# Soft Objects Analysis

## – A modelling approach for analysis of interdependent work practices

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**Abstract:** There is an increasing need for analysing problematic situations and creating visions for computer systems that are getting used as means of communication and coordination of work in and between work practices in an organisation. In this paper an extension of object oriented frameworks with Activity Theory and elements from Soft Systems Methodology is used to develop an analysis technique that address such issues.
**Keywords:** Object Orientated Analysis, Activity Theory, Soft Systems Methodology, Interdependent work

## 1 Introduction

Object oriented techniques are used within application areas that include human work within some organisation. Lately, the techniques have also been used to capture aspects beyond the domain of work, e.g., aspects relating to actors, communication, coordination of work, task flow, and work procedures (see e.g. Jacobson, et al. 1994; Bürkle, et al. 1995). This is due to a shift of perspectives regarding the role of the computer in work settings; from a focus on the computer as means of control and administration of a problem domain, to a focus that also include the computer as a mediator in the work setting, e.g., as in groupware or workflow applications. Carstensen et al (1995)

point to inadequacies of object-oriented modelling in these respects; e.g. that interactions between actors involved in coordinating their activities seem to «disappear» in the models.

Kaasbøll and Smørdal (1996) argue that this shift of perspectives has not been accompanied with extensions of the theoretical foundation for object oriented modelling, except for engineering approaches. Consequently, they argue, the suggestions for improvements of the techniques has been too restrained by implementation considerations, and has not extended the mechanisms of object-oriented programming languages. In this paper, I argue for a softer approach to object oriented analysis, that are based on a combination of work oriented perspectives and technical perspectives found in the engineering approaches.

Systems developers need to understand problems of the current organisation, as well as creating visions for the future. Cooperation with and involvement of the users is necessary in this process. This is expected to be a problem in an organisation with interdependent work practices because the work practices and interests of several groups in the organisation need to be compared and contrasted in order to agree on the common parts of future information systems. This paper regard problems in relation to interdependence to be problems related to: the role of the computer in work tasks; the role of the computer in communication among workers in and across work practices; and the role of the computer in the division of labour in the organisation.

Two problems regarding the use of current object oriented techniques related to interdependent work are identified in this paper. First, most techniques do not address the work setting, only the domain of work. Hence, the various roles of the computer in a work setting are not focused, and it may thus be difficult to find problems related to these roles, and to how the various roles are integrated from the workers point of view. Second, the current approaches to object oriented modelling may be too structured, and too grounded in engineering approaches to support the creative process of finding problems related to computer use in interdependent work settings.

An approach to an object oriented analysis technique based on a combination of Activity theory, elements from Soft Systems Methodology and object orientated concepts is presented in this paper. In order to have a short name for the approach, the term Soft Objects

Analysis is introduced. The approach is developed in an ongoing project in one municipal agency in Norway dealing with town planning, building permits, and geodata (referred to as «the agency» in this paper).

The paper is structured as follows: The rest of the introduction presents the research approach for this work. Section two explains the shift of perspective regarding the role of the computer as mentioned above. Section three explains my approach to interdependent work arrangements. Section four presents how my approach is made softer than current approaches. Section five presents the tools and activities of the analysis technique, and an example of using this approach in the agency is presented in section six. Section seven concludes the paper.

## 1.1 Research approach

The method used in this work is presented and discussed by Kaasbøll and Smørdal (1996) , who argues that object oriented modelling techniques should be developed according to knowledge about human work within organisations. In order to point to how to bring such knowledge into the process of developing techniques, a learning cycle consisting of practice, evaluation, theoretical contribution, and suggestion of improved techniques is outlined.

In order to develop the techniques such that they can model issues related to work, knowledge of work  has to be included in the ways modelling problems are explained and new modelling mechanisms are suggested.  Therefore, the theoretical scope of development of techniques should be widened from the focus on formal and implementation considerations to a system development research learning cycle that is open for any contribution to understanding the domain that is to be modelled. It is argued that the perspective on work is fundamental to the selection and development of theoretical foundations for modelling. (ibid.).

