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# Dependencies between Work Activities, Technical Artifacts, Space, and Work Organisation: Flexibility issues

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## Abstract

*In order to better understand the role of a computer application in organizational setting, we propose a conceptual framework. The framework focuses on four different aspects of an organization—work activities, technical artifacts, space, and work organization—while at the same time addressing the dependencies between these elements. An additional concern is not only to uncover the dependencies of one element on another, but also to understand how the flexibility of one element affects the other elements. The applicability of the framework is demonstrated by analysing a specific organization, the radiology department at a hospital.*

## 1. Introduction

Our starting point is rooted in the idea that information technology needs to be seen in the context of its use in specific work situations. Instead of the technology bending to work practices we see technology as part and parcel of the surrounding work situation. The idea of viewing computer support in the context of the workplace is outlined in the book *Design at Work* (Greenbaum & Kyng, 1991). Here we build on three fundamental concepts:

- Contextual analysis requires seeing technology and activities as situated actions, in the sense that the use of computer tools depend on the situations they are used in.
- Work is fundamentally social, requiring extensive communication

and co-operation between the people involved.

- Work activities are not easily describable and the complexity of activities are generally only known fully to the people involved.<sup>1</sup>

More specifically we assume that:

- Tasks can and will be done differently by different groups of people using the same system;
- There will be emerging situations that don't fit existing rules; and
- Different departments within the same organization may do things differently using the same tools and procedures.

In this paper we develop and apply a conceptual framework focusing on the dependencies between work activities, technical artifacts, work organization, and physical space. We focus on the technology for obvious reasons and extend our concern to include other kinds of technical artifacts as well.<sup>2</sup> Historically, work organization has proved to be of significant importance when studying technology in an organizational context and, recent studies have indicated the importance of taking physical space into consideration as well. However, we do not claim that these aspects are the only one of interest when introducing computer artifacts in an organization, but as will be demonstrated in the case study in the last part of the paper, focusing on these aspect have provided valuable insight into the use of technology. The purpose of the framework is to provide others with a platform for reflecting on the use of computer artifacts in an organization.

The framework applies the basic distinction between process and structure.

The structural elements (i.e. technical artifacts, space, and work organization) provide the conditions for the work activities by inhibiting or enabling the process (the work activities). On the other hand the work activities themselves may modify the technical artifacts, space, and work organization. Between the various structures (i.e. technical artifacts, space, and work organizations) there is another kind of interdependency. An aspect of one structure may restrict what is feasible in the other elements, and an aspect of one structure may compensate for deficiencies in another element.

In addition we apply the framework as a vehicle for addressing *flexibility* issues—flexibility in the sense of the potential for making the kind of mutual adaptation mentioned above together with the potential for coping with dependencies among the structural elements. That is, our particular concern is not only to uncover the flexibility or lack of flexibility of a single element, but also to understand how change in one element may either trigger or constitute a barrier for change in another element.

We have applied the framework during our investigation of the Radiology Department at a large municipal hospital. The setting constitutes a rich opportunity for applying the framework. Numerous professions and trades are at work: medical doctors, nurses, secretaries and other occupational groups. Information is available in various media: digitized pictures, analogue pictures, recorded speech, video, paper forms etc. We entered the organization around the time of the introduction of a new PACS (Picture Archive and Communication System) system and during the period

when the radiology department was planning a move into a new wing within the hospital.

The paper unfolds as follows. After a description of the context of investigation we present the background of the framework. Then we lay out the framework itself, followed by a set of specific examples of applying the framework at the Radiology department.

## 2. Context of the Investigation

The context of the investigation is formed by the organization in question, the specific systems development project taking place, and our research agenda.

### 2.1. The Organization

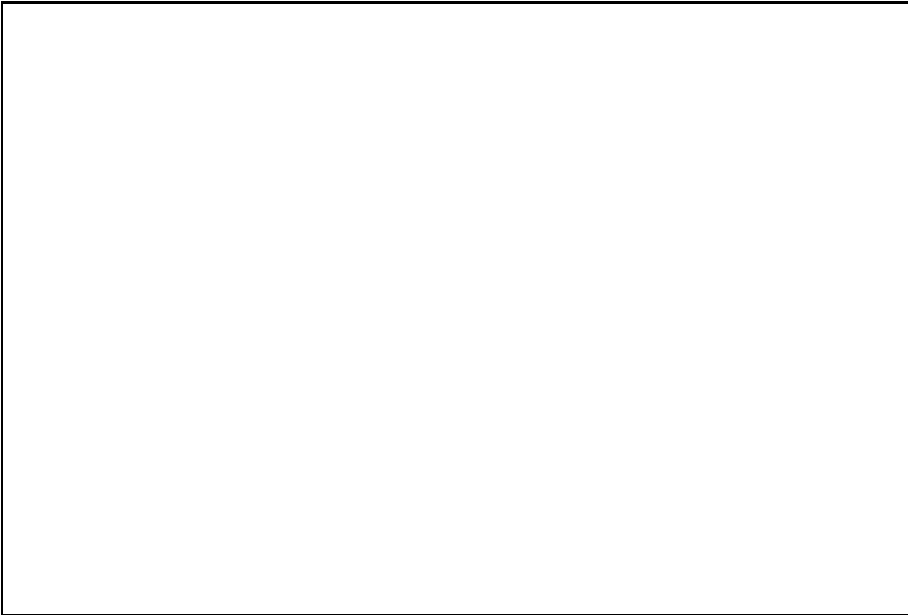
The investigation was conducted at the radiology department of the local county hospital. The radiology department offers a number of sophisticated examinations using a variety of technologies beyond conventional X-ray radiography. During ultrasound examination sound waves are projected into an area of the patient's body and the returning echoes are converted into electronic signals which are interpreted by a computer as an picture displayed on a monitor. Other examinations combine the injection of iodine dye or other chemical substances into the blood vessel followed by a rapid series of X-ray pictures taken to track the movements of organs, for instance the heart. Still other imaging devices, for instance digital subtraction angiography (DSA) combine conventional radiography and computer image processing to produce images of anatomical structures. Computer aided tomography (CAT) produces images of cross sections of the

body by taking X-ray pictures from a number of angles.

