Scalability through Cultivation

Designing IT Support for Co-ordination Work

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Abstract

The objective of this thesis is to discuss how to enable the staff at an order-packaging department to cope with a drastically increasing scale of operation. In order to do this we introduce the term scalability and based on co-ordination theory we formulate a case specific method for designing for an increasing scale of operation. We argue that it is the co-ordination work that is lacking not the actual productive work performed. We apply our method to the results of an ethnographic field study conducted at the order-packaging department, and design a new work setting adapted to the increasing rate of growth. We state that the design method was very useful in our case, but we need to conduct further empirical studies in order to make a conclusive evaluation of its applicability in a more general sense.

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1 Introduction

What happens when a small-scale department suddenly has to deal with an annual growth in production of well over fifty per cent? Is it at all possible to save the way of working that has developed over the years?

We have conducted an ethnographic field study at a packaging department of a large Swedish company that is experiencing a similar growth rate.

In this thesis we will discuss how to enable the staff to cope with the increasing scale of operation. In particular, we will explore the important aspect of scaling up the current work setting and present a design strategy that makes it possible to transform non-scalable work into scalable work.

The department has been, and still is working very well. However, the production is growing rapidly[1], and many customers have announced that they will start to order more often, but in smaller quantities each time. This means a rise in the number of orders by four.[2] The growing throughput in the factory is giving the order-packaging department two kinds of problems: (1) The number of important events that must be monitored and controlled has grown and they are becoming difficult to keep track of. (2) The old way of working is not efficient enough: They are already working at full capacity and are unable to increase the throughput.

The workers as well as the management find today's way of working satisfactory, but they both fear that the rapid growth will cause severe problems and feel that it is time to "do something" in order to prevent a total breakdown in delivery precision and packaging quality.

Because the work practice today is satisfactory we choose to base our study and design on the current work practice. As opposed to a more radical approach (Gallier, 1997), where you question the purpose and existence of the whole department, we are interested in investigating whether it is possible to cope with growth with only minor changes in the work practice.

Thus, the most important issue in our study is the possibility of scaling the current work practice to match the growing workload. We introduce a term we call ”scalability”, which we define as the ability of the current work practice to cope with a growing workload.

The basis for our discussion of scalability is co-ordination theory (Carstensen, 1996), as described in the CSCW field (Schmidt and Bannon, 1992). According to Schmidt (1993) a means of articulating work (co-ordinating work) is not provided via the work it self. If a work setting is small enough, the articulation may be handled in an ad-hoc fashion, but as the work setting grows, and therefore becomes increasingly complex, it is essential to provide adequate support for co-ordination of activities. We want to scale the work by designing new support for co-ordination, thus minimising the effects on the actual work performed. In order to accomplish this, we will analyse the results of the field study from a co-ordination theory perspective by identifying key issues essential for achieving scalability. These key issues constitute the basis for our design.

[1] This year alone the anticipated growth is 100%.

[2] Twice the number of manufactured units and an average order size cut in half.

Thus, our objective is to establish what work practices need to be changed to support a higher scale of operation.

We find our work interesting from mainly two different perspectives:

- Business Perspective: The company needs an evaluation of today's work practice and suggestions for future work practice.
- Research Perspective: This thesis introduces and discusses a case-specific method for analysis and design called *Designing for Scalability*. Is it possible to build a design proposal on an incremental approach when the obvious choice would be a radical approach?

CSCW has gained a lot of interest the past years in the Informatics research community. The research has, however, mostly focused on geographically distributed groups with the basic assumption that the users are sitting in front of a networked stationary computer. Research as well as practice in the CSCW (Schmidt, 1992) field has established the use of IT as an essential tool for co-ordinating work. However, since the work at the site of our field study is highly mobile, we will explore the possibilities of using mobile IT for co-ordinating purposes.

A shorter version of this thesis has been accepted for the IRIS Conference held in Sæby, Denmark in August 1998.

2 Theory

2.1 Informatics

The authors of this thesis are students of Göteborg Informatics as defined by Professor Bo Dahlbom (1995) of the Department of Informatics, Göteborg University.

Bo Dahlbom defines Göteborg Informatics as ”a design oriented study of information technology use with the intention to contribute to the development of both the use and the technology itself”, discussing the definition using the following key points.

1. *Use Orientation*
   Technology itself does not change anything until it is put to use. Information Technology (IT) has not changed the way we live, but the *use* of IT has. He stresses that ”the focus has shifted from information systems to information technology, and from systems development to technology use”.
2. *Theory Orientation*
   Dahlbom points to the critique that methods are seldom practically useful. We should rather concentrate “on developing concepts and theories making it possible to describe, analyze, and design the rapidly diversifying field of information technology use which people sometimes call information society”.
3. *Artefact Orientation*
   Informatics is a social science in the sense that we are interested how people affects as well as are affected when using IT. However, we are only interested in the social element when it is combined with artefacts.
4. *Design Orientation*
   Design orientation means that we are not only interested in describing the world as it looks today, but we also want to design in order to improve the use of IT and IT itself. Dahlbom states that ”We are interested in the use of technology because we are interested in changing and improving that use, and the technology”.
5. *Future Orientation*
   With the rapidly developing information technology and use thereof it is crucial to have a future oriented approach in order to ”contribute to that process rather than just observe and describe it”.
6. *Customer Orientation*
   Our research field, as well as our education are customer oriented in the sense that we are not interested in doing research for the sake of research, but rather that is relevant and interesting for the customers. The customers can be enterprises, governmental agencies or increasingly the society at large.

The thesis is based on a real case at an organisation that is in the process of investigating new forms of IT use for changing work. The thesis is therefore use oriented, design oriented as well as customer oriented. We use co-ordination theory, which discusses artefacts for co-ordination. This makes the study artefact oriented as well. It may on the other hand be argued that the thesis is not explicitly theory or future oriented.

2.2 Co-ordination Theory

According to Schmidt (1993) the need for co-ordination increases when the workload grows. In order to gain understanding of the current work practice with the intent of enabling it to cope with growth, we therefore focus on the co-ordination of work taking place today. Malone and Crowston (1994, pp 87) defines co-ordination as follows:

> ”Coordination is managing dependencies between activities”

We choose to analyse the work at the department by trying to formulate what activities are significant for the work at the department. Malone and Crowston identify several different types of relationships between work processes. One of these is the *producer/consumer relationship*. The core of producer/consumer relationships is the dependencies that exist between two processes where the first process produces the product/information needed to perform the second process. Malone and Crowston define several dependencies caused by the producer/consumer relationship:

Transfer is the process of transferring the output of the producer activity to the consumer activity.