According to the learning cycle, the problems addressed in this paper are both on a theoretical and on a modelling technique level. The work reported in this paper is a reflection upon problems a group of information systems researchers faced doing a needs assessment for the agency.

# 2 Shift toward including the work setting in object oriented models

## 2.1 Seamlessness

An argument for object-oriented development is the seamlessness from analysis to design and implementation: the same concepts are used in all phases, such that no magic transition is needed. When arguing for richer concepts for modelling, the seamlessness principle may be put in danger. It would be useful also for an initial analysis to be used in further object oriented analysis or design without magic transitions. The approach presented here aims at a structured start for object oriented development, because phenomena and concepts in the initial analysis are candidates for objects and classes. Further, the approach gives a context for each object or class in terms of what role it plays in the work setting. Whether this approach supports seamless transition to further analysis or design is subject to further research.

To be precise in the further discussion, we first define areas that can be modelled during system development, based on similar concepts in Mathiassen et al (1993).

- The problem domain of a computer system is what the computer system is about; the part of the world that the computer system is supposed to handle, control or monitor. Examples (with basic components): a flight booking system (flights, seats, reservations, customers), a banking system (customers, transactions, accounts, loans, interests).

- The application domain of a computer system consist of the users, the organisational context, and the work in which the computer system is sed, e.g., a travel agency, a bank. Elements of the application domain are employees, the coordination of work, communication, power structures, ad-hoc organised work, interruptions in work, etc.

- The computer system including its application program, data/object base, user interface module, and communication modules.

When analysing functionality requirements of a system, one could make a model of the application domain. Since it is assumed that the problem domain is more stable than the functional requirement, making an object-oriented model of the application domain is often not considered worthwhile.

Many object-oriented methods suggest that one should model the problem domain, because this is what the computer system will be designed to represent. The model is supposed to describe how the system developers and users conceive the problem domain. An advantage of an model of the problem domain is that the model is independent of the technology for implementing the system. The model can be used as part of a specification, such that computer systems conforming the specification can be implemented on several platforms or with different languages.

A model of the future computer system will often be an extension of a model of the problem domain in order to include software modules and objects needed for implementation. Because the same concepts are used in all models and in the implementation, the model of the future computer system can be aligned with the model of the problem domain. This is referred to as the seamlessness of object oriented system development (see e.g. Coad and Yourdon 1991; Henderson-Sellers and Edwards 1994).

However, iterations are carried out during development, and implemented systems are changed during long periods of further development. Experience shows that changes are often carried out directly on the code, without updating the models. To keep the seamlessness, it should be possible to keep the models in alignment with the code. If other concepts are introduced in the model of the problem domain, more effort may be required to keep the models updated.

As mentioned in the introduction, a shift in the perspective in respect to the roles the computer systems may play in human work within organisations have been noticed. Earlier, a common view of the computer was that it was used for handling or controlling a problem domain , hence the models did not address elements in the application domain explicitly. Lately there has been an increasing attention in both system development practice and in the research community toward using the computer as a medium in the work organisation, thus enabling the use of computers as means of coordi-

nating work and communication in and about work. (Simone and Schmidt 1993; Carstensen, et al. 1995). This implies that issues of the application domain need to be included in the models.

## 3  Interdependency in work

In any cooperative work community, the individual worker shifts between individual and cooperative activities, depending on the situation at hand. The boundary between the individual and cooperative work is dynamic, and individual and cooperative work are mutually constituting and delimiting each other (Schmidt 1994). However, individual work has to be articulated in some way to get the whole work done (Schmidt and Bannon 1992; Schmidt 1994). The term «articulation work» refers to putting together tasks and task sequences in order to accomplish the work (Strauss 1988). Articulation work is thus an important aspect of understanding cooperative work as interdependence in work (Schmidt 1994). This term does not necessarily indicate that the individuals are working on the same tasks at the same time, or sharing the same material and resources. **Interdependence in work** also indicate that the individual workers need to coordinate or articulate their activities and work tasks in some way to get the whole work done.