Radiologists (i.e., physicians who have specialized in radiological examinations), secretaries, radiographers (i.e. nurses who have specialized in radiological examinations), and nurses are the main staff categories of the radiology department. Radiographers carry out examinations either on their own or together with radiologists. The most complicated examinations, including those involving incisions and catherization, are carried out by radiologists. The radiologists are also responsible for approving the examinations requested and for reporting on the X-ray pictures. The secretaries handle the administrative work including receiving referrals for examination, filing and retrieving referrals as well as hard copies of pictures, and type the X-ray reports dictated by the radiologists.

No patients come directly to the radiology department; they are initially admitted through one of the other wards. Requests for examinations are phoned from the ward to the secretary responsible for scheduling examinations (requests for emergency examinations are directed to the radiologist on duty). A referral is also sent via internal mail. The day before the examination one of the secretaries retrieves the referral and, if available, previously taken pictures. In the morning the chief radiologist on duty reviews the examinations requested, and if required notes, which further examinations are needed. After the examination has been conducted one of the radiologists reports on the X-rays. The X-ray report is typed by one of the secretaries immediately afterwards. During X-ray conferences results are discussed by the radiologists and the physicians from the

**PICTURE 1. Displaying analogue pictures**



ward. Conferences are conducted for the specific ward in question, for instance I-conferences for patients from intensive care and C-conferences for patients from the cardiology ward.

#### *2.2. The Systems Development Project*

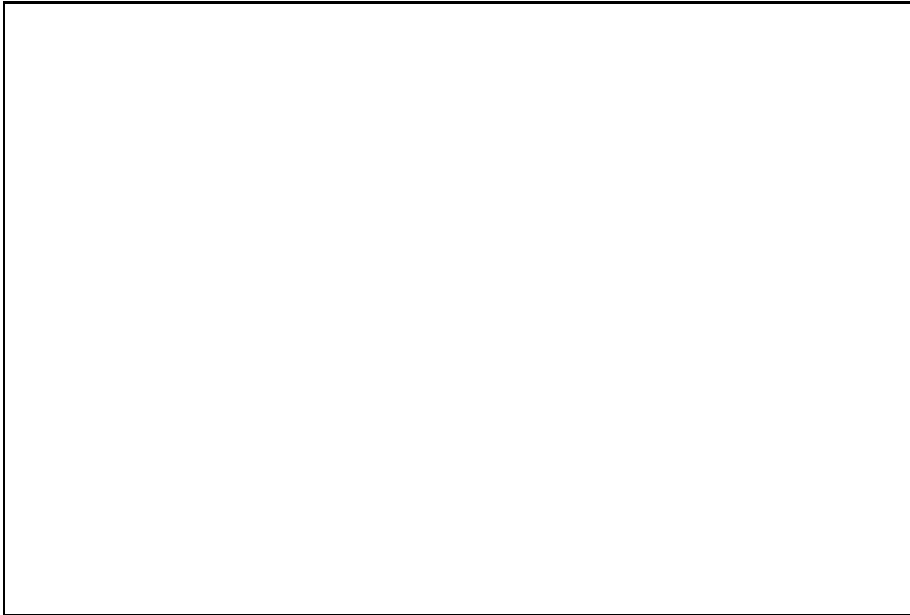
The Radiology Department is test site for the introduction of new PACS hardware and software. Picture Archive and Communication Systems (PACS) are quite new, representing a change in media; rather than using film-based pictures (Picture 1), they process digitized pictures which can be stored and transferred directly to computer screens (Picture 2). The new imaging systems are expected to process a wide range of radiographic pictures including X-rays, ultrasound, and CAT scanning.

One of the intended advantages of digitized X-rays and other medical pic-

tures is that they can be easily stored, retrieved and transmitted to other departments within a hospital. A major concern of radiology departments is the time lost trying to locate pictures that are sent on loan to other departments or to other hospitals.

The department while interested in applying the new technology was aware of the fact that the introduction of the new system can have far-reaching effects throughout the department and the hospital. The situation was further complicated by the radiology department's planned move to a larger building and the efforts of the hospital's computer department towards developing an interface between the existing Hospital Information System (HIS) and PACS.

**PICTURE 2. Monitors displaying digitized pictures**



### 2.3. *The Research Agenda*

In the early fall of 1991 we were contacted by the Chief of Radiology who was interested in getting documented the (hopefully positive) effects of the new technology.

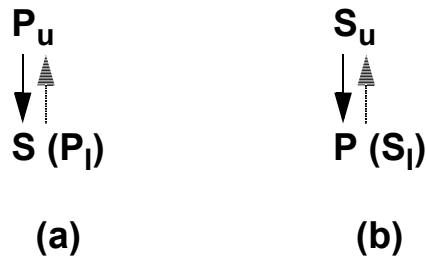
A meeting was set up between us and the radiology department's PACS Group (made up by the chief radiologist, the head nurse, the chief secretary and a radiographer who is the local PACS super user). The group is responsible for coordinating the introduction of the new system, including providing feed-back to the vendor.

During a series of meetings over approximately half a year the contents and the nature of the project were discussed and negotiated between us and the PACS Group. Initially there was some discrepancy among the parties involved concerning the nature of the project. The

chief radiologist expected a purely analytical project in no way affecting the use of PACS at the department. We, on our side, argued in favour of a participatory project involving staff members with a day to day work experience; an approach which was likely to affect their perception of the situation at the department including PACS.

The controversy was resolved when we clarified our research approach. Our interaction with people from the department participating in the project would affect their perception of the situation, but it was the departments own decision whether to change work procedures, change PACS requirement, or formulate other systems requirements. Since action planning and action taking were not an integrated part of the project it was not an action research project, cf. Susman and Evered's Action Research Model as

FIGURE 1. Process–Structure views



discussed in (Baskerville & Wood-Harper, 1992).

The project at the hospital evolved from our initial research interests in flexibility issues and incorporated the needs of the radiology department to understand the implications of use of PACS technology. The hospital's move of its radiology department to new a building gave reason to look at the use of physical space. In addition, the PACS system was just one of a number of new types of equipment being introduced, and this fact motivated us to consider technical artifacts as a broader element for study rather than relying on a traditional definition of technology. And as it often happens when new technical artifacts are introduced, organizational changes were initiated, which made it particularly relevant to look at work organization. Hence, in part driven by our research interests, the goal of the project was to focus on the dependencies between the element of the framework with an additional concern for flexibility aspects of the elements of the framework.

