# Some comments about information systems design for production control from the perspective of an integral sociotechnical organization philosophy

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## Summary

The plea for an integrated design of technology and organization has become widely accepted as a basic philosophy for innovation. Modern Sociotechnology - as it developed towards a management science approach covering the micro, meso and macrolevel in the organization - has proved to be a powerful paradigm for integral redesign of the total organization. Such a holistic transformation is necessary to survive in a turbulent environment. Modern production organizations need to be controllable to become flexible. Information technology certainly has much to offer in supporting new forms of work organization, in which decentralisation and semi-autonomy are key concepts.

This paper emphasises the relationship between information technology and work organization from an explicit sociotechnical design perspective. The implementation of sociotechnical principles in the design of information systems will always facilitate the development of integrative organizational design.

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## 1. Introduction

### 1.1. Context of the problem

Information and organization have become key aspects of modern enterprise. Looking for flexibility and controllability managers are very well aware of the close interconnectedness between the two. They are very anxious about the occurrence of unintended consequences when one aspect is unilaterally tackled at the cost of the other. In production departments the successful integration of aspects is of vital importance for appropriate functioning. But also in systems development the necessity of (further) integration is being felt. Tailor-made solutions with built-in developmental opportunities are asked for by the users.

This paper takes a theoretical strand. It approaches the concept of integration from a method(olog)ical point of view. As being argued, contemporary design theories are only *beginning* to focus on the interaction of organization and information. Modern Sociotechnology offers a conceptual framework for integration of organization and information.

Our main interest is in the structure of the organization. Early theories about organizational design have been based on three main assumptions: that organizations could be considered as machines, that they were functioning in a stable environment, and that they were using people as a sort of machine-parts (Taylor, 1911; Weber, 1947). But all things have changed, and are continuously changing since. As Bolwijn (1988) has noticed, market demands altered drastically over the past 30 years. In the sixties, the market was dominated by the concept of mass-production, price was the decisive factor for the client and organizations tried very hard to be as *efficient* as possible in order to lower the costs of production. During the next decade price no longer consisted the only important criterion; quality was added as a major feature. Organizations were confronted with higher complexity and were looking for efficiency *and* quality. The eighties came up with two new demands. Product choice and short delivery times became vital; organizations needed flexibility on top of efficiency and quality. Bolwijn predicts that in the nineties uniqueness of products will become the dominant market claim. In order to survive, organizations should become innovative by that time.

Quality of work, controllability and flexibility are three basic functional claims modern production organizations should obey. Modern Sociotechnology delivers an organizational strategy to meet these demands.

### 1.2. Focus and point of departure

The link between information and organization can be assessed from different angles, stressing information or organization as the focus of change.

- From an *informational* point of view, the attention is directed towards feasibility. The main question is which constraints/boundaries/demands should be placed upon the organization in order to build a useful information system. In automation this has been the predominant view.
- On the other hand, from an *organizational* point of departure, the attention is directed towards basic structural features which should be considered before an information system can be build. In this case, frequently reorganization preceeds automation, in order to innovate the enterprise from inside.

The current situation shows a definite change from the first to the second point of view. Partly due to problems of integration and implementation, the focus is slowly changing from information as a starting point to organization as point of departure.
In this paper we strongly adhere an interactional point of view, integrating informational and organizational aspects within a modern-sociotechnical framework.