Representing interdependency in work in models may be difficult, due to the contingent and situated nature of work (Suchman 1995). In this approach, I regard two aspects of work as important as structures for interdependent work: 1) The communication patterns, both explicit and implicit among workers in and between work practices, and 2) the division of labour in and between work practices. Hence, these two aspects are addressed in Soft Objects Analysis.

I have not identified theoretical foundations of object oriented modelling techniques that include these two issues of work. However, theoretical contributions related to object oriented modelling of work tasks (Wang 1995), and approaches that focus the relation between an individual worker and the tools and materials of her/his workplace (Bürkle, et al. 1995) exist.  I find these contributions important in modelling related to interdependent work. Due to the lack of theoretical foundations, the learning cycle (see section 1.1) have started with a search for a theory that address the above mentioned issues of work context and how computers are used in order to mediate communication, coordination and interaction. Engeström's
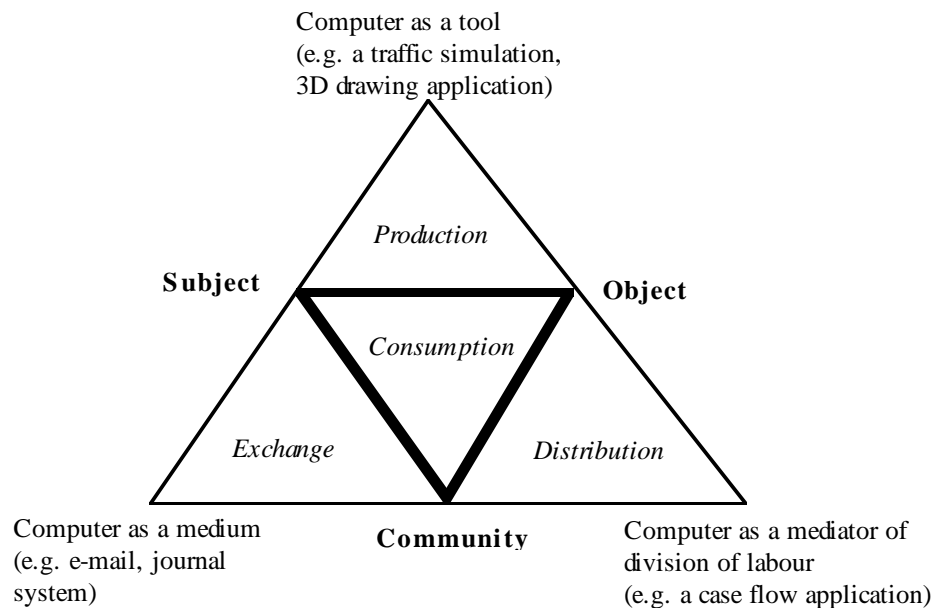
(1987) interpretation of Activity theory is selected in this approach to explain role of the computer in work contexts. The rationale for this selection is found in Fjuk et al (1995).

Activity theory addresses human work within a social context (Engeström 1987). The theory accounts for the individuals' relations to the object of work, and to the fellow workers. The relationships are not regarded as binary, but as mediated through various instruments. I use the relationships as a basis for understanding the roles of computers in an activity, see Figure 1. Engeström (1987) identifies four basic aspects of an activity:

- Production denotes the relationship between subject (a human) and object. The relationship is mediated through tools. The computer may be regarded a tool in this relation.

- Distribution denotes the relationship between community (e.g. the workgroup or the employees in the organisation) and an object. This relation is mediated through the division of labour. The computer may be regarded a mediator of this division of labour, e.g. that coordination of work may be done by means of the computer.

- Exchange denotes the relationship between the a subject and the community. This relation is mediated through rules of social behaviour and communication. The computer may be regarded a communication channel in this relation. E-mail and conferencing software are examples of this role in the work context.