Prerequisite constraints describe the rules for initiating transfer between processes. In the case of a producer/consumer relationship the first process must be concluded before the second can begin since the latter is entirely dependent on the output of the former.

These dependencies existing in a work practice can be described using the term co-ordination mechanism. Peter Carstensen (1996, pp. 74) defines co-ordination mechanisms as follows:

> ”A coordination mechanism is a protocol, encompassing a set of explicit conventions and prescribed procedures and supported by a symbolic artifact with a standardized format, that stipulates and mediates the coordination of distributed activities"

This definition identifies two parameters essential for describing co-ordination. Firstly, a co-ordination mechanism is a *protocol* that stipulates the means (procedures, conventions, etc.) of co-ordination, i.e, a set of rules to be observed when communicating. Thus, in a producer/consumer relationship, the protocol enforces the prerequisite constraints of a particular transfer. Secondly, it is a *symbolic artefact* that is ”accessible independently of the particular moment”, e.g, a note (the symbolic artefact) can be read long after it was written and still convey meaning to the reader. The artefact is the mediator of the mechanism, making it possible to co-ordinate work over time.

We use Carstensen´s distinction between the actual productive work carried out by the workers, i.e. the *work activities*, and the work conducted to co-ordinate these work activities, i.e. *co-ordination work*. A co-ordination mechanism is the result of co-ordination work mediated through a symbolic artefact.

We also use the terms *work practice* to describe how work activities and co-ordination work are actually being carried out on the shop floor and *work setting* to refer to work practice in a specific environment.

Co-ordination is characterised by different degrees of formalisation, ranging from what Carstensen refers to as *ad-hoc co-ordination* to *formally specified co-ordination*. Ad-hoc co-ordination is where the reaction to information is not specified, as opposed to the formalised co-ordination where the rules are rigid and information triggers predetermined responses.

A term closely related to ad-hoc co-ordination is *awareness*. Dourish and Bellotti (1992) define awareness as "*...an understanding of the activities of others*, which provides a *context for your own activity*." Awareness is the sum of all the information an actor receives and does not in itself trigger any response. It does however serve as a frame of reference for later decisions making.

Dourish and Bellotti also makes a distinction between *explicitly generated* information (with the intent of creating awareness) and *passively collected and distributed* information.

2.3 Design Strategy

2.3.1 Intervention

In order to discuss the profession of systems engineering, Dahlbom and Mathiassen (1993) make a distinction between three different approaches, construction, evolution and intervention. Our design strategy is inspired by the intervention approach. The reason we have chosen intervention is that it is highly pragmatic and useful when analysing the dynamic nature of social systems, for instance work. It is therefore suitable for our needs. This means that you cannot hope to isolate a single aspect of a work setting and change it without interfering with other aspects of the same setting. You must consider the ramifications of what you do and how it affects other issues. Intervention gives the following advice on this matter, start to pull on one thread of the fabric and see what happens. When you observe the consequences of this action you will discover the patterns woven into the fabric.

We intend to start off by analysing and designing the work setting for a single of our identified issues and then proceed by analysing the impact the changes have on other issues. We believe that a pattern will evolve and then we will follow it. As we design to eliminate the problematic issues we will be affecting other – maybe today fully functional – parts of the work practice. In those cases we must also redesign those parts.

A point made by Dahlbom and Mathiassen is that it is fully possible to make use of both construction and evolution within the parameters of intervention, albeit not at the same time. This is a consequence of the pragmatic nature of intervention. Depending on the result of the analysis we will no doubt have use for both when discussing designs for the different issues.

Another point in using the intervention approach is the stated intent not to provide a solution to a problem but rather to move from one state of affairs to another, which is more appropriate to the current situation. This means that we will not attempt to achieve a perfect work practice in our design but rather offer a more adaptable and flexible work practice in order to allow the department to cope with the high rate of growth they are currently experiencing.

2.3.2 Cultivation

As the term *cultivation* (Dahlbom and Mathiassen, 1993) implies the assumption behind this approach is not to tear down the old and build a new organisation from scratch, but rather to allow the existing organisation to grow and evolve into new shapes adapting to new sets of circumstances as they occur. The point of using the cultivation approach in conjunction with intervention is to take a more conservative

approach to change, and make a point of always investigating the current work setting in order to identify well functioning parts and (within reason) build upon those parts. Basically it is a way of making sure you do not throw the baby out with the bath water, which is more likely to happen using a radical approach such as Business Process Reengineering (BPR) (Gallier, 1997). We take this stance in the thesis and during our field study we have become increasingly convinced of its merit. We have encountered no one who does not approve of the current work practice, in fact both the workers and the management are quite satisfied with it, yet they are all worried because they feel they cannot cope much longer with the growing amount of orders.

2.3.3 Scalability

Having established the design strategy, discussing intervention and cultivation, we now introduce the term *scalability*, which we define as *the ability of the current work practice to cope with a growing workload.*

The most important factor in our study is to investigate the possibility of achieving scalability at the order-packaging department by better supporting the co-ordination of work using the intervention and cultivation approaches to design.

3 Research Approach

The research presented in this thesis adopted the ”Action Case” framework (Braa & Vidgen, 1997). Braa and Widgen define different research intentions: change, prediction and understanding (figure 1). The different intentions are visualised by a triangle, each corner representing an intention. Braa and Widgen discuss different types of research approaches and their placement in the triangle. Action research is in the upper third of the triangle, while field experiment can be found in the lower right part of the triangle. Based on this framework, Braa and Widgen define a new type of research method, called ”Action Case”. The Action Case method is basically a trade-off between *understanding* (e.g, soft case) and *change* (e.g, action research). An Action Case study begins with a study of the organisation in focus, continued by an analysis of the findings and finished with an intervention stage, for instance by implementing findings from the earlier stages. The understanding in an Action Case study is *understanding for change*.

In our case the understanding phase comprises of field study and analysis based on Quick-and-Dirty Ethnography and co-ordination theory, respectively. The change phase consists of further analysis and design, both based on co-ordination theory and an incremental approach towards design.