## 2. Contemporary integral organization design

### 2.1. Modern Sociotechnology

We use Modern Sociotechnology as our theoretical guide to integral organization design. The term 'sociotechnical system' has its roots in England, at the Tavistock Institute of Human Relations. Originally the concept was used to express the idea that an organization does not entirely exist of technical aspect systems, but that social aspect systems are at least equally important in reaching organizational effectiveness. From this notion a massive organizational design method arose: the Classical Sociotechnical Systems Paradigm. For a review see Van Eijnatten (1990a; b).
In Holland, this classical paradigm was further developed towards an integral design theory and methodology (De Sitter, 1973; 1986; 1989). We have called this organization-wide approach 'Modern Sociotechnology', which actually combines principles for the design of the production and control structure with design-oriented methodology, in order to meet the already mentioned multiple market claims (Van Eijnatten et al., 1988; 1989; 1990). The design of an appropriate information structure is an explicit step in this design strategy (Van Eijnatten and Hoevenaars, 1989), see figure 1.

figure 1 about here

The modern-sociotechnical design method has been tested in the past few years in its first 14 steps (Den Hertog and De Sitter, 1990; Hoevenaars, 1989a/1990; Landré, 1990). The next step to be tested in practice is the sociotechnical design of the information structure (Van Eijnatten and Hoevenaars, 1990).

## 2.2. Sociotechnical principles for information systems design

Modern Sociotechnology deals with the interaction of different aspects in the organization from an integral point of view. The informational aspect should fit in the overall organizational design philosophy, which means that the new information system predominantly should serve the already redesigned production and control structures.
The consistency of information structure with production and control structure should be explicit. This means that information systems should resemble sociotechnical principles. Modern Sociotechnology has adopted much of the principles of the Classical Sociotechnical Systems Paradigm (Cherns, 1976; 1987; Kuipers and Rutte, 1988; Kuipers, 1989; Van Eijnatten, 1990a). In table 1 major design principles are shown, supplemented with their implications for information systems design. In each phase of the design trajectory particular principles become dominant over others.

table 1 about here

There are two sociotechnical principles that have implications for the organization system as a whole: 'support congruence' and 'information flow'. Support congruence indicates that additional support systems should be designed to reinforce the behaviors the organization structure originally has been designed for. This includes information systems. The information flow principle states that information systems should be designed to provide information as near to the point where action can be taken. As can be seen in table 1, three sociotechnical principles concern the iterative change process: compatibility (the system should be compatible with it's objectives), transitional organization and incompletion. These principles stress that an organization is always changing. It is far from possible to simply stop the functioning of the organization, than implement change and finally continue operations. There has to be a multiple schedule, including a possibility to carry on during the alterations.

Apart from the more general principles discussed above, there are specific principles dominant in each particular design phase. During *the design of the production structure* the most important principle is 'boundary location': the aim is to separate production into independent parallel production flows, eventually also segmented in consecutive parts. This principle shows a major advantage for information structure design: unnecessary coordination is abandoned. In designing the production structure the 'multi-functional principle' is also dominant: on an operational level people have to be able to execute different system functions: information should therefore be available to the level of the group as a whole in order to be able to provide each individual with the particular information he or she needs.
During the second phase in sociotechnical design, *the design of the control structure*, the basis for the information system is laid. Three sociotechnical principles become dominant in this phase: 'minimal critical specification', 'variance control' and 'power and authority'. These three principles stress the idea that problems have to be solved as close as possible to the point they have arisen, very low in the organizational hierarchy. Therefore the information system

design should start at the lowest level.

In the last phase of sociotechnical design *the information system* is built. If the production structure and the control structure are well-designed, there should be no obstacles for a consistent information system. 'Boundary control' becomes now the dominant criterion: information systems should work within the same boundaries as the production control structure does, and the exchange of specialized information should be possible through 'free' networks.

### 2.3. Control structure as a basis for information systems design

Modern Sociotechnical Design Theory distinguishes between three levels of aggregation in the organization: micro, meso and macro (De Sitter et al., 1986). As figure 2 illustrates, according to Van Amelsvoort (1989) on the micro level the basic organizational unit is the semi-autonomous work group. On the meso level the operational group is the focal structure and on the macro level the bussiness unit forms the organizational nucleus. Although it is really a matter of emphasis, each type of group encounters predominantly with different control dimensions: the semi-autonomous work groups focus on maintaining processes, operational groups concentrate on improvement processes, while business units put main efforts in the renewal processes.

figure 2 about here

Our main thesis is that a specific sociotechnically redesigned control structure, consisting of a taylor-made combination of the groups already mentioned, should be the basis for information systems design. This is a counterplot to many designers who build 'universal' information systems based on some global organizational inspections, resulting in a bad fit between organization and information. We argue that information systems design should serve modern organization structure, and not the other way around.
Table 2 supports our thesis about control structure as a basis for information systems design. It shows some examples of items in a control structure while immediately translating those into informational needs.