- Consumption is a meta aspect on an activity, and covers the use of products and/or services of the activity. The rationale for the activity is covered by this perspective. The arguments of including this perspective in Soft Objects Analysis is presented in the next section.

The four aspects, and examples of corresponding computer systems are illustrated in Figure 1.

*Figure 1.* *The aspects of a human activity, and the corresponding roles of a computer system.*

Computer as a tool
(e.g. a traffic simulation,
3D drawing application)

*Production*

**Subject**

*Consumption*

**Object**

*Exchange*

*Distribution*

Computer as a medium
(e.g. e-mail, journal
system)

**Community**

Computer as a mediator of
division of labour
(e.g. a case flow application)

According to Engeström, the four relations constitute a systemic whole, meaning that changes in one aspect implies changes in the other. Fjuk et al (1995) argues that the systemic whole of an activity should put emphasis on how the roles of the computer in a human activity can be integrated.

In Soft Objects Analysis, models are structured according to the four aspects of a human activity. Since the aspects are perspectives on an activity, the same real world phenomena may be included in several parts of the model. The perspective gives clues as how to interpret the real world phenomena. E.g. an application form may be regarded both a material in production, and as a means of communication among the front office and a clerk. If fields on the form is filled out and used differently in different work areas, the form may be included also in the division of labour aspect.

Hence, the connections and dependencies between the various roles of the computer should be made explicit in the Soft Objects Analysis models, to put focus on how the roles are integrated or separated.

Related work include Bürkle et al (1995) who suggest a tools and materials metaphor for designing information systems using object oriented concepts. The domain of modelling is restricted to (in activity theory terms) subjects using tools to probe and transform materials (part of object of work). The communication and division of

labour aspect is missing from their modelling domain. However, they state a need for addressing cooperative work forms. I regard the framework of Soft Objects Analysis useful in this respect.

Jacobson et al (1994) presents an approach to business process reengineering with object technology that does not include extensions of object oriented frameworks, except engineering approaches. One contribution of this approach is the use case, but I regard that this concept does not address articulation work or interdependency in work, because work is regarded as work tasks being executed according to predefined courses of events. If regarding the inherent perspective of use cases as being in line with the «Organisational View» on work found in Sachs (1995), this claim is supported.

# 4 Handling differences in world views and creation of visions

It is a basic assumption in this work that various members of the organisation usually disagree on  what the problems are, how work should be organised, even how basic concepts in the domain of work should be defined. These problems are larger and more complex in large organisations, with many users at different levels and in different contexts (Bos, et al. 1993).

Elements from Soft Systems Methodology (SSM) are used in this work to express alternative systemic wholes that a work practice may constitute.

SSM is a methodology that aims to bring about improvement in areas of social concern by activating the people involved in the situation in a learning cycle which is ideally never-ending. The learning process of using systems concept to reflect upon and debate perceptions of the real world, taking action in the real world, and again reflecting on the happenings using system concepts. The reflection and debate is structured by a number of systemic models. These are conceived as holistic ideal types of certain aspects of the problem situation rather than accounts of it. it is taken as given that no objective and complete account of a problem situation can be provided. (Bulow 1989;  cited in Checkland and Scholes 1990, p. 28)

A rich picture is a personal drawing, with no formal syntax, describing the area of concern, possibly pointing at problems. A root-definition is a textual description expressing the core or essence of the perception to be modelled.

In Soft Objects Analysis the rich pictures is structured according to the aspects of a human activity; one picture for each of production, distribution, exchange and consumption. This gives a representation of one activity, with focus on the various roles of computers and other artefacts in that activity. The pictures are supposed to give a overview of a current work practice from one particular viewpoint in the organisation. Several such semi-structured rich pictures may be drawn from different organisational levels and work areas.

The root-definition is supposed to give the essence of the activity, in terms of an abstract notion of customers, actors, transformations, world views, owners and environment for the activity. This is done in order to give an account of a situation somewhat detached from the actual work practice that is expressed in the rich pictures. The rich pictures gives a work oriented perspective and the root-definition gives a more management oriented on the activity. In the field of tension between these perspectives, visions for the future and possibilities for change should be discussed.