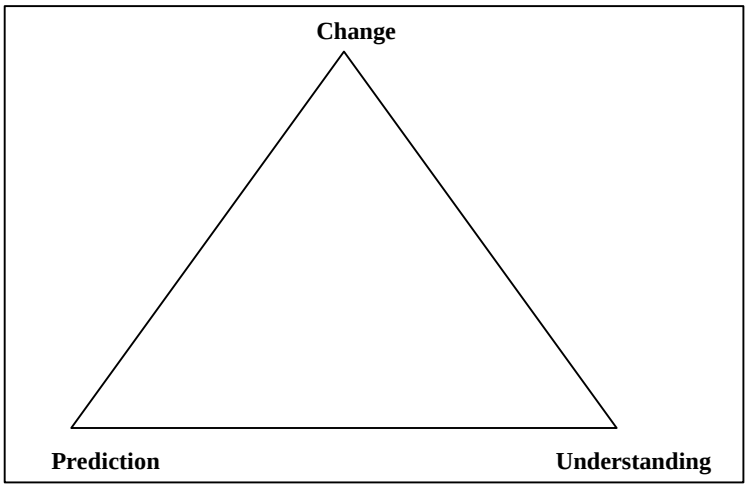


Figure 1: “The IS Research Framework”

4 Method: Designing for Scalability

Based on the scalability term and the design strategy, we introduce a method for *Designing for Scalability*. The method evolved from our early findings at the department and we then continued and concluded the field study according to the Designing for Scalability method. We do not claim this method to be generally useful for systems development, and we only argue its suitability for this specific case.

The Designing for Scalability method consists of two major elements, the understanding phase and the change phase, derived from the Action Case framework by Vidgen and Braa presented above. In figure 2 below we show how the different elements of the Designing for Scalability method relate to the Action Case framework. The circles represent the iterative nature of each of the two stages, while the dashed arrow shows how the entire process progresses from understanding towards change.

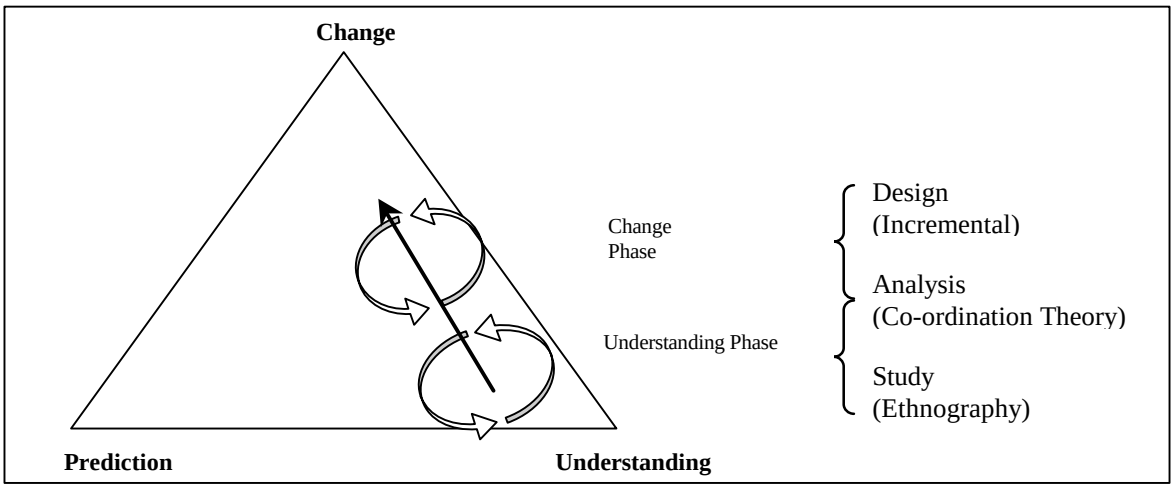


Figure 2: Designing for Scalability elements in relation to the Action Case framework:

4.1 The Understanding Phase: Field Study and Analysis

The designing for scalability method is distinctly bottom up oriented and this is why the first phase comprises of both a field study and the primary analysis of the results. An important point we make is the tight linking between the study and the analysis. Study and analysis is intertwined in an iterative fashion, resulting in constant corrections in the focus of the field study. The method we have chosen for our field study is ethnography.

Ethnography has recently gained a lot of interest from IS researchers as a new method of gaining knowledge about work practices in an organisation. Ethnographers have already done a lot of research in this area (Bellotti, 1996; Button, 1997; Button, 1996; Bowers, 1995; Hughes, 1994).

However, the ethnographic method is a very time-consuming. Ethnographers tend to do their field studies over a period of years, but IS researchers do not require the same deep general understanding. The IS researchers are not so much looking at whole cultures as on specific work practices in organisations (Hughes, 1994). A period of a few weeks or months is usually a sufficient time frame for conducting field studies for IT-design. This kind of study attempts to establish a deep understanding of

perceived relevant phenomena. However, the methods must be modified somewhat to fit to our needs. A lightweight version of ethnographic field studies has therefore emerged: ”Quick-and-Dirty Ethnography” (Q&D) (Hughes, 1994).

Q&D is basically a short, focussed field study, normally conducted over a period of 2-4 weeks. By focused, we mean that there is a focus on relevant subjects, while ethnologists aim for a complete understanding of everything. The study is driven by the goal of gaining knowledge about phenomena relevant for design; i.e. it is design driven. Further more Hughes et al. maintain that the Q&D study should be started with a design goal in mind, for instance designing a groupware application. The characteristics of Quick-and-Dirty Ethnography are very suitable for our needs. We have limited time resources, and we want a strong focus on what we find to be relevant subjects for informing design.

Two fundamental methods used in the ethnographic approach are observations and interviewing. (Hammersly and Atkinson, 1993) In our field study we used observations but not interviewing. Instead we opted to conduct more informal conversations with the workers as we were doing observations. The observation period of two weeks was short from an ethnography point-of-view. In these observations the focus was to investigate the work practice, i.e, how work is carried out in the actual work setting. The observations were documented by taking notes when observing the work. We also asked questions while observing the people performing the work. A very important question that recurred throughout the conversations was ”How do you know what do to next?”, since the answer points to co-ordination mechanisms used in the work practice. Interviews are aimed at collecting qualitative rather then quantitative information about the work. We did not use this strict interviewing technique, but rather conducted less formal conversations with the workers. The subject of the conversations was the work practices we were observing at the time of conversation. Based on these conversations a number of new observations were set up.

What we intend to do is to identify issues affecting the scalability of the work practice. According to Schmidt (1993) the need for artefact based co-ordination increases when the workload grows. In order to identify interesting issues we therefore continuously analyse our findings using co-ordination theory with the intent of finding co-ordination mechanisms. We then investigate the co-ordination work (Carstensen, 1996, pp. 74) these mechanisms support. We are interested in three different sets of co-ordination work:

1. *The co-ordination work that functions poorly*, since we can learn what the problems are. Co-ordination work in this category must most likely be completely redesigned or its existence questioned entirely.
2. *The co-ordination work that still functions, but which is likely to collapse with only a minor increase in workload*. Such co-ordination is likely to function satisfactorily with modifications.
3. *The co-ordination work that functions satisfactorily, and is likely to cope with an increasing scale of operation*. This is interesting since we can learn why it does not experience any problems. Such co-ordination work is likely to keep on functioning without changes.