### 3. Background

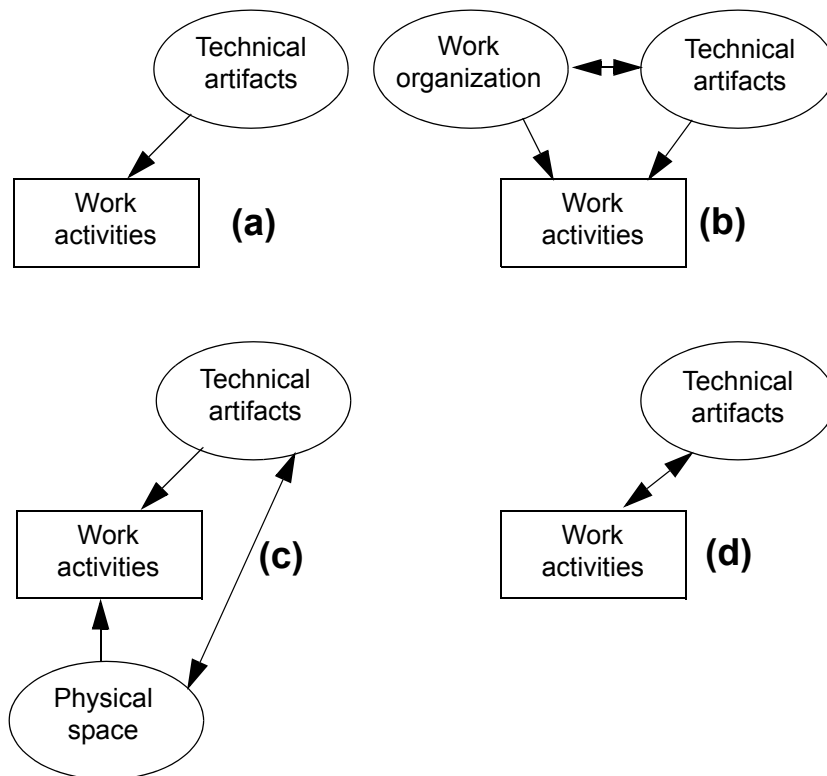
Mathiassen (1981, 1987) distinguishes between a structure perspective and a process perspective on an organisation. The *structure perspective* emphasises the relatively stable aspects of the organisation, covering the formal structure of the organisation, the division of labour, the technical artifacts, etc. The *process perspective* emphasises the dynamic aspects of the organisation.

To address the complex interplay between the relatively stable aspects of an organisation and the dynamic aspects, Mathiassen introduces two different *process-structure* diagrams, capturing the dialectics of the two aspects, Figure 1.

In Figure 1(a) the focus is on the structural aspects (S), i.e. the relatively stable part. The lower process ( $P_l$ ) behave within the structural frames of S. The upper process ( $P_u$ ) strives at changing the structure S (solid arrow), but the structure may inhibit those changes (dotted arrow).

In Figure 1(b) the focus is on the process (P) which aims at changing the lower structure ( $S_l$ ). The upper structure ( $S_u$ ) may both inhibit and enable the process (dotted arrow), at the same time

FIGURE 2. Elements of the framework



there may be other parts of the processes which aims at changing the upper structure (solid arrow).

Mathiassen's specific purpose for introducing the distinction between process and structure is to analyse the conditions for introducing computer systems in an organisation and for the systems development process in particular. Our concern have been to study how work activities are carried out in an organization, but rather than addressing the general organizational conditions for work activities we focus on three aspects: Technology, Work organisation and Physical space. Hence, we have chosen to focus

on these selected structural aspects of an organization while at the same time consciously leaving out other aspects, for instance the role of management and organizational culture. Our specific focus is motivated below.

### 3.1. Technical artifacts

Building technology that supports work activities is the apparent goal of software engineering and information systems design, Figure 2(a). As Ehn (1988) phrases it

"... in designing artifacts we do not merely design the artifacts themselves: deliberately or not, we also design the



conditions for their human use."<sup>4</sup>

In many cases technology does support work activities in an efficient and productive way, but in numerous instances technology disrupts work, (Bjerknes *et al.* 1987). For instance, Klein & Alvarez (1987) discuss the productivity and counter productivity of hotel information systems, and Perby (1987) questions the significance of the influence of computerization on improvements in weather forecasting. Poor fit between technology and work activities seems to be rather common, not an exception. More generally, Göranson *et al.* (1982) contains a description of the changes in the jobs when introducing a new computer based system to support the social insurance and security system.

We prefer the term technical artifacts to the more narrow word 'technology' since the tools that support work include a wide range of artifacts including, for example, the telephone system, various paper-based documents and wall charts. At the radiology department the technical artifacts include both the conventional X-ray equipment and the new picture imaging system, as well as existing information systems, and other tools and devices used to carry out daily work. The head nurse, for example uses a scheduling board made out of Lego blocks to show daily and weekly assignments. While such a schedule *could be* included in a desktop computer system, the Lego scheduler is a visual reminder which is easily read, changed and discussed by the staff during their working day. Seen from the perspective of work activities, this Lego 'device' is no more or less technology than a screen that might dis-

play schedules or a print-out of assigned tasks.

Technical artifacts can be materialized in a different media, including more tangible media like bulletin boards, and wall charts, and more portable media like paper documents, clip boards and note cards. Of course most of these artifacts can be computerized, but the choice of media is crucial for the efficient operation of any organization. In this case, as we describe later on, it is interesting to note how the introduction of PACS system both complements and conflicts with existing artifacts.

### 3.2. Work organization

Work organization includes the formal and informal division of labour among and within the various occupational groups and their skills and qualifications. Work organization is a crucial element in understanding the impact of technical artifacts on the work activities (Figure 2(b)) (Bjerknes *et al.* 1987). In a study comparing the use of the same information systems at two different hotels, Bermann & Thoresen (1992) note that flexible work organization due to overlapping competencies was a crucial factor for the successful use of the information.

When new technical artifacts are introduced at a workplace the work organization often is changed. Bjerknes *et al.* (1990) contains several case stories about the need of organizational competence in system development, but also it illustrates how the work organization will change when a computer system is installed in an organizational setting. Checkland & Scholes (1990) contains case stories based on their use of the Soft System Methodology that also illustrate the need for changing the work organiza-

tion when introducing new computer systems. Though new technical artifacts in some instances lead to de-skilling, the impact of a specific system does not necessarily determine a specific organization of work. On the contrary, what appear to be a negative impact from the technical artifacts can often be resolved by adopting a more flexible work organization (Hirschhorn 1984).