This approach agrees with Mogensen (1992) who argues that changes should be rooted in current work practice. In order to do so, notions of both visions and the current work practice should be integrated in systems development. Kuutti (1989) concludes that there is a growing need to integrate conception and execution aspects more and more into the same jobs, making «managerial» and «planning» tasks moving towards «lower» job positions. This also points to integration of visions and notions of current work.

Studies on tradition and innovation in systems development (Stage 1989) suggest that some structure in a situation is necessary in order to be creative in the situation. Since creativity is important both in formulating the problems, and in creating visions for the future, the role of structures is important.

Related work include Bratteteig and Øgrim (1994) who also use SSM as part of an approach to requirements analysis. Their approach is not concerned with the various roles of the computer in a work setting, and is not connected to object orientation. Hence, their approach is more general.

Mathiassen et al (1993) present an approach to object oriented analysis. They suggest using rich pictures to get an overview of the situation before using conventional object oriented analysis. Their approach is not structured according to knowledge about work, however certain hints to elements to include in the rich pictures is given, like actors, roles, tools, etc.

# 5  The activities of 'Soft systems analysis'

The approach includes the following activities, carried out in sequence, and repeated when necessary:

## 5.1  Draw semi-structured rich pictures of the current work

This activity is the same as drawing rich pictures in SSM, except that the pictures are more structured. This is due to identification of problems related to interdependencies, and due to seamlessness, making it easier to use the pictures in further object oriented analysis and/or design. The drawing could be done by a group of systems developers, or by system developers in cooperation with the users. In the latter case, the different perspectives of the pictures must be explained to the users. The pictures represent the current understanding of the situation, and should focus on problematic areas both within and across the different perspectives in the picture. The perspectives are the same as the aspects of a human activity:

**Production** Pictures typically include tools and materials for one persons job, and the main contributions made to the overall service or product of the organisation.

**Exchange** Pictures typically include shared materials and other communication channels. Also the flow of material between various people are drawn.

**Distribution** Pictures typically include the roles of the people involved in a work practice, and identifications of their responsibilities and how they should perform in order to do a good job.

**Consumption** Pictures represent the client or customer perspectives on the production. The pictures could indicate how and why the products or services are used. In case of internal support functions in the organisation, clients are the other relevant departments in the organisation.

### 5.2 Create root definitions

While the rich pictures express the current work practice, root definitions are used to express the systemic whole of an work practice. Several root definitions should be made, expressing each one unique perspective on that particular practice. This activity is the same is in SSM, and implies a more managerial perspective on the situation compared to the rich pictures.

### 5.3 Make a chart of current work practices

This activity is done by the systems developers in order to make an overview of all the rich pictures. The chart is divided by activity theory elements vertically and work areas horizontally. In the cells the main elements from the drawings are written, computer based elements are marked, e.g. set in boldface.

### 5.4 Identify interdependencies and problems hereof by arranging workshops in and across work practices

The semi-structured rich pictures, the root definitions and the chart can be used as a point of departure for workshops within each work practice, and across work practices. The aim of the workshops should 1) encourage mutual learning in respect to each others work and 2) identify problem areas that should be addressed in further systems development and create visions for future information systems.

## 6 Illustration of use

The approach is developed in an ongoing project in one municipal agency in Norway dealing with town planning, building permits, and geodata. The agency has three main responsibilities: Keep new and changed buildings applying with current building standards and plans; make overall and detailed plans for the city areas; and keep geodata for the city up to date. The agency operates as professional support for the city government, and needs to follow political signals from an elected city planning board.

The agency has 350 employees in 5 departments, with a total of 20 sections. 3 of the departments are dealing with building permits and plans in their geographical area. One department deals with geodata, and one with administration. The agency uses a journal, archive and case handling system (called JAC here), that is used throughout the organisation to record in and outgoing mail, old and

ongoing cases, assignment of case-handlers to a case, various case handling actions and invoice data related to cases. Further there are computer systems for electronic maps, and location based data (like land and building owners, and area plans and regulations) that are used in case handling.