The results of this phase will a general understanding of the work practice and specifically in what state of scalability its parts are. This is visualised as a table containing the important key issues identified and their individual state.

4.2 The Change Phase: Analysis and Design

As stressed above, we claim the best way of achieving scalability is to preserve as many of the current work activities as possible while focussing on changing and augmenting the artifact based support for co-ordination work.

This approach also follows from the cultivation approach presented in the theory chapter since we use the results of the empirical study in order not to adversely affect existing well functioning work practices at the department. During our initial study we have observed that the work activities generally work well and that it is the co-ordination work that is lacking.

Furthermore we have expressed the need for an incremental approach to change in the current work practice. This implies that the design proposal presented must be possible to implement in stages while still allowing the work to be carried out at the department. The work cannot be completely shut down at any time. This naturally affects the design.

In order to arrive at a design proposal satisfying these criteria we further analyse the identified issues from a co-ordination theory perspective in search of similarities and common problem causes. Once this has been accomplished we broaden our view somewhat and investigate the relationships between the issues and how a change in one issue would affect another. At this point in time we will also make decisions as to whether some issues must be extensively redesigned or in fact completely eliminated. In this theoretical experimental fashion we arrive at a well-rounded and consistent set of design issues which compose a design satisfactorily supporting the scalability of the work practice.

Due to the short time span of this study we will not present a plan for how the design is to be implemented at the department but be satisfied with a conceptual design proposal (however rather detailed) which will be submitted to the company for evaluation.

5 Field Study and Analysis: The Current Work Practice

Picture 1: A view of the order-packaging department.

For the purpose of presenting this field study we have divided the department into three distinct parts. Firstly, the *administrative area* where all the clerks and other administrative personnel reside. Secondly, the *product-packaging area* where the first stage of the packaging takes place, and thirdly, the *order-packaging area* where the second and final stage of the process is conducted. There are also several external plants, where some products are manufactured and stored.

In order to structure the description of work at the order-packaging department we have divided the section into two parts. Firstly, we describe important co-ordination mechanisms in use and secondly, we show how a single order moves through the department, describing the main processes, highlighting important issues.

5.1 Co-ordination Mechanisms

During our study we have identified two artefacts central for supporting co-ordination work, *the work order* and *the board*. The importance of these artefacts will become evident in the description of work below and in the discussion following it.

5.1.1 The Work Order as a Co-ordination Mechanism

A clerk receives orders from customers and enters these orders into a central computer system, registering delivery date, customer information, etc. Every week another clerk, the planner, sorts the orders in the system by giving priority to the most urgent orders and orders from the most important customers, to ensure that these are processed and shipped quickly. This results in a chronological list of what orders to package each day of the week. Another clerk prints the list, and for each item (i.e, order) in the list a separate work order is compiled and printed. This work order represents the customers order throughout the packaging process and consists of two E-orders, one of which is the actual delivery note and the other is an administrative tool. Furthermore, there is a T-order, which is a bar code version of the E-order for internal use and finally a map of the work floor. The work order is a *co-ordination mechanism* that supplies the operative information a worker needs to perform his work. By existing as only one copy, it insures that no order is handled by more than one worker at the time making the processes sequential, thereby enforcing *the prerequisite constraints* of the packaging process. In conjunction with the board it also regulates the *transfer* between the product-packaging process and the order-packaging process as elaborated on in section 5.2.

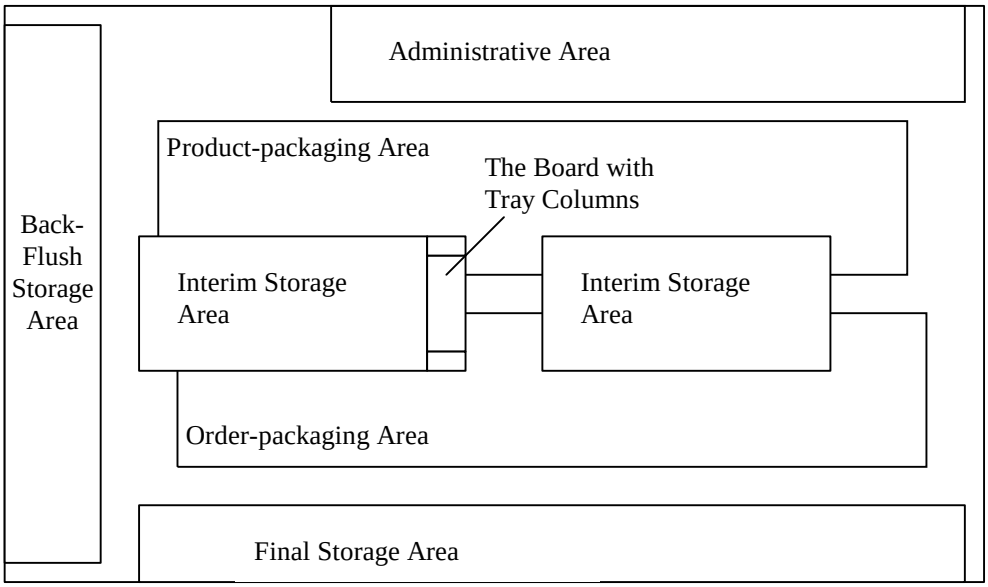
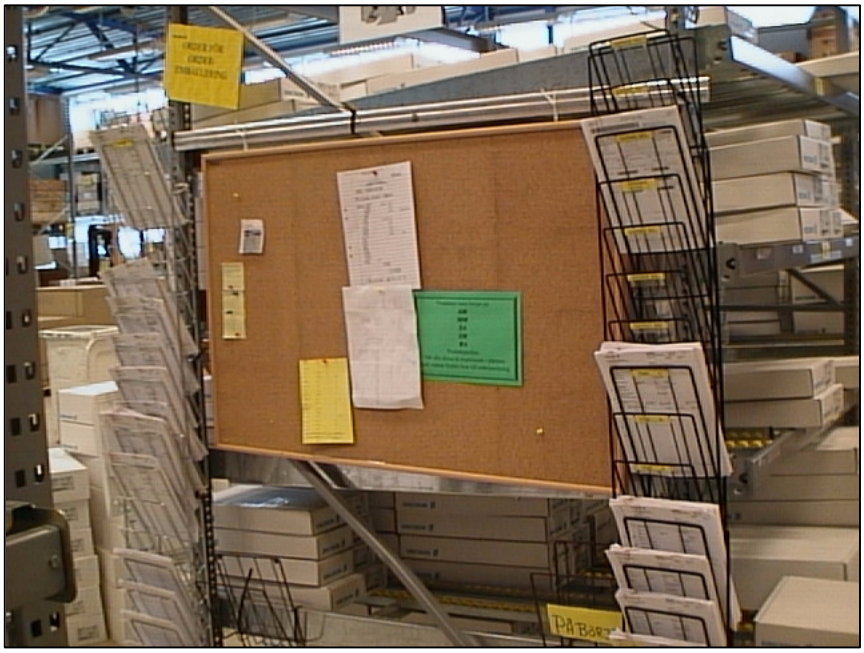


Figure 3: A schematic view of the order-packaging department.