The table specifies some informational needs of sociotechnically designed structural units. This information can be used to control production aspects by goal-directed actions. Also the source of the needed information is being stated.

table 2 about here

## 3. Information and organization

### 3.1. Towards integrated information systems

Computer capacity and software development are no longer the (only) main aspects in information development. In the eighties interest shifted towards data-base systems; the connection

between different systems and the synergetic effects of these connections have been explored (Maes, 1989). What we are looking for now are 'integrated' information systems; systems with an adequate infrastructure that can be used throughout the entire organization.
The importance of an adequate infrastructure is illustrated in figure 3: the communication and control links between departments differ according to the type of production and control structure.

figure 3 about here

In a *functional structure* (production grouped by process) separate production departments are controlled by functional staff services. Since staff activities are very different from production processes, there are information links between each production department and each staff service.
In a *line structure* (production grouped by product) separate production departments are also controlled by functional staff services (just as in the functional structure). When the product difference becomes large enough, parts of the staff will differentially concentrate on specific production lines.
In a *sociotechnical structure*, the staff is decentralized; small staff groups ('operational groups') support production in one and the same organizational department.

### 3.2. Characteristics of integrated information systems

The ideal system information, as we see it, is fully adapted to the basic structure of the organization. A sociotechnically redesigned organization has a basic structure which is suitable to function as an integrated system. This integration will be reflected in the information system. As we have seen in figure 3, the information loops in such a basic structure are relatively short. This facilitates communication within departments. Of course an ideal control structure can seldom be effective without a sophisticated information system. The information system typically has to be multi-level and has to cover many aspects.
To start with the multi-level characteristics, organizational levels and control levels are not congruent (see figure 2), this implies that "production-information" and "management-information" can not be separated and unilaterally allocated to a particular organizational level. All sorts of decisions should be taken at *all* levels in the organization and all respective information subsystems have to be integrated.
This brings us to another characteristic of modern, integrated information systems: information is owned by the group that produces it and is delivered to others if necessary. People are responsible for their own job, so production information has to be in the hands of the production group (before someone else comes in and takes command on the basis of his or hers information).

### 3.3. Modular information systems

In our search for suitable information systems we have found an interesting approach that fits our purpose. It is called the 'object-oriented approach', and considers an organizational system at each level as a *combination* of autonomous objects. These objects have sufficient information about each other and their environment *to serve each other without interfering* in each others internal organization. The concepts of autonomy and cooperation are central in this approach (De Ridder, 1990). At the moment there are about seventy languages available for this object-oriented approach (Constantine, 1990a; b).

Pels and Wortmann (1989) presented an approach that is related to the object-oriented approach. They suggest modular information systems that use a conceptual scheme that specifies the possible contents of the information-base and their meaning. In their conceptual scheme Pels and Wortmann use modules as building blocks. A module is defined as 'a unit of authorization for retrieval or update of information'. Figure 4 gives an example of a module in such a conceptual scheme. Each module administers a domain. This domain consists of a private part (not accessible for others) and a public part (over which others have no authority for change). A module also has the possibility to retrieve information from other modules.

figure 4 about here

These modular information systems offer flexibility at 'lower' levels in the organization. In sociotechnical terms they use three basic principles:

1. minimal critical specification: they do not impose unnecessary restrictions in the conceptual scheme;
2. boundary control: they deliver a clear understanding of the division of responsibilities;
3. variance control: the private domain always stays within the module and the relations between modules are clear and never redundant.