The agency had problems with their use of JAC, both within the various work areas and across organisational boundaries and professions. The director of the administration department in the agency hoped that a needs assessment identified problems of current use of JAC, as well as suggestions for a future journal, archive and case handling system (either changes in JAC, or a new system).

Our major problem was to understand the work within each functional area and how this affected the interdependencies between the work practices. This was difficult due to:

- A large number of documents, maps and forms flowed between various work areas.
- The division of labour was not easy for us to understand, in terms of who did what, who was responsible, and who controlled the work.
- There were informal ways of communication related to case handling.

The various work practices had adopted their own ways of using JAC in their work.

It was difficult to know how the data-fields in JAC was used in the various use contexts.

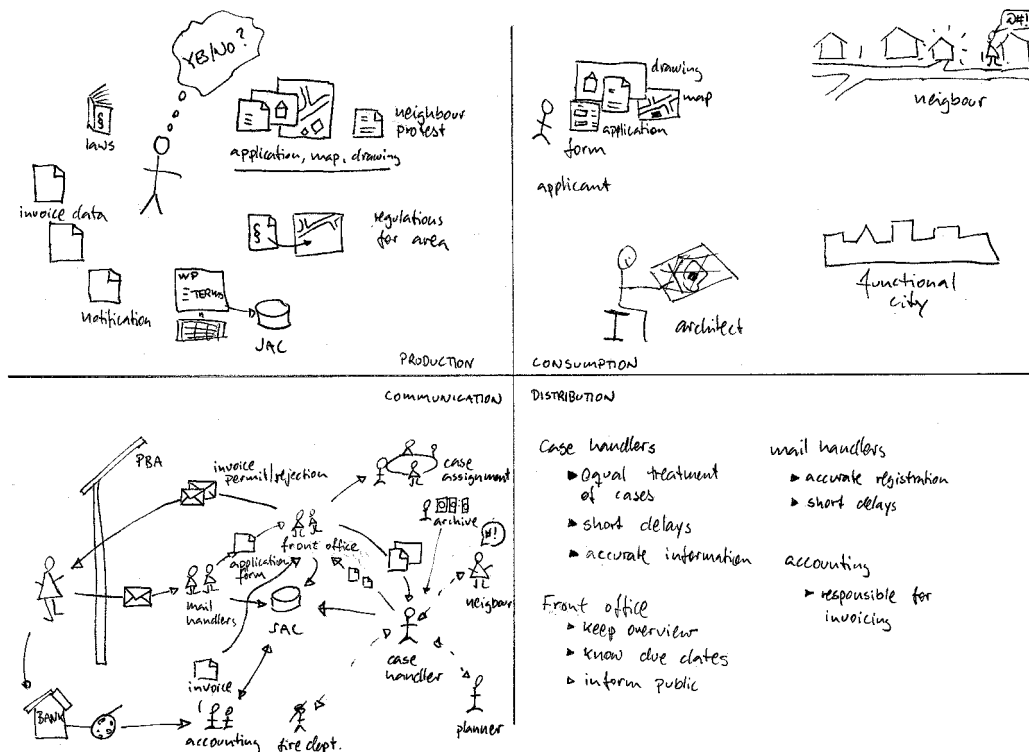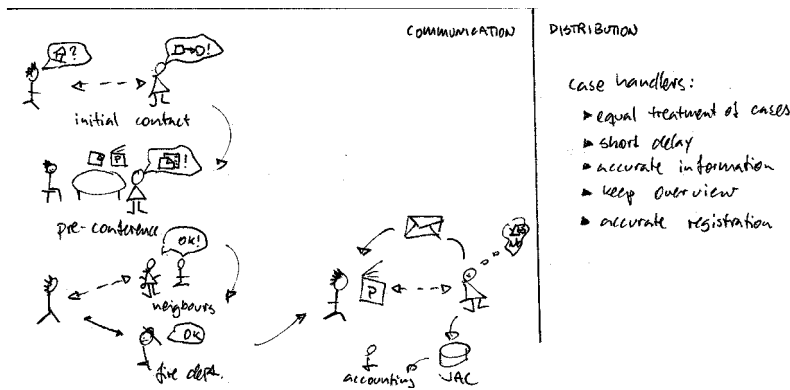*Figure 2.  Semi-structured rich pictures of building permit handling*