5.1.2 The Board as a Co-ordination Mechanism



Picture 2: The board, without order lists. On the left-hand and right-hand sides are the paper tray columns used both by order-packaging and product-packaging to store work orders in.

The board consists of four different parts: A large notice board and three columns of paper trays. The notice board contains listings of all current orders. These are posted in order to make the workload and the status of each individual order visible to all. This is an example of what Dourish and Bellotti (1992) refer to as *explicitly generated* information for facilitating awareness[3]. This list supplies the workers with enough information to set the pace of work during the week. The board is a co-ordination mechanism that facilitates awareness. The awareness function must be supported in the future work practice.

The first column of paper trays is where work orders are placed when first issued from the planner, the second column is where the work order is placed when the product-packaging process is completed and the third column contains faxes of E-orders with stock information from external plants. The placement of a work order informs the workers as to whether the order should be processed by the product-packaging department or the order-packaging department. The board is co-ordination mechanism that (in conjunction with the work order) co-ordinates the *transfer* of products between processes, as well as enforces *the prerequisite* of the packaging process.

[3] A few weeks after the field study was completed, we returned to the order-packaging department for other reasons, and discovered that there were no longer any listings posted on the board. The number of orders had grown so much in those few weeks that the lists no longer fitted on the board. The awareness function of the board has already been diminished due to the lack of scalability of this particular co-ordination mechanism.

5.2 A Work Order's Journey

This section describes how a work order moves through the order-packaging department. We focus on the work order for the purpose of making the different processes explicit in order to make the *co-ordination mechanisms* visible and thereby making it possible to identify the *co-ordination work* associated with them. The main processes are the *product-packaging process* and the *order-packaging process*.

5.2.1 Product-packaging

The journey of a work order begins when the clerk places it in the product-packaging tray column. Product-packaging is where the individual products are wrapped in carton, together with cables and other standard accessories. The work orders are stored in chronological order, with the one with the closest delivery date in the top-most tray.

When a product-packager does not have any task to perform, he goes to the board and checks the tray column to obtain a new task, i.e, a work order to process. He takes a work order from the top tray and checks what kinds of order items are listed on the work order. The product-packaging department is split into two parts, each responsible for packaging one of two different product families. If he finds any order items that should be packaged by his department (i.e, him) he takes the work order to his work desk and starts to package the products. For each order item there is an index number, indicating what kind of accessories should be included with the product in the same carton. Some clients want manuals, some just need a set of cables and some want no accessories at all. Each carton is labelled with bar codes representing the product number and index number.

The packaged products are stored in an interim storage area. The location is marked on the map included in the work order, and the order items packaged are marked as well. Because there is a large number of combinations of accessories there is also a correspondingly large number of indices. The products are therefore stored in the interim storage area as per order and not as per product number and index number. The growing throughput in the department has made it difficult for the product-packaging personnel to fit all the processed products ready for order-packaging into the area reserved for interim storage. Often they place the products in an adjacent floor area instead. They mark the spot on the work order map with an ”X” and jot down a nearby shelf number next to the mark. It is clear that this work practice will not be able to cope with the growing workload. This is a key scalability issue.

Picture 3: The Interim Storage Area

Depending on whether there are any products from the other product family yet to be packaged, the product-packager puts the work order back in the product-package tray or in a tray in the next column. If he chooses the second option the work order is passed on to order-packaging. This choice is an indication of both the *transfer* co-ordination function (The work order is turned over to order-packaging, by placing it in a tray predefined by the *protocol*) and the *prerequisite constraints* enforcing function (The work order is only passed on to order-packaging if the product-packaging process is completed) of the board, viewed as a *co-ordination mechanism*.

5.2.2 Order-packaging

At the order-packaging department the assignment of tasks works in a similar way. An idle order-packager goes to the board and checks the order-packaging trays for work orders to handle. First he checks the list of order items to make sure everything is ready (i.e, that everything requiring product-packaging has in fact been processed). If there are any products handled at another plant (members of product family C), he checks the E-order faxes in the third tray column. An E-order fax contains a colli number for each order item packaged at another site. If he cannot find any such fax he puts the work order in a special tray with a post-it sticker showing what product is missing. The order will not be order-packaged until all order items from product family C are packaged. (Another example of enforcing the *prerequisite constraints*) The management has decided that the product-packaging should be completed, but not the order-packaging if there are order items missing from the external sites. It sometimes happens that products are stored in the interim storage area for weeks. The process of co-ordinating the packaging when there are products manufactured and packaged at external plants is a problem. This is an issue we identify as important for making the work practice scalable.

Once the order-packager has ascertained that a work order is ready to handle, he first registers the order in a time-measurement machine. This machine is used to divide the labour cost between different customers. Even though the customers are not charged by the hour, the invoice department and the management want information

about how long time each order takes to order-package.

To facilitate the order-package work and ensure good quality a small handheld computer is used. The device works very well, and has increased the quality[4] dramatically. However, the functionality of the handheld computer as well as the connection to the central computer systems is very limited. The bar codes on the T-order are used to scan all order items, quantities and other order information into the handheld computer. There are two bar codes for each order item (item number and quantity) and also bar codes for the order as such (date, order number, customer number etc).

The packager examines the order items and tries to estimate whether the order is to be shipped in one or more collis. If the order turns out to result in more than one colli he should try to split it up with the sequence of the order items on the E-order in mind. However, this is not always the case, since he also needs to optimise the space available in each colli. It is common practice that products that formally should be shipped in colli number two are in fact packaged in the first colli and vice versa in order to save space. The rules regulating this matter are flexible and the order-packager uses his acquired knowledge of ”how things are done” to find a satisfactory compromise between the rules and the need for saving space.

He decides what order items to package first and checks the enclosed map to find out where the products are stored. He selects a free space on the floor area reserved for order-packaging, and there he gathers enough products to assemble a colli. For each product he scans the product number bar code. The handheld computer warns the packager if he forgets to package a piece of an order item since both what products to package and their quantities are stored in the computer. However, if the packagers accidentally package too few items, the handheld computer will not sound the warning until the packager tries to dock the handheld computer. The order-packaging personnel spend very much of their time searching for the items to package. This is due to the fact that the interim storage area is no longer large enough to accommodate all the products that should be stored in it. This has two negative effects: Firstly, all products are not stored in their appropriate shelves, but are instead placed in an adjacent floor area and its approximate position is marked on the map that is included in the work order. Secondly, it means that the floor area available for the actual order-packaging process is diminished.