Pels and Wortmann (1989) summarize these principles as follows: "The criteria for good modularity must always be kept in mind by those who design systems for the exchange of information between organizational units. Every time a position accepts the obligation to provide information to another organizational unit it must realize that it makes one or more entity classes public to another module and this increases its coupling" (p. 235).

## 4. Concluding remarks

Changing market demands ask for new developments in informational and organizational theories. In this paper we have advocated that information and organization should be approached in an interactional way. Divergent specialists should work together to design new organizational systems with adequate information systems for production control.

This paper aimed to support those who are fighting problems in complex organizations, and who are trying to develop new information systems that facilitate the creation of decentralized structures. Coming from different fields, cited authors are surprisingly unanimous in their suggestions for structural solutions to problems of organization and information. Organizational specialists advocate self-management in small-sized organizational units; informational specialists promote the idea of information systems as a combination of autonomous objects. The modern-sociotechnical framework also supports semi-autonomy as a basic feature. Certainly it cannot and will not claim superiority or even pioneering in this respect. The paradigm will not replace or fritter away other contributions. The actuality and usefulness of Modern Sociotechnology primarely lies in its method: it adds to a factual integration of organization and information. The sociotechnical method, which has adapted useful techniques from other disciplines, has proved to be effective in designing new production structures accompanied with tailor-made control structures. Now design-oriented research is planned in order to investigate what sociotechnically designed information systems look like and to assess the differences between those and more traditionally designed information systems.

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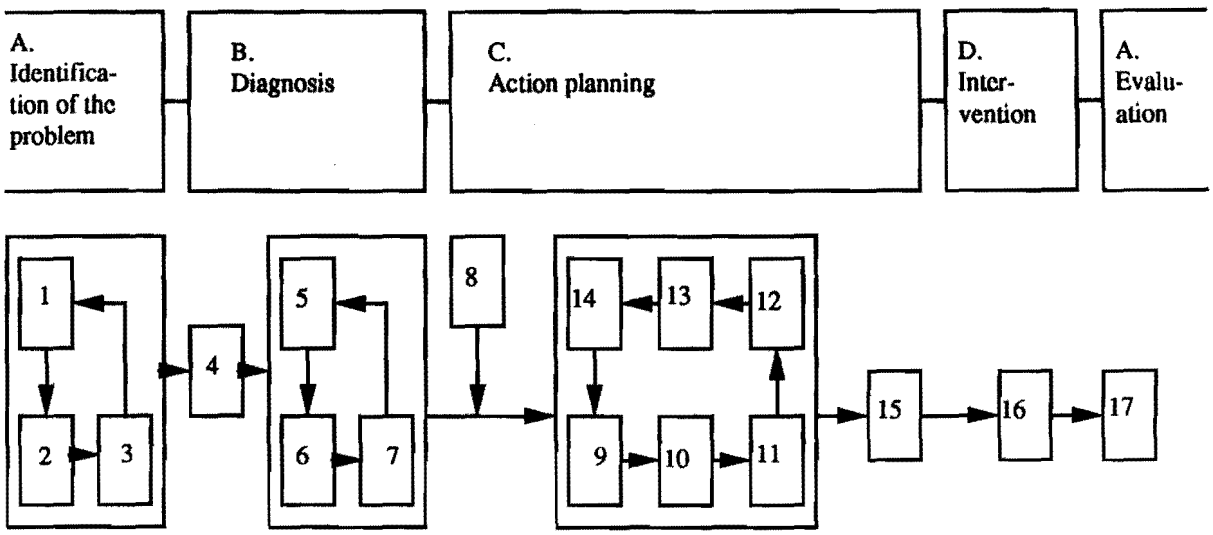



Explanation of codes used

I. Methodological (re-)design cycle
II. Sociotechnical phases in the method

A. Problem identification/evaluation
1. global strategic analysis (macro level)
2. global system analysis (meso level)
3. identification of bottle necks