Within the hospital there are contractual as well as union agreements concerning working times and agreed-upon activities for each occupational group. Yet even within the rather formal hospital division of labour there are many informal arrangements and room for departments and occupational groups to arrange their schedules and activities. Among issues that arise with the new PACS system include the future role of radiologists and possible changes in functions performed by secretaries and nurses.

### 3.3. *Physical space*

Use of space constitutes an important element in understanding work activities and technology, Figure 2(c). In a workplace each area has its dedicated function (Holt 1986), for instance the use of storage place, assembly stations, and sales office functions. In the non-electronic environment, physical proximity is a prerequisite for doing tasks, for instance the tools, the materials and the person have to be near each other. A recent extensive study conducted by researchers from Xerox PARC looked at ground operations at a US airport and highlighted numerous instances where a concern for workspace is crucial when coming to grips with work activities, (Brun-Cottan et al., 1991). For instance, smooth co-or-

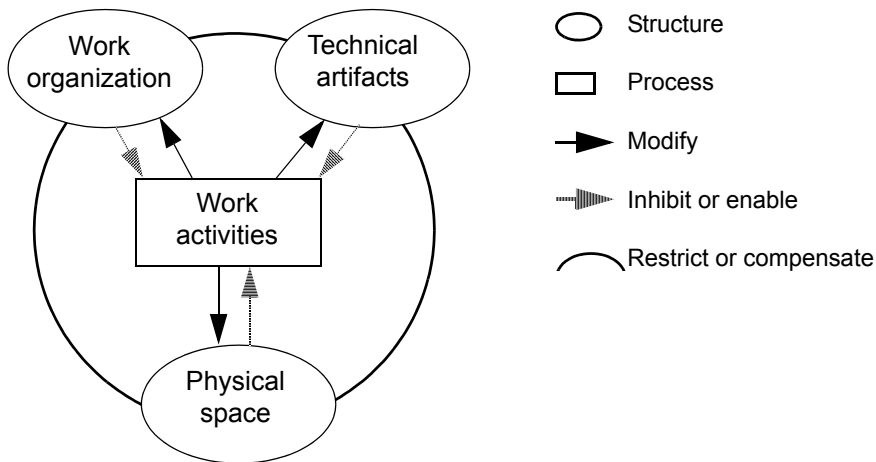
dination and peripheral monitoring was facilitated not only by the technology available but also by the visual space. A similar observation has been made by Heat & Luff (1992) based on their study of Line Control Rooms on London Underground. The work activities of the control room is not only facilitated by technical artifacts like the line plan and the paper time table (with cellophane coated pages for easy mark and erase) but also by the physical layout of the control room. A media space, as defined by Bly *et al.* (1993), is:

“... an electronic setting in which groups of people can work together, even when they are not resident in the same place or present at the same time.”<sup>5</sup>

That is, media spaces are separate physical spaces connected into coherent space by technology supporting numerous space related work activities like having awareness of colleagues, chance encounters, locating colleagues, and group discussions (Bly *et al.* 1993).

In the radiology department at the hospital that we are studying the conference room is central to doctors' daily meetings and briefings about patient status. How the room is arranged, who is in charge of the meeting and where the pictures or X-rays are placed on the lighted screens in the room, all play crucial roles for both carrying out work activities and reinforcing work organisation and division of labour. The new picture imaging system which is being introduced is designed to show the pictures and X-rays on a computer screen. This is both a change in media and a marked departure from the traditional practice of hanging pictures on light screens around the room.

FIGURE 3. The framework



### 3.4. Tailorability

Part of background of the framework include current discussions about tailorability.<sup>6</sup> The idea in designing tailorable applications is to offer the opportunity to adapt the actual application to the actual work practice, and to change this adaptation as the work practice changes. A common way to do this is to design the application using a number of parameters to be decided by the user. The appearance of tailorable applications should be seen as an answer to the problem that standardized applications have been shown to be too inflexible to bend to the diversity of workplaces and varying work practices. Mackay has investigated users adaptation of customizable software and has found that the users not only adapt the technology to the work situation, but they also adapt the work situation to the technology (Mackay 1990). Therefore Mackay talks about technology as a co-adaptive phenomenon, Figure 2(d).

From our point of view, this may be seen as flexibility in relation to one of the structural elements. As lined up in the following section, we see flexibility as a broader phenomenon in the organisation.

## 4. The Framework

Motivated by the essential role played by various combinations, Figure 2(a-d), of work activities, technical artifacts, work organization and space, we propose a framework which provides an approach to address the mutual dependencies among those very elements (Figure 3). The difference between Figure 3 and Figure 2 is a graphical representation of the contribution of the framework as compared to related research.

Basically, what we do is this:

1. Generalize relations or dependencies already acknowledged among one set of elements to be relevant among other elements as well.

2. Address those relations, not in isolation, but with explicit concern for how they mutually affect each other.
3. Incorporate awareness of not only the technology but also work organization and physical space.
4. Apply Mathiassen's (1981, 1987) basic distinction between processes (Work activities) and structures (Technical artifacts, Work organization and Space).

The framework is not meant as a model of reality, but rather as a map or frame of reference useful when addressing the various dependencies among work activities, and the other elements. Applying the process-structure distinction implies two kinds of dependencies. On the one hand a structure (for instance the technology) provides the *conditions* for the process (i.e. the work activities) by *inhibiting* or *enabling* the processes. On the other hand the process may *modify* the structure (compare Figure 1). Mathiassen talks about the relations as contradictions,<sup>7</sup> and some may be so. But we prefer to talk about the relations as tensions or dependencies.

In addition to Mathiassen's concern for the relation between process and structure we address the relation between the various structure parts. Between the various structures (i.e. technical artifacts, space, and work organisations), there is another kind of interdependency. An aspect of one structure may restrict what is feasible in the two other elements, and an aspect of one structure may *compensate* for deficiencies in another element. This kind of analysis seems particularly valuable when uncovering conflicting or contradicting requirements for the three key el-

ements. Informally think of it in this way: changes at one place may affect the space of possibilities at some other places.