To sum it up, we discovered that not only does the increase in interim stored products make it more difficult to find the products listed in an order, but it also hampers the order-packaging process itself by reducing the available floor area usually reserved for this process. Both factors contribute to lower work efficiency. This is a very important issue from our scalability perspective. The co-ordination mechanism supporting the transfer of products between the product-packaging and the order-packaging is the map in the work order depicting the interim storage and the product’s location within it. This co-ordination mechanism is not working well even today. When the workload increases the transfer between the processes will most likely break down.

In addition to the two product families that are interim stored, there are a number of standard products stored in another storage area called the Backflush storage. The products in Backflush storage are not stored according to any system at

[4] By quality we mean the proportion of packaging errors, i.e., missing products in a shipped order or wrong products included in a shipped order. This proportion should of course be as low as possible.

all. When arriving they are simply placed in a convenient empty space. In order to find the items to be packaged the order-packager either remembers where the products are or has to confer with a colleague. Usually there is someone around who knows where they are. If this is not the case the packager has to search the Backflush storage in order to find them, and since it is rather large it may take quite a while. Spending fifteen minutes searching for a specific product is not unheard of. The Backflush storage is an issue that must be addressed. This is not functioning efficiently today, and it will become even more difficult to find packagers that have knowledge about where products are stored when the scale of operation increases. This means that it will take even longer to find the right products unless the situation is remedied. IT-support is needed to co-ordinate storage and retrieval from the storage.

Some packagers use the handheld computer to count standard products to be sure they get the number right. If the packager tries to scan too many products the handheld computer sounds a warning.

Sometime during the process the order-packager also has to mark the cables (if included in the order) with the appropriate colli number. To do this he has to leave the building and walk some hundred yards to the out of doors tent, which houses the cable drums. The cable drums are not stored there according to any system what so ever. He has to search through the entire tent in order to locate the drum marked with the correct order number. This can sometimes take up to half an hour according to the workers. Once the correct drums are located a note with a colli number is attached to each of them. When the order is to be shipped the forklift driver has to locate the cable drums again causing the whole process to slow down even more.

Once a colli is fully assembled the packager prints out a number of labels at the label printing station. The colli is labelled with bar codes representing the colli number and order number and a label with delivery address. Depending on the destination a label with content information and another label with customer specified markings may be attached to the colli as well.

The order-packager then measures the height of the colli (due to the standard size of a pallet he does not have to measure the width and length of the colli) and writes down the figure on the colli. He uses a special pallet truck with built-in scales to weigh the colli and jots down the figure next to the dimensions. These figures are then copied onto a weight list. If necessary, the packager also uses a special machine to wrap the colli in order to make it sturdier during transport. He then separates one of the E-orders from the work order, stamps the colli number on it and puts it in a small plastic bag together with a quality report form, also stamped with the colli number, and attaches it to the colli. The remaining E-order is given to an administrator. If it is an international shipment, the administrator faxes information about the consignment to the company speditor.

If the colli is to be shipped within the country a consignment note is written using an ordinary typewriter. The note contains the following information: address, order number, number of collis, volume and weight. The consignment note, which is sticky on the back like a post-it note, is then attached to the colli. The colli is placed directly in the loading bay by the packager himself.

If it is an international shipment the forklift will collect it and place it in final storage, where it will remain until the speditor arrives to collect it.

The packager docks his handheld computer and downloads the packaging data into the central computer system. He walks over to the board and marks the packaged order items on the order listings with a magic marker. When all order items of a given

order are marked, the packaging process is completed. Sometimes this takes a while since products from external sites may be late in arriving.

The packager takes a new order from the board and the process begins again.

5.3 Key Issues

The following table contains a summery of key issues identified during the analysis of the field study. The "Type of issue" column in the table refers to the classification defined in chapter 4.1.

1. *The co-ordination work that functions poorly.*
2. *The co-ordination work that still functions, but which is likely to collapse with only a minor increase in workload.*
3. *The co-ordination work that functions satisfactorily, and is likely to cope with an increasing scale of operation.*

Issue	Type of issue	Description
The overview function of the board is diminishing	1	The overview is important to set the work pace. Until now it has been working well, but now another solution is needed due to the growth.
The interim storage is not well functioning	1	It is impossible to store all products in the small interim storage. Due to the growth the problem will become even more severe as time progress.
Order-packaging / external site products co-ordination is difficult	2	The co-ordination is barely functioning today and with an increasing scale of operation a lot of time will be spent on deciding whether all products have arrived so that the order-packaging process can begin.
The workers have to search for products in the interim storage	1	It is difficult to find the products in the interim storage area today. It will be even more difficult when the scale of operation increases.
Work orders disappear	2	It sometimes happens that work orders disappear. Sometimes they are packaged into a colli, sometimes they are dropped under a shelf. As the number of orders, and thereby the number of work orders increase it is likely that the numbers of disappearing work orders will increase as well.
Stop orders are difficult to issue	2	Today the clerks have to find the work order manually. It works since it is still a small department. When it grows it will take longer time to find the work order.
The Backflush storage area is not working properly	1	The Backflush storage is not well functioning today. As the workload increases it will be even more chaotic.

Issue	Type of issue	Description
The final storage area will not work properly when scaling up	2	The final storage works very good today due to the IT-support. When the scale increases, some problems will arise due to the limitations of the current IT-support.
The cable handling is not working properly	1	The cable handling is not well functioning today. It takes a very long time to find the right cables, and there are two persons that have to find the cables at different times: The order-packager and the forklift driver.

Table 1: Identified key issues affecting scalability.

6 Analysis and Design: The Design Proposal

In this section we discuss our design suggestions. We start off by describing the co-ordination mechanisms (6.1). Changing the co-ordination mechanisms affects the two main processes, product-packaging and order-packaging. This is addressed in 6.2 and 6.3. Before discussing the technology elements of our design (6.5) we present a redesigned storage management system (6.4).

6.1 Co-ordination Mechanisms: The Board and the Work Order

A central mechanism for co-ordination and awareness of the current work practice is the board. The board is used for getting an "at a glance" overview over the workload, to provide information about the different processes ranging from production to delivery, and information about why a delayed order has not been packaged.

All orders for each day are printed as lists, which are tacked to the board. Due to the increase in order volume, these lists have become problematic to manage, and they are no longer displayed because they have become to long for the space available on the board.

