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### Simulation in information systems development.

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## SUMMARY

People in organizations face problems which might be solved better by the use of computers. This study deals with the development of information systems, where computers support the solution of ill-structured problems.

For a discussion of problem situations and of strategies for problem-solving we take problem-solving by individuals as our starting point. Subsequently, we analyze how the content of this process changes by co-ordinating decision-making processes of humans in organizations. We depart from a paradigm which views decision-makers as behaving bounded rational. We adhere to a modelcycle which specifies and tests premises in an inductive way. With this in mind, we look into approaches to the development of information systems. We observe that the systelological area of the development of information systems is relatively neglected as opposed to the infological, datalogical and technological one. Possible contributions may be sought in a computer-supported activity of expressing the premises behind human problem-solving, and in instruments for decision support, especially for problem specification and solution finding.

The points of departure lead to various requirements for the activities in the process of problem-solving and for the supporting instruments. We conclude that the description form of entities together with their attributes and actions is most flexible for the expression of bounded rationality. We develop the notion of an inquiry system for problem-solving as a system of instruments for conceptualization, specification, solution finding and implementation. An inquiry system serves as a context for conceptualization, a base model for problem specification, a model system for solution finding and as a target system for implementation. The successive models as products of the various activities can be laid down in layers. Subsequently, we turn to the question in which language or languages inquiry systems can be expressed. We argue our choice for the programming language Simula, in view of our premises and of recent developments in (system) programming languages. Documentation aspects are also considered.

In an inquiry system for the problem area of organizational decision-making, the inductive-hypothetic modelcycle is given a specific shape in the methodology of simulation. We identify the instruments of a conceptualizer, a modeller, an experimenter and an evaluator. The way to express these in the programming language Simula is investigated. The degrees of freedom presented by the Simula environment lead to a family of Simula(tion)-based inquiry systems, in which various simulation languages and techniques can be reflected. Recent methodological developments are demonstrated to be implementable. The experimentation may be supported by an experimentation data base. An example of an application is presented. We conclude that the

effectiveness of simulation depends heavily on the contexts provided by the various members of the Simula family. The efficiency is determined by various mechanisms, namely for controlling simulated time, for input data generation from a data base, for interactive run control and for output data collection on direct access files.

The use of computers for ill-structured problem-solving in an organizational setting belongs to the subject area of a theory of information systems. The problem of developing an information system is ill-structured as well. For its solution we introduce a Simula(tion)-based inquiry system and a design theory. After an assessment of various approaches, we can identify problems in the development of information systems that ought to be addressed.

We outline as our research subject: Is the application of a Simula(tion)-based inquiry system to the problem of developing information systems feasible, and what can we learn with regard to its effectiveness and efficiency? To look into this question we introduce a hypothetical case of a Multiple Store Company. By application of a Q-Gert-network simulation we show that the project duration in our approach need not to be significantly longer than in 'traditional' ones.

For the conceptualization of the problem of developing information systems in the Multiple Store Company a context is formulated. The latter is the starting point for the identification and specification of a base model of the Company. This is guided by a theory focusing on a distinction between local and global decision-making and on the way co-ordination of decision processes is achieved. Primarily, we address the possibilities of controlling inventories at various levels through aggregation and disaggregation of data. We conclude that the context can be quite simple. Besides the entity-attribute-action description form, it is not necessary to introduce special concepts for an easy description of interacting entities.

From the context for conceptualization and the base model of the Multiple Store Company, a simulation model and a simulation model system are developed. The degree of correspondence of the simulation model system is tested. An experimentation data base and a set of separate programs for analysis are added. The analysis of the actual situation reveals a few significant relationships between exogenous and endogenous variables at article level. Time series suggest relationships which cannot found back in a more detailed examination. Thus the currency of information is of little importance. By aggregating attributes of articles over time, over location or over other characteristics, not many relationships can be accepted for decision-making at a global level.

The results of the analysis of the actual situation in the Multiple Store Company and our theory lead to various alternatives for design. After a screening of important variables an experimental design is made. Experiments are carried out after an inquiry into the feasibility of each treatment. Detailed analysis of the outcome leads to a few remaining alternatives. These are evaluated in the light of infological, datalogical and technological realizability, partly by separate simulation models. Finally, a target system is arrived at, based on s,S-ordering systems at store and warehouse level together with a decision support system in a decentralized data processing setting. If we use an appropriate context, the target specification can be constructed from the base model of the Multiple Store Company. By a small change in the context, infological and datalogical constraints can be analyzed.

The target system resulting from the systelological problem-solving is a well-defined point of departure for the solution of the infological, datalogical and technological problem. The target system is refined into a conceptual information model. Through simulation of prototype systems, information and operational requirements are specified. The conceptual information model can easily be mapped into a conceptual data base model and a conceptual processing model. From these models data and program structures can be generated. Simulations are useful to analyze and ameliorate the efficiency of these designs, as well as in dealing with the introduction.

We conclude that our approach to the development of information systems is applicable to the case of the Multiple Store Company. An inquiry system using the entity-attribute-action description form presents a context, a base model, a model system and a target system as successive layers in the solution of the systelological, infological, datalogical and technological problem. The transition from systelological problem-solving to infological analysis, datalogical design, technological design, and implementation is less difficult and time consuming than expected. A participative design and evolutionary development are realized.

When aggregation of data on local decisions does not present insight for global decision-making, we may relate the latter to the local decisions through simulation-based disaggregations. We make the observation that the Simula(tion)-based inquiry system for the solution of the systelological problem then may reappear as decision support system in the concrete information system. The decision support system not only contributes to the generation of alternatives, but it also may realize a better co-ordination.