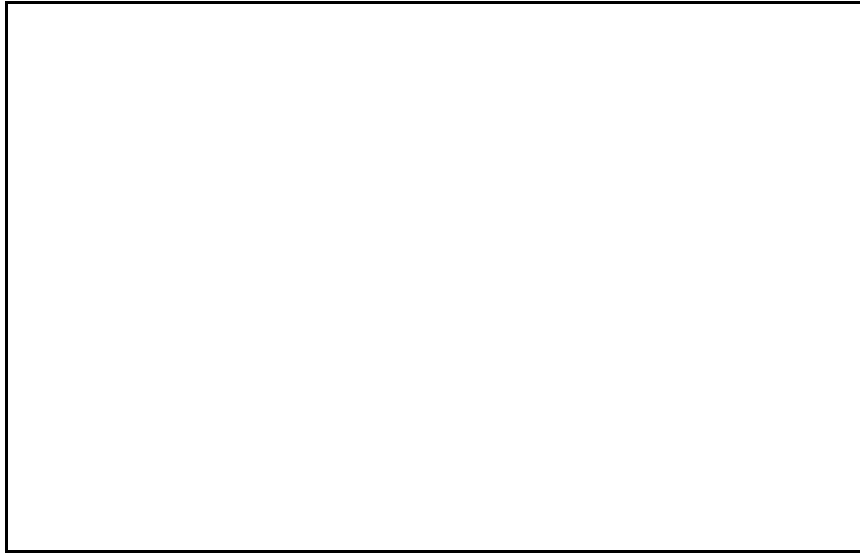
As a consequence, our notion of tailorability, or co-adaptation as Mackay calls it, goes a little further than merely addressing the relation between the work activities and the technology. It also examines the mutual adaptation of the work activities and the physical space, and the work organisation. We use the term flexibility to capture the potential for making such mutual adaption together with the potential for coping with dependencies among the structural elements.

Put in another way our framework covers two points. First, work organization and physical space depend on the technical artifact and on each other. Second, as there are limitations in the possibilities of adapting technical artifacts to the work situation, there also exist both possibilities and limitations for adapting the work organization and the physical arrangement.

To explore flexibility implies investigating not only the multiplicity of the individual structural elements, but also to be concerned about how they mutually are interdependent as well as how they provide both possibilities and limitations for the work activities.

## 5. Applying the Framework

In the following we apply the framework to the case of the radiology department presented in the beginning of the paper. The empirical investigation of the radiology department reported here was conducted during the spring of 1992 before

**PICTURE 3. Viewing pictures in the corridor**

the move to the new building. During the initial investigation we applied fairly conventional techniques like interviews and observations. We conducted 14 interviews with people representing the four professions and staff from both the radiology department and the wards.<sup>8</sup> The focus of the interviews—which were audio taped to facilitate exact reference—was the general work procedures and the roles of the professions involved. The interviews were supplemented with observations at numerous locations including the secretaries' office, the conference room during various types of conferences, as well as the different examination rooms. In addition a series of black and white pictures were shot as documentation of the physical setting before the move. Moreover seven of the staff members from the radiology department participated in two workshops. The focus of the Storytelling Workshop

(Greenbaum & Madsen 1993) was exceptions and deviance from the standard work procedures. In the Future Workshop (Jungk & Müllert 1987, Kensing & Madsen 1991) the focus was visions about the future PACS technology.<sup>9</sup>

Starting at the workplace level we have used the framework to analyse not the organization as a whole, but to demonstrate how the selected structural elements inhibit as well as enable the work activities, and how conditions set by one structural element may be compensated for or restricted by one or both of the other structural elements.

#### 5.1. Example 1

This example revolves around one of the technical artifacts, the pictures produced at the radiology department and the way the media of the pictures and physical space mutually depend on each other.

Analogue pictures are not maintained in computer files which inhibits their use in the work activities. Keeping track of pictures is time-consuming and frustrating for the staff, and a major problem for the radiology department. Pictures can only be at one place at a time, yet sometimes they are needed at different places at the same time, e.g. at the radiological department, when the pictures are made, analysed and described, *and* in the ward. Managing pictures is a time-consuming activity and in some cases pictures simply are misplaced or lost.

On the other hand the fact that analogue pictures and their folders are portable enable bringing them wherever they are needed, e.g. to the ward to discuss with the patient, to the surgery room to be used in relation to an examination or an operation, or to the office or the corridor for doctors to discuss the treatment of the patient (Picture 3). The doctors do not need to be near a display terminal to view the pictures. That is, the tangible nature of pictures compensate for the complex nature of the physical space which otherwise would inhibit work activities. Or in other words the nature of the work organization with a the need for taking pictures to other physical locations to discuss them with colleagues calls for need of portable pictures.

Shifting media changes the conditions for the work activities. Digitized pictures enable easy managing and tracking of pictures at the same time compensating for the complex nature of physical space. For example a PACS system helps avoid misplacing pictures, as well as enabling staff to get access to the pictures from different physical locations at the same time. But it also raises new problems, such as restricting the ac-

cessability of the pictures in physical space since pictures have to be viewed on a display screen (Picture 2).

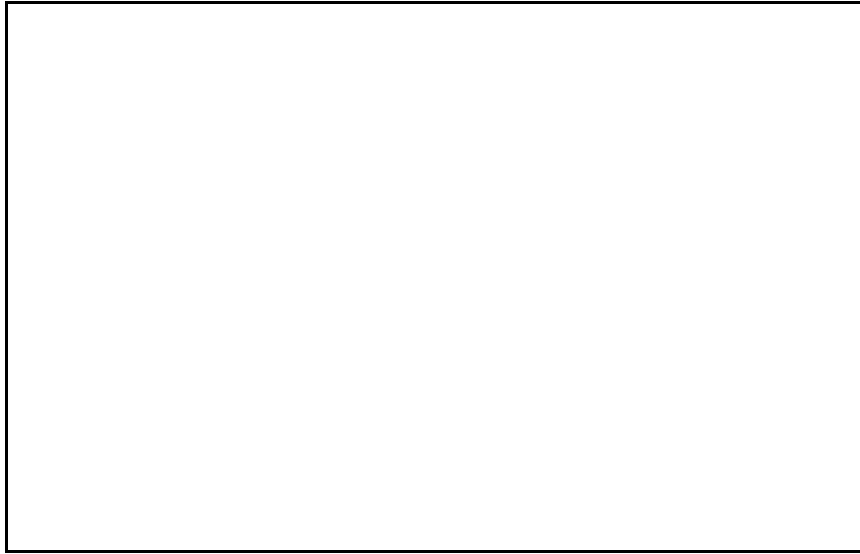
This example raises for discussion the important issue that different work activities may require different media. Some of the problems could be solved technically; for instance, if the doctors need to carry the pictures around this may require printing capabilities in locations throughout the hospital. One trade-off here may be between the additional expense of printers to support work activities like doctors meeting in the hallways, versus screen pictures which may limit doctor mobility. As mentioned and illustrated here, a technical solution to problems in some work activities may raise new problems in other work activities.