Because of the increase in orders there is also a corresponding increase in the number of physical paper work orders in circulation at any given time. This makes it difficult to raise stop orders (searching for the work order takes time) and also causes some work orders to disappear (there are a great many paper work orders to keep track of).

Each work order consists of a map where the location of each order item stored in the interim storage is marked, two copies of the delivery note (called the E-order), and a bar code version of the delivery note (called the T-order) for use with the handheld computer. The work order follows the process of the order, both to provide information about the order and to co-ordinate the different processes of packaging the order.

We suggest that the board is replaced in its entirety by a computer system consisting of one or several large computer screens and a large number of handheld computers connected to a central server via a radio based LAN. The screens will display awareness information such as the number of order to process during the day, how far along in the process orders are and so forth. Basically it is replacing the listings function of the board and since it displays statistics generated from the central computer system it is possible to display this in new and interesting fashions.

The work orders information will be downloaded directly into a more sophisticated version of the workers handheld computer and is displayed as lists of items to package. This way the paper-based co-ordination would be removed. The T-order will disappear since the functionality of the T-order is to provide data for the handheld computer used today. This solution does not only eliminate the need for a cumbersome paper based work order, but also the need for scanning every single order item of each order into the handheld computer before the actual packaging work can begin.

If a handheld computer with a large graphical display is used the map previously included in the work order could be shown graphically on the handheld computer. It is also possible to use a system of co-ordinates to store information on

where different products are located.

Since all the order information is stored on the server there is no need to print the E-order until it should be attached to the colli at the very end of the packaging process. Using this system all the information, both co-ordinating and awareness generating, can be accessed and displayed electronically eliminating the paper based co-ordinating mechanisms causing problems today.

Since all events are registered and reported electronically to the server, it is also possible for the administrative staff to access the system and see whether the handling of an order has begun and how far along in the packaging processes it has come. If necessary the staff can send out stop orders directly to the packager via the handheld computer and tell him to stop working on the specific order.

This also rids the packager of the paper handling at the end of the process where he checked off the packaged order on the notice board and turned the work order over to an administrator. This is automatically handled by the computer system.

This eliminates many of the problems arising in the order-packaging process today. It not only allows the packagers to work more autonomously but also to be more efficient since much of the searching conducted today is eliminated. The operative information needed to perform the packaging process is immediately available in an updated form. This is clearly an improvement compared to the current paper based work practice.

6.2 Product-packaging

The reason for having a separate product-packaging process is that some customers want their products configured in a special ways. They may also want different sets of accessories. We have identified no serious problems with the product-packaging process per se, but how the process is conducted has a serious impact on the interim storage area, where the processed items are placed until they can be handled by the order-packagers. Until now it has been easier to interim store the products according to which order they belong to, as opposed to what product number and index they have. This system worked very well as long as the number of orders was relatively low and the number of different configurations was large.

Today the number of orders is ever increasing and storing order specific products gives a much more complex storage system than if only standard products where stored in the interim storage area. The space available in the interim storage is limited and it has currently spread out into adjacent areas, stealing workspace from the order-packagers. The location of products not placed on reserved shelves is not covered in the E-order, thus the need for ad hoc markings on the enclosed map. As a consequence it takes the order-packagers a long time to find the products, and since each product is tied to a specific order it is essential to find the exact item, not just one with the right product type and index number.

It is vital to find a solution where interim storage of large quantities of order specific products is not needed. Some products must still be manufactured and configured for specific customers, but our ambition is to remove the direct relationship between the product-packaging process and work order.

We suggest a change in the product-packaging process, which will result in an interim storage with standard products. The products will not be stored as per order, but rather as per product type and index number. When the order-packager needs a product he only has to locate the right product type, not a specific item.

According to the product-packagers non-standard orders make up less than 20% of all products passing through the department. A proportional part of the interim storage area will dedicated to storing these special items as per order.

The new product-packaging process will be arranged as follows.

The product-packagers will get their tasks directly from the computer system, as opposed to the indirect route by work orders taken today. The product-packagers' assignments will be based on stock information and on what orders are to be shipped in the near future. This way the interim storage will be both simply ordered and kept as small as possible, yet always have just enough products in stock for the order-packaging department.

The new design does not affect the current work activities as to *how* products are packaged but only as to *what* products are packaged. This way as much as possible of the product-packaging competence is preserved.

This design suggestion allows the product-packaging process and the order-packaging process to become more loosely coupled, thus decreasing the need for co-ordination. It does however place great demands on the information systems supplying the product-packaging process with tasks to perform.

6.3 Order-packaging

The new order-packaging process we are proposing begins when a packager turns on his handheld computer connected to the departments server by a wireless LAN. He enters a request for a new order and receives one automatically. From now on he is the person responsible for this specific order. He immediately gains an overview of the order size and composition. He is also notified as to whom the customer is.

At a push of a button the order is displayed as a list of items to package. The handheld computer can sort the list depending on different criteria of the order items, perhaps he wants them ordered by product number or by what storage area he is to collect them from. Each order item has up to date location information supplied by the server over the wireless LAN. As the listed products are picked up they are scanned using the scanner on the handheld computer. The packager can choose whether he wants to collect all the order items first and then assemble the collis or if he prefers to collect the items as per colli. The handheld computer must therefore be able to handle other functions while the task of collecting order items is still unfinished. It shall however clearly tell the packager that the entire order is not yet finished so that the packager does not risk missing items.

We also suggest that label printing can be initiated from the handheld computer. The software controlling the label writer must be connected to the other systems. That way the packager can be notified as to special cases, such as a certain customer wants a label of contents on a particular colli.

When the packager wraps the colli, he should be able to estimate the height of the colli from markings on the wrapping machine. Both height and weight is noted in the digitised version of the weight list using the handheld computer.

Once a colli is fully assembled the packager makes a note of this on his handheld computer. A message is immediately sent to the forklift driver who collects the colli and places it in a suitable position in the final storage area.

This design suggestion leads to reductions in the amount of co-ordination work the individual order-packager has to perform, allowing him to concentrate on the work activities. With better co-ordination mechanisms and higher quality operative

information he can accomplish his productive tasks much easier and more efficiently as well.

6.4 Storage Areas

Only the final storage area works satisfactorily today, much due to the truck computer system. We propose a more extensive computer system, which is integrated into the overall information system by a wireless LAN. There are two reasons for this. Firstly, the current fork lift computer has all storage information on its hard drive and this data is not available unless you interact directly with this isolated computer. Should the department purchase a second forklift this system breaks down since there is no way to keep the storage information consistent. With the connection to the department server this information can be stored in a common database and accessed and maintained from any number of computers. Secondly, the forklift computer will also be able to send and receive messages just like the handheld computers.