B. Diagnosis
4. determination of system boundaries
5. detailed strategic analysis (macro)
6. detailed system analysis (meso, micro)
7. aggravation/sharpening of (re-)design objectives (macro, meso and micro level)

C. Action planning
8. reconsideration of product design
9. production structure (macro)
10. production structure (meso)
11. production structure (micro)
12. control structure (micro)
13. control structure (meso)
14. control structure (macro)
15. information structure (macro, meso and micro level)

D. Intervention
16. implementation of new structure

E. Evaluation/problem identification
17. checking of bottle necks

Figure 1: Modern Sociotechnology: integral organization design strategy

Van Eijnatten & Hoevenaars, 1989

Table 1: Sociotechnical design principles and their implications for information systems design.

| action planning | dominant design principles and their implications for informations systems *) |
|---|---|
| **all phases:**<br>**organizational system** | **information flow**<br>information systems should produce information for those who could take action<br><br>**support congruence**<br>in all control systems this leading string can be recognized: information systems should fit other systems |
| **all phases:**<br>**the change process** | **compatibility**<br>**transitional organization**<br>**incompletion**<br>organizations change and information systems change, but the organization simply cannot be stopped operating during all these changes. |
| **phase 1:**<br>**design of production structure** | **boundary location**<br>- less need to regulate between departments<br>- implicates less coördination<br>- implicates less need for exchange of information<br><br>**multifunctional principle**<br>people decide what is right, and information systems deliver the right information, at the right place, at the right time, to the right person, in the right form |
| **phase 2:**<br>**design of control structure** | **minimal critical specification**<br>information systems should not restrict people and organizations more than strictly needed<br><br>**variance control**<br>regulating at the source implicates need for information at the source<br><br>**power and authority**<br>those who regulate and are responsible are the first aim for the information system |
| **phase 3:**<br>**design of information structure** | **boundary location**<br>- information systems work within the same boundaries as the production control structure;<br>- exchange of information through 'free' networks of specialists |

*) The relative dominance of particular sociotechnical principles is determined by the action planning phase.

Van Eijnatten & Loeffen, 1990

| level of aggregation | basic organizational unit | functional control dimension |
|---|---|---|
| macro | I business unit | renewal |
| meso | II operational group | improvement |
| micro | III semi-autonomous work group | maintaining |

Figure 2: Organizational units and their relative contributions to respective functional control dimensions

Van Amelsvoort (1989)

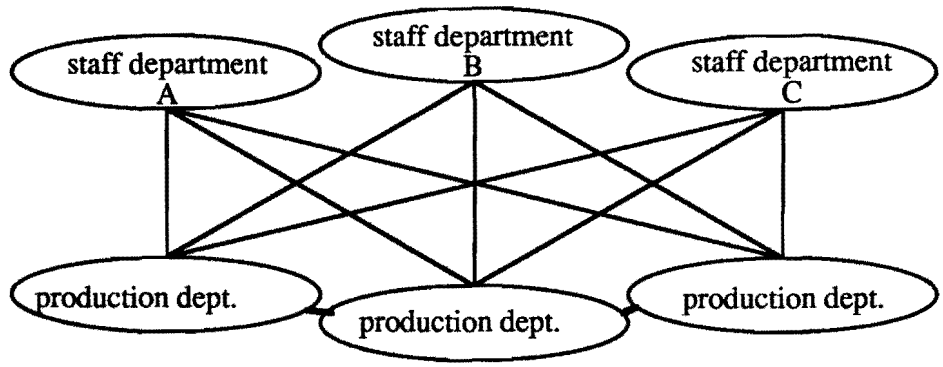
Table 2: Examples of the relationship between control structure and informational needs in a modern-sociotechnical conceptualized work environment