*Figure 3.  Semi-structured rich pictures of «Permit in a day»*



### 6.1   Using Soft Objects Analysis

Rich pictures where drawn in some of the work practices of the agency. Figure 2 represent the handling of building permits. The picture at top is drawn in the perspective of a case handler in one of the building permit departments. The production aspect shows documents, sheets and tools used for deciding and handling applications. The communication perspective shows the case flow starting at the

applicant, trough the mail handling office, the front office, the case assignment meeting, the case handler, and back to the applicant. Use of JAC is indicated. Informal communication is drawn by dotted lines. The distribution is about division of labour, and the various roles and expectations are indicated. The consumption perspective shows various client and citizen perspectives on building permit handling.

Figure 3 represents a new department handling simple building permits, called «Permit in a day». The picture for production and consumption aspects are not shown, since they are rather similar to corresponding pictures in Figure 2. The communication aspect is different, since the applicant must do much of the case handling herself/himself. In terms of distribution the case handler does all the administrative work herself/himself, hence the demands on this job increases.

The rich pictures turned out to be useful in terms of our overview of a current situation in the agency, and when discussing problem areas with the agency management. The management had prior to our activity usually been thinking in terms of production only, not considering issues of interdependency in sufficient depth. The main conclusion from the analysis was that JAC did not work as a case handling tool, but rather as a means of knowing where the physical documents and case folders were.

We made a Soft Objects Analysis chart(see Table 4) with all work practices we had visited.

*Figure 4. Chart of work areas vs. aspects of work*

| Object of work | Subject | Work Community | Production | Communication | Div. of labour | Consumption |
|---|---|---|---|---|---|---|
| handling building applications | case handlers | front office, archive, infobank, mid-managers, accounting | reg. map, house drawing, application, rejection, approbation, terms, building regs, invoice sheet, wp, JAC | application, rejection, approbation, terms, advising, wp, invoice sheet, JAC | case flow sheet, strict according to function except: permit in a day more integrated | citizens, builders, architects, society |
| handling plan applications | planners | front office, archive, infobank, mid-managers, accounting, town planning board, info people | models, reg. map, drawings, reg. rules, application, alternatives, rejection, invoice sheet, wp, traffic simulations | top-3, JAC | case flow sheet, strict according to function | builders, architects, society |
| 6 work areas omitted here | | | | | | |

This chart was used in order to get an overview of interdependencies in the agency, and the role of their computer systems in and across work practices. One important finding using this chart was that the agency does not have much support for production at all, and that JAC was poorly designed to be used as a means of communication and distribution.

# 7  Conclusion

New computer applications address issues of work context, in addition to representing the object of work. Object-oriented models of such systems therefore have to capture some aspects of work, e.g., the division of labour and communication. Since human work is complex and governed by rules to a much lesser extent than computer processing is, the modelling techniques have to avoid making assumptions about regularities in work. This paper suggest that object oriented modelling techniques should be developed according to knowledge about human work within organisations.

The approach described in this paper makes use of elements from Soft Systems Methodology, Activity Theory and Object Oriented Modelling. Soft Objects Analysis offers an open, multi-perspective and semi-structured approach to initial analysis of interdependent work activities. It aims at identification of problem areas and creation of visions for the future information system. One strength of this approach is that seamless transition to other object oriented system development activities is possible, hence making it easier to have an iterative development process. The approach has been developed in a real life system development setting.

Further research will investigate how Soft Objects Analysis could be used to involve workers and management in situations where computer systems are to be used across user groups.

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