There are three other storage areas, which are not working well. These are the Backflush storage area, the storage area for product family C and the cable storage. They all suffer from lack of structure and are all entirely without computer support. This we intend to amend by using the system from the final storage area here as well. Thus we make all the storage areas in the department accessible for stationary computers as well as handheld computers. By increasing the quality and availability of the storage information we reduce the time spent searching for products.

6.5 Technology

This section is included since it is an integrated part of the suggestion presented to the company. It is basically a clarification of the design described above. The choice of what brand the wireless network or the PDA should be is not within the scope of this thesis.

6.5.1 System architecture

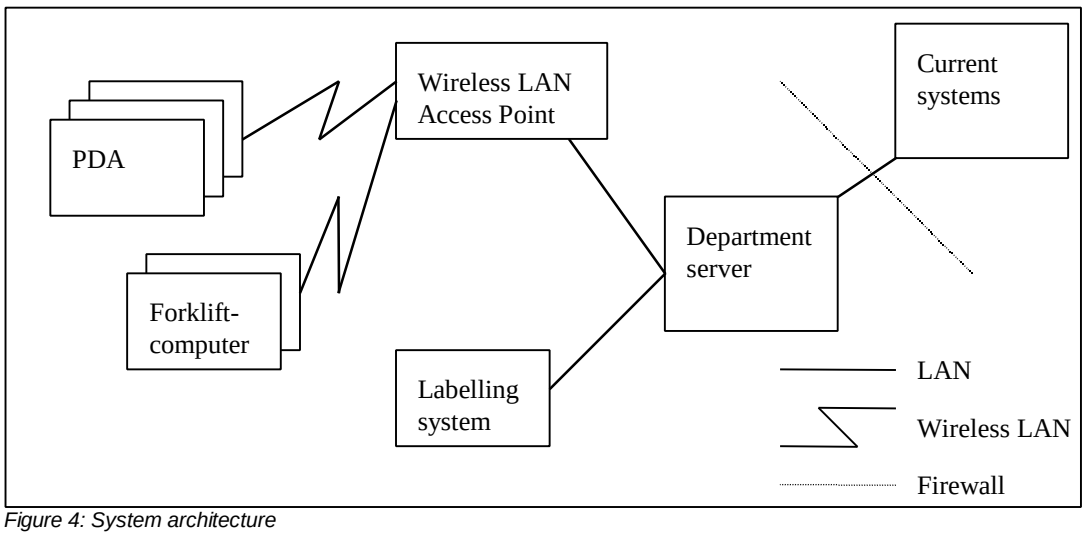


Figure 4: System architecture

We suggest a simple and open architecture to make the system as scalable as possible. It should be easy to update and extend the system with new modules. Using open standards will decrease the cost of the system. The use of a web-based solution means

that several important functions are implemented and integrated in the web server functionality. The clients can use a standard browser, which will lower the administration costs of the clients. Only the business logic must be developed in house.

6.5.2 Department Server

Our solution is based on wireless LAN. Wireless LAN creates a security problem for the company, since radio waves may leak outside the plant. This is not acceptable to the department.

To keep the security at an acceptable level we choose, after meetings and discussions with the computer department, not to design the system as directly connected to the current systems. We therefore need a database on the department server replicating the relevant data from the current central systems.

The use of a replication server with two different network cards (one connected to the current network and the other to the local packaging network) provides an acceptable level of security, while the proposed system does not suffer much in ways of functionality.

There will also be a number of server applications handling the information flow between the server and the clients. The figure above (figure 4) shows a schematic picture of the architecture of the packaging system.

7 Discussion

7.1 Summary

The objective of this thesis is to establish what work practices need to be changed to support a higher scale of operation at the order-packaging department of the company.

In order to accomplish this we have made two basic assumptions:

1. There must be another way to achieve scalability than using a radical approach such as BPR. We therefore turn to the cultivation approach.
2. The workers perform their tasks well, but the department is still experiencing problems. We therefore assume that it is the organisation of work that is not well functioning. We study the organisation of work using co-ordination theory.

Based on these assumptions we have identified the following key issues affecting the scalability of work at the department:

- The overview function of the board is diminishing
- The interim storage is not well functioning
- Order-packaging / external site products co-ordination is difficult
- The workers have to search for products in the interim storage
- Work orders disappear
- Stop orders are difficult to issue
- The Backflush storage area is not working properly
- The final storage area will not work properly when scaling up
- The cable handling is not working properly

Our design proposal for achieving scalability by addressing the identified key issues listed above, is composed of the following parts:

- *Co-ordination mechanisms*
  The work order and the board should be implemented in a computer system. The co-ordination mechanisms and awareness functions will be supported by this system.
- *Product-packaging*
  The product-packaging process is changed only as to how task assignment takes place.
- *Order-packaging*
  The work activities remain basically the same, but with improved IT support the co-ordination work is augmented as well as simplified from the workers point of view.
- *New technology*
  In order to implement the changes we suggest, a number of new technologies must be used. Among other things a wireless LAN is to be installed and new more powerful handheld computers must be used.

7.2 Conclusion

We have now presented a design proposal based on the Designing for Scalability method, a method we have developed for this specific case. The method is based on co-ordination theory applied to the results of an ethnographically oriented field study. The main point of this proposal is to achieve a scalable work practice by changing the co-ordination work rather than the work activities as such.

We have submitted the proposal to the company. They have expressed their approval of the design and will incorporate our suggestions in their plans for future change.

Therefore, our conclusion is that by using our Designing for Scalability method, it is possible to achieve a scalable work practice without resorting to a more radical approach.

7.3 Reflections

The Designing for Scalability method is made up of several different theories and methods. These include co-ordination theory and ethnography. In this section we will try to elaborate on the possibilities of generalising the Designing for Scalability method.

The use of co-ordination theory turned out to be a powerful tool for analysing the work practice from a scalability perspective. Inspired by Carstensen (1994) we decided to discuss work by dividing it into co-ordination work and work activities. The assumption we made was that by restructuring the co-ordination work and co-ordination mechanisms we would achieve a scalable work practice, while retaining as much as possible of the current work activities. Even though it was sometimes difficult to make the distinction between work activities and co-ordination work it was well worth the effort. This distinction facilitated the analysis of the dependencies between the different activities and processes at the department, as well as the designing of new and more powerful co-ordination mechanisms to support well functioning work activities.

Applied to this specific case the Designing for Scalability method proved to be a useful tool. We cannot however make any statement as to the methods applicability in any other case. In order to make such a general statement about the method we need to conduct further empirical studies, applying it to a number of different cases.

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