| **sociotechnical structural unit** | **example of main control aspects and associated actions** | **related informational needs (informational sources between brackets)** |
|---|---|---|
| **semi-auton-omous group** | logistics:<br>. ordering auxiliary materials<br><br>quality:<br>.working with statistical process control<br><br>technique and maintenance:<br>. solving small troubles and saveguard machine performance | . materials in stock (s.a.g.);<br>procedure for ordering (o.g.)<br>production plan (o.g.)<br><br>. control results (s.a.g.)<br>standard results (s.a.g.& o.g.)<br><br>. standards (s.a.g. & o.g.)<br>prior results (s.a.g.) |
| **oper-ational group** | logistics:<br>. development of ordering procedures<br>quality<br>. development of test methods<br><br>. evaluation of suppliers | . suppliers information (environment)<br>production standards (s.a.g. & o.g.)<br><br>. delivery standards (b.u.)<br>technological data-base (o.g., b.u. & environment)<br>. technological information (suppliers) |
| **business unit** | marketing:<br>. development of new products and market research concerning potential clients | . market information (b.u. & environment) |

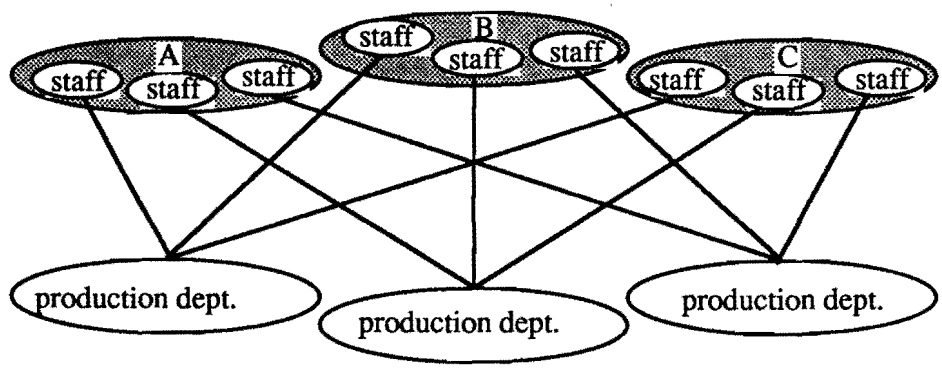
Van Eijnatten & Loeffen, 1990

explanation of codes of informational sources:
s.a.g. = semi-autonomous group
o.g. = operatonal group
b.u. = business unit

**1. functional structure:** each part of production (grouped by process) exchanges information with the different staff disciplines.




**2. line-structure:** each part of production (grouped by product) exchanges information with the different staff disciplines




**3. sociotechnical structure:** each part of production (grouped by product) has its own decentralized staff, exchanging information only within the same bussiness unit

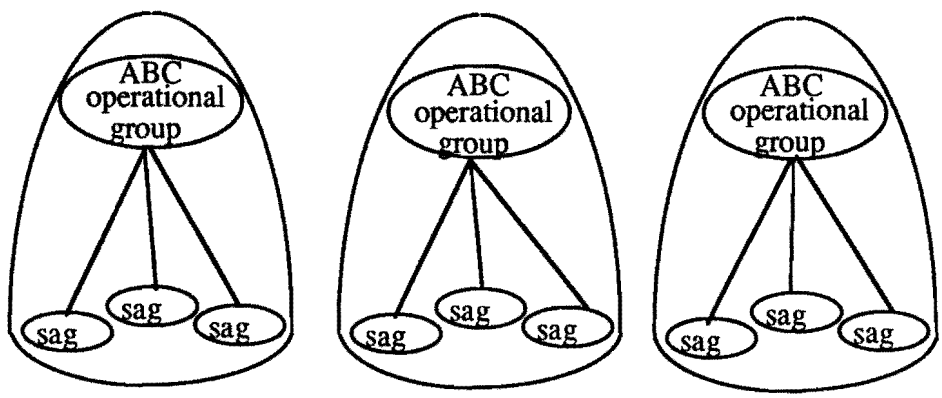



Figure 3: Information exchange at a daily basis in production environment. (sag= semi autonomous group)