To summarise, analogue pictures—in different circumstances—enable as well as inhibit the work activities, the tangible nature of pictures compensate for the complex nature of the physical space. In contrast, changing the technical artifact to digitized pictures compensate for the nature of physical space by enabling access to pictures at a number separate physical location at the expense of restricting portability in physical space.

### 5.2. Example 2

This example concerns the physical location of one kind of examinations and associated work organization.

Before the move to the new quarters, there was a physical distance between the main part of the radiology department and one of the examination rooms. This examination room was located in a separate building because of lack of space in the main area.

**PICTURE 4. Booking examinations**

A secretary in a separate building was only required sporadically and the physical distance limited the extent to which the secretaries in the main part of the radiology department could assist the radiographers in the remote examination room. Due to the distance, the department had adapted the work organisation in relation to those examinations by having the radiographers register the actual examinations conducted, a task conventionally handled by the secretaries. While some would argue that the work could alternatively be handled, for example, through a communications link to the other examination rooms, such a technical solution has not been adopted.

To summarize, the radiographers have adapted their work organization to compensate for the physical distance between the separate building and the main part of the radiology department. Alternatively, a technological solution could

have compensated for the physical distance.

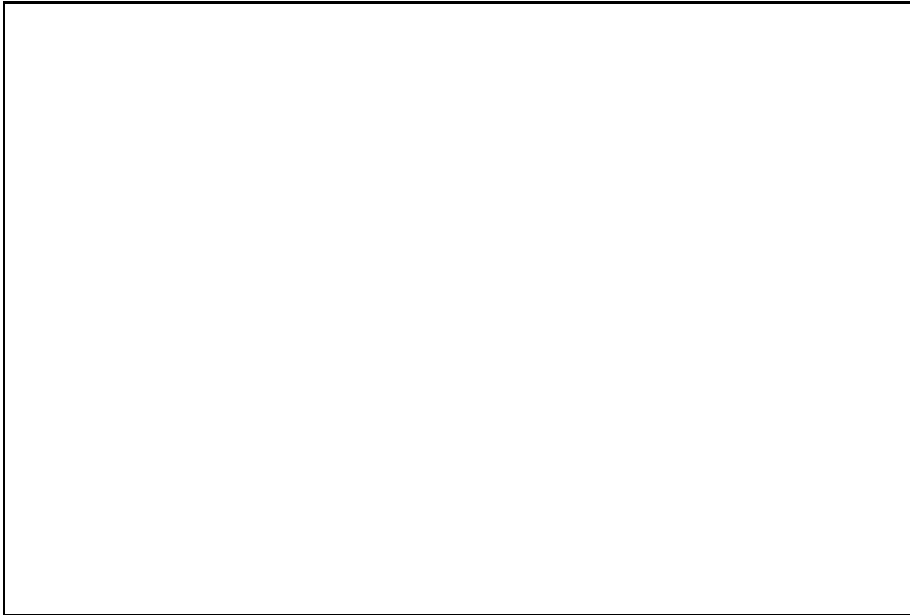
### 5.3. Example 3

The next example concerns the work organization in relation to booking of examinations using various technical artifacts.

In a historical perspective, part of the division of labour between secretaries and nurses has been that the nurses book examinations. This has changed at the radiology department for some of the examinations, for example:

- The secretaries at the radiology department book the ordinary X-rays and most of the thorax (chest) examinations (Picture 4).
- The nurses at the radiology department book the artery examinations.

**PICTURE 5. Part of the picture file**



- The secretaries at the intensive care department book the thorax examinations for their own department.
- The doctors at the radiology department book the emergency examinations.

What we see here is an example of work activities that have modified the work organization: changes involving discussions about who is going to take care of booking the examinations and which knowledge and qualifications are needed to do so. At the same time limitations for these changes exist, because the doctors have the ultimate responsibility for insuring that appropriate examinations are done in time.

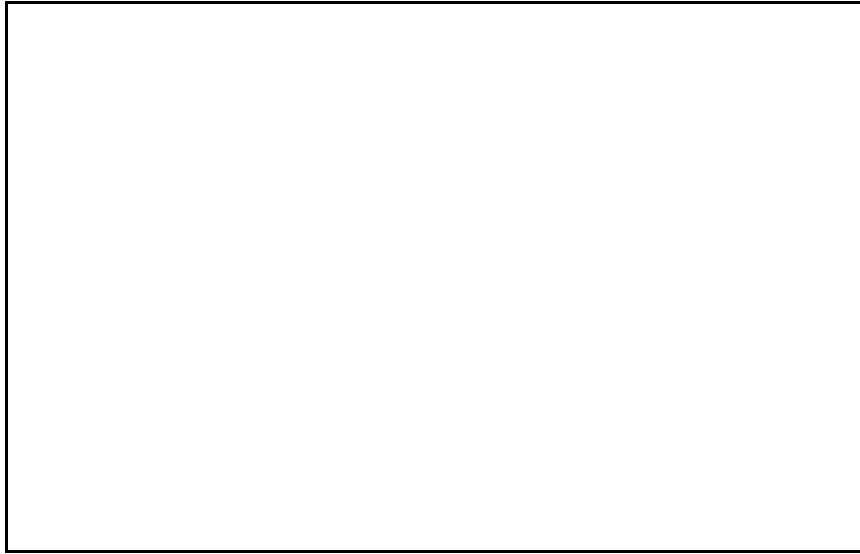
The radiology department has tried to apply the hospital's standard computerized booking system but it didn't support the work activities of the department.

The hospital's standard booking system requires that secretaries make appointments, that is, the technical artifact restrict work organization.

Recently, the computer department has finished a modification of the system in order to meet the requirements of the radiology department. A crucial point for testing the new version of the system is whether it fits the fact that different occupational groups handle booking at different times or whether they need to compensate by changing the work organization.

To summarize, the work activities have modified the work organization concerning booking, and the standard computerized booking system restrict work organization.



**PICTURE 6. Collection and daily folder**

#### 5.4. Example 4

This example concerns keeping track of analogue pictures produced within the confines of physical space.

