Nor has this way of interacting been very successful, mainly due to the difficulties for a person from outside the company to promote new ideas within the company.

The newly established industrial research schools are a possible solution to this dilemma. At these schools, people from the industry are given a research education while they at the same time are working in a company. This is also a prerequisite from the government who is sponsoring these schools. Thus, there is an arena for both reflection and action, and a strong interaction between the two on the personal level. My personal experiences from working as an industrial researcher for about a year is:

- The university - reflection side of the arrangement works very well. Attending doctoral courses makes it possible to finalise ideas emanating from previous industrial work.
- A long industrial experience makes it fairly easy to get attention at the university. There seems to be a surge for people from the industry who can enhance the work at the universities with down-to-earth practical experiences.
- It has been difficult to convey the research results back to Ericsson. There is no arena for doing this other than trying to implement the results directly in ongoing projects.´The awareness of the industry about the advantages of the research schools needs to be improved. The attitude so far is that participating in the school is a very much a personal matter.
- It is very difficult to balance between research- and industrial work. The action-oriented projects always have a higher priority. Usually, this is solved by working overtime on both the research and industrial tasks, which is not a very good solution.
- It is a clear advantage to be an 'insider' in the company when doing research work. For example, it is quite easy to ask people about their experiences from participating in industrial project work.
- The economical arrangement where both the company and the university pay the salary of the researcher, is a good one. This encourages both parties to take a responsibility in the arrangement. It is also important that the work done at the company is directly related to the research.

In summary, the research schools seem to be a good way of implementing the reflecting-acting way of achieving new knowledge. Whether the personal experiences related above are general is a matter of further discussion.

7 References

Berger, P. and Luckmann, T (1966): *The Social Construction of Reality*, Reprint by Penguin Books, London 1991.

Goldkuhl, Göran (1993): *Aktörer i samarbete - aktörsteori som grund för förståelse av förändringsarbete,* (in swedish), VITS memo-93-02, IDA Linköpings Universitet.

Humphrey, Watts S. and Kellner, Marc I. (1989): *Software Process Modelling: Principles of Entity Process Models*. SEI-89-TR-002.

Kosik, K (1978): *Det Konkretas Dialektik,* (in swedish), Röda Bokförlaget AB, Göteborg.

Molander, Bengt (1996): *Kunskap i Handling,* (in swedish), Daidalos, Göteborg.

Nilsson, Gert (1976): *Oordning, ordning - Studier i kärlekens villkor*, (in swedish), Korpen, Göteborg.

Polyani, M. (1966): *The Tacit Dimension,* Reprint by Peter Smith, Gloucester, Mass. 1983

Rolf, Bertil (1995): *Profession, tradition och tyst kunskap,* (in swedish), Nora: Nya Doxa.

Taxén, L (1995) *The Dialectical Approach to System Design*, Proceedings of Integrated Design and Process Technology, Austin, Texas.

Taxen, L (1998): *Project Decisions subject to Contextual Insecurity,* Linköping: uppsats i doktorandkurs Industriell Projektledning

Taxen, L. and Karlsson, E. A (1998): *Incremental Development for AXE 10,* Frankfurt, Ericsson Conference on Software Engineering.

Volosinov, V.N. (1986): *Marxism and the Language of Philosophy*, Harvard University Press, London.