Van Eijnatten & Loeffen, 1990

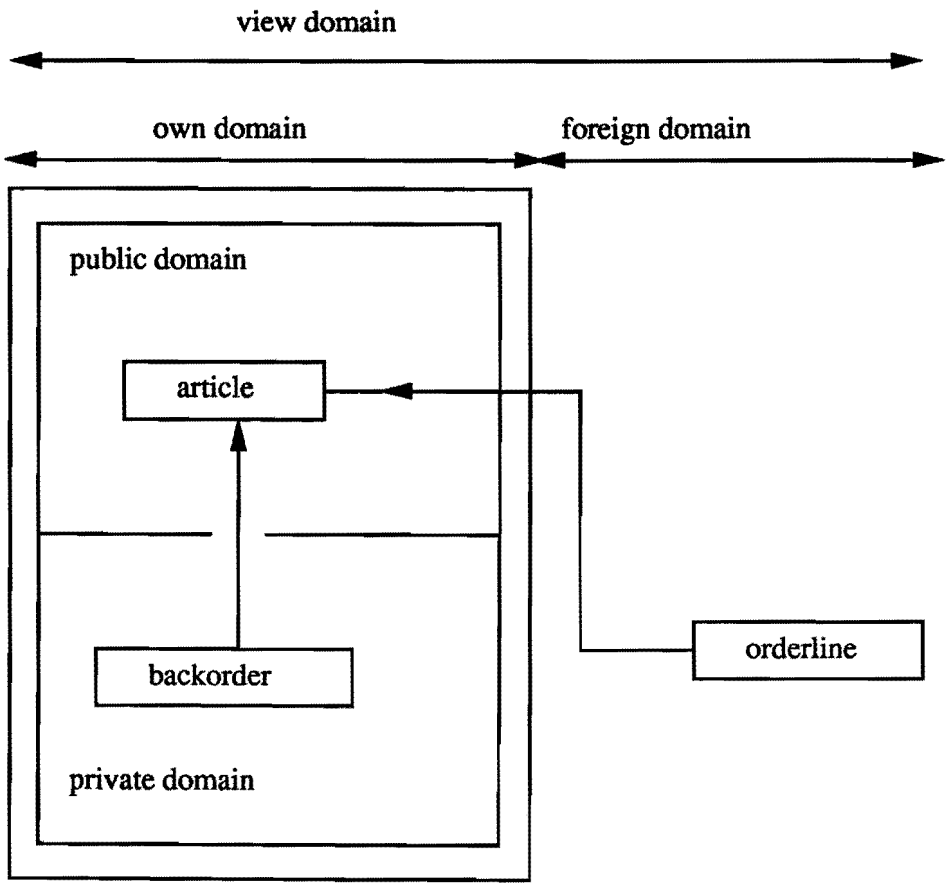



Figure 4: Example of a subscheme for a selling-module

Pels & Wortmann, 1989

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Name : José M.J. Loeffen

Name of Co-Presenters : Frans M. van Eijnatten

Title of Presentation :

Some comments about information systems design for production control from the perspective of an integral sociotechnical organization philosophy

Please type or print clearly a brief biographical sketch to be used by your session moderator in properly introducing you to the Conference:

Biographical Sketch Ir. J.M.J. Loeffen

After having completed her study of Industrial Engineering and Management Science at the Eindhoven University of Technology, Miss José M.J. Loeffen (1960) started her professional carreer at IHC-Shipyard at Kinderdijk, Holland, contributing to the development of a new navigating bridge for dredging vessels. From 1986 till 1989 she joined Dutch PTT Groningen (Telecom Division) as a quality-of-work-life consultant. Now she is a university lecturer at Eindhoven University of Technology. Her main research interest is in sociotechnical design of information systems for production control.

Miss Loeffen is a member of the board of the Dutch Ergonomic Association.