The department has the formal responsibility for keeping radiographic pictures taken at the hospital (Picture 5). On a daily basis, work activities consist of taking pictures of patients and keeping these pictures in a daily folder, with one folder for each patient. Prior additional pictures are kept in collection folders, again one folder for each patient (Picture 6). In order to keep track of pictures the radiology department has designed the work organization with the

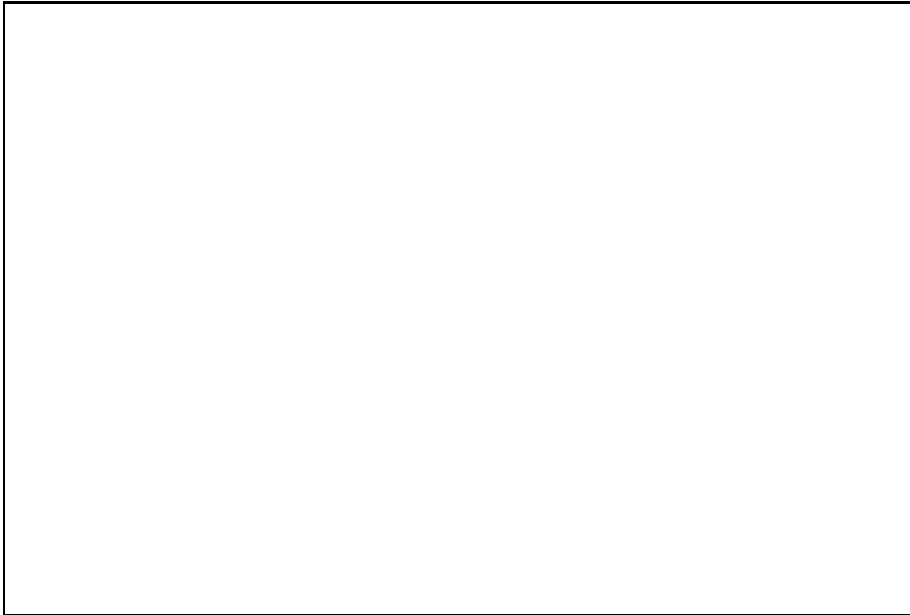
policy that all daily folders should be kept together in the collection folder and that these collection folders should follow or remain near the patient whenever the patient is in the hospital.

Patients are generally hospitalised the day before an operation in order to

conduct tests and have additional pictures taken. The patient's collection folder should be available to the consulting physicians to review before planning the operation. During that same day the patient is sent to the radiology department to have additional pictures taken, which causes problems since previous pictures taken need to be available to radiologists.

What we see here is, how work organization designed to fit requirements in work activities in one place (the radiology department's responsibility for maintaining picture), causes problems for work activities elsewhere (the physicians planning of an operation).

A computerized picture archiving system could, in a radical way, change the conditions for work organisation and work activities. First of all, pictures would in effect be available at multiple places at the same time. Secondly, pictures would not get lost, because other

**PICTURE 7. Morning conference using analogue pictures**

departments only get an electronic copy of the picture, transmitted to their local computer.

To summarize, a computerized picture archiving system would to a lesser extent restrict the ways of organizing work by compensating for the separation of physical locations.

#### 5.5. Example 5

Picture 7 shows the conference room before the introduction of PACS.

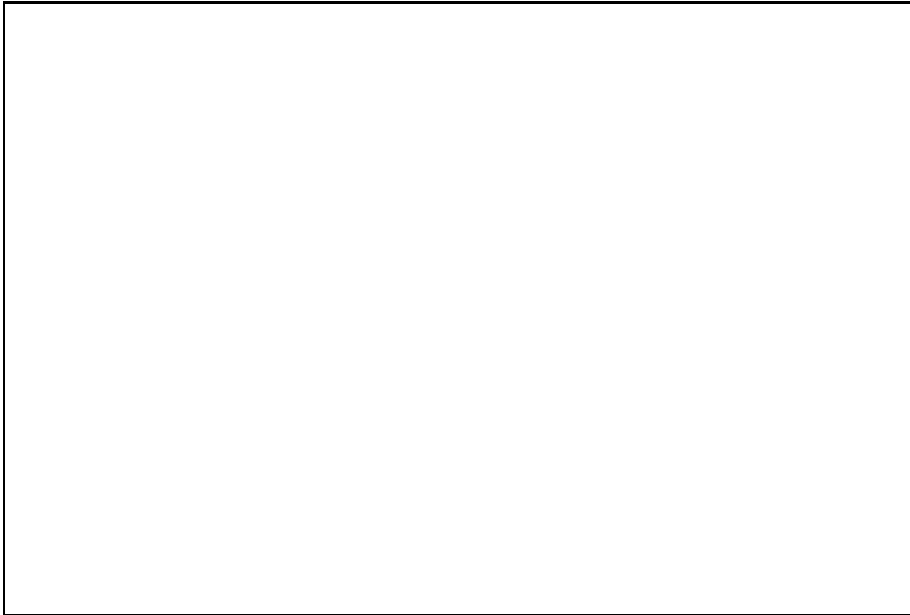
The work organization was as follows: The secretaries mount the pictures on the light screens and make a lists of where the pictures of each patient can be found. During the conference, the doctor in charge presents the pictures in the order they have been arranged. After the conference, the secretaries put the pictures back in the daily folders and the collection folders. The technology (the

light screen) and the physical space (the conference room) is designed so that it is possible for everybody to view the pictures at a distance while at the same time providing the doctors the possibility to point at one or more pictures. Moreover, the whole set up provides the conditions for viewing a series of pictures in order to track the development of the condition of a patient.

At the department, there are basically two different types of conferences:

- At the morning conference a larger number of doctors from different departments participate with the doctor in charge from the radiology department presenting the pictures and with only limited discussions of the pictures (Picture 7).
- At the afternoon conference only a few doctors from one specific

**PICTURE 8. Afternoon conference using analogue pictures**



department participate. The purpose of the conference is to discuss and agree upon further treatment for a specific patient (Picture 8).

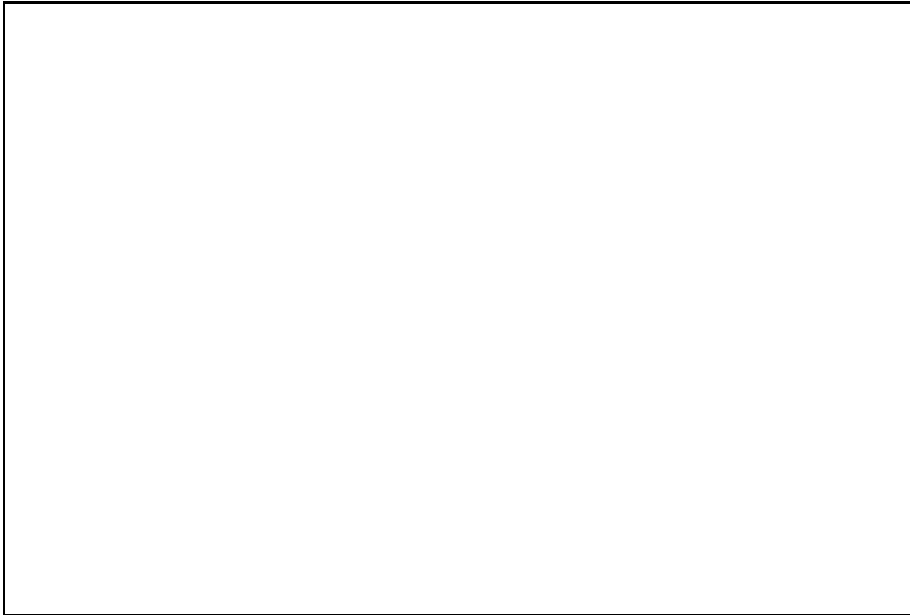
The new picture archive system, constituting a change in one of the structural elements (the technical artifacts), may affect the other structural elements.

The current physical arrangement, in effect for only a couple of months, encompasses using conventional display screens placed on top of each others and having the radiologist in charge directly facing the screen, at the same time providing him or her easy access to the mouse and keyboard (Picture 2 and 9). Such a utilization of physical space (one of the structural elements), perhaps enforced by the technology (another of the structural elements) could reinforce the traditional and formal division of labour between physicians (the third basic

structure) since physicians seated in the back (often having low seniority) only have a poor view of the pictures displayed.

A number of crucial issues are currently under investigation. Are the conventional computer screens appropriate for the morning conference where one radiologist presents pictures for many others to view? Would it, for instance, be feasible to consider whether larger display monitors located at face-height could offer the participating physicians a better view of the pictures at the same time?

Another issue is, whether the set-up meets the requirements of the afternoon conference, where there are fewer people present and a different kind of co-operation with more extensive interaction. Would it be feasible for all the participating radiologists and physicians to have

**PICTURE 9. Morning conference using digitized pictures**

access to a mouse and a keyboard, i.e. a system with multiple pointing devices and cursors? This may affect the physical arrangement of the conference room, as well as the way the doctors may decide to alter their work activities. Still another question, not yet resolved, concerns the division of labour between radiologists and secretaries: For instance, should the secretaries still prepare the conference or should this task shift to the radiologists?

To summarize, the conventional technology (the light screen) and the physical space (the conference room) is designed so that it is possible for everybody to view the pictures at a distance whereas the new display screens placed on top of each others may enforce a different division of labour among physicians. In addition, the different kinds of conferences may require different tech-

nology and a different utilization of space in order to fit the work organization in the various circumstances.

## 6. Conclusion

We began our analysis of the radiology department with an examination of the situated actions taking place at the shop floor or workplace level. The examples provided above have been seen through the lens of our framework. While—like any account—leaving out some aspects, the framework has facilitated a focused perspective on work activities (like keeping track of pictures, scheduling examinations, registering examinations, planning operations, and conducting conferences) technical artifacts (like analogue pictures, digitized pictures, display screens, the PACS system, the

booking system, and folders), physical space (for instance the offices, the corridor, the separate building, the conference room, the wards, and the radiology department), and work organization (for instance the responsibility of the secretaries versus the responsibility of radiographers, the responsibility for booking, and division of labour among physicians during conferences).

We have provided evidence that the elements in important ways are interdependent. In particular we have pointed out that

1. Analogue pictures—in different circumstances—enable as well as inhibit the work activities, the tangible nature of pictures compensate for the complex nature of the physical space. In contrast, changing the technical artifact to digitized pictures compensates for the nature of physical space by enabling access to pictures at a number separate physical location at the expense of restricting portability in physical space.
2. The radiographers have adapted their work organization to compensate for the physical distance between the separate building and the main part of the radiology department. Alternatively, a technological solution could have compensated for the physical distance.
3. The work activities have modified the work organization concerning booking, and the standard computerized booking system restrict work organization.
4. A computerized picture archiving system would to a lesser extent restrict the ways of organizing work

by compensating for the separation of physical locations.

5. The conventional technology (the light screen) and the physical space (the conference room) is designed so that it is possible for everybody to view the pictures at a distance whereas the new display screens placed on top of each others may enforce a different division of labour among physicians. In addition, the different kinds of conferences may require different technology and a different utilization of space in order to fit the work organization in the various circumstances.

*Re-interpreting* the observations in flexibility terms we may note that: (1) analogue pictures may in a flexible way be carried around in physical space independently of other kinds of technical artefacts, while digitized pictures offer a different form of flexibility because they can be accessed simultaneously at multiple physical location at the expense of flexibility in portability in physical space; (2) the segregation of the examination room in the separate building has triggered a flexibility in work organization; (3) the standard computerized booking system was without any redesign and change of software too inflexible to fit the existing work organization; (4) a computerized picture archiving system would enable a more flexible way of organizing work and compensating for inflexibility caused by separation of physical locations; and (5) the new display screens in the conference room may constitute a barrier for flexibility in work organization.

The analysis presented here, we believe, has clearly demonstrated the inter-

dependence of the elements of the framework, and we also believe that we have started to zero in on the fairly broad notion of flexibility. Many other aspects of an organization may play a role here, for instance organisational culture and politics, motivation, management's role etc.—all areas for research outside the scope of this paper.

## Notes

<sup>1</sup>(Greenbaum & Kyng 1991, p. 4).

<sup>2</sup>The relevance of these aspects are outlined in the section "Background."

<sup>3</sup>Cf. Giddens (1984): "... the structural properties of social systems are both medium and outcome of the practices they recursively organize. ... Structure is not to be equated with constraints but also both constraining and enabling."

<sup>4</sup>Ehn (1988), p. 3.

<sup>5</sup>Bly, Harrison & Irwin (1993), p. 30.

<sup>6</sup>Among others see for instance Mackay (1990) and Trigg (1992).

<sup>7</sup>Mathiassen (1981, 1987).

<sup>8</sup>We interviewed the local management at the department (4 people) and 5 people doing the ordinary tasks at the department. Beside this, we interviewed the manager from the local edp department, and a physician, a nurse, and a secretary from three different wards.

<sup>9</sup>Investigations from a recent follow-up study in (Kjær & Madsen 1995) which also discuss some of the accompanying techniques.

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