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ANALYSIS OF ORGANIZATIONS USING MULTIPLE METAPHORS

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Introduction

A comparison of two research projects

This chapter compares the results of two research projects in the Faculty of Management and Organization at the University of Groningen: the FARSYS (Flexibility Audit and Redesign System) project and the MAGSYS (Multi-Agent Grammar-based Organization Analysis and Change System) project. Both projects aim at developing methods and instruments for observing, interpreting and analyzing changing organizations. They are based on non-traditional organization metaphors such as the organism metaphor and the mind metaphor.

The problem area

The problem area is the transformation process of organizations which are capable of becoming more, or less, flexible and pluralistic. Are there ways in which the management can influence these change processes to reach the goal of a more acceptable organizational structure? The main research question for both research projects is: "How can management influence organizations in transitions from bureaucratic and non-flexible structures to pluralistic and flexible structures, and vice versa?".

Before that question can be addressed, the following preliminious questions have to be considered.

- is it possible to analyze successfully an organization from the view point of organizational metaphors?
- is it possible to give advice as to how an adequate level of stability, flexibility and pluralism can be reached?

- is it possible to develop and implement a change method by which the desired type of organization can be reached?

These research questions stem from the changing management perspective in the last decennium.

A changing management perspective

Order, stability and control have been emphasized since Taylor (1911) established his school of scientific management at the beginning of this century. At present, changeability, variability, instability and moveability of organizations are receiving more attention both in the practice of management and in the development of organization and management theory. Rosemary Stewart (1983: 82-97) describes these changes in management focus based on empirical research of management (see Table 14.1).

Table 14.1: ***Changes in the Dimensions of Management***

Dimension changing from:	**To:**
orderly	disjointed, fragmented
planned	instinctive / reactive
vertical relationships	lateral relationships
stable relationship	developing and maintaining reciprocal relationships
formal information	informal, speculative information
predetermined goals	individual and group goals
non-political	political

The traditional description of managerial functions includes planning, organizing and controlling. The emphasis in that description, and in much writing on decision-making, is on logical, sequential processes. The empirical studies of managerial behaviour analyzed by Stewart suggest a major shift in emphasis towards political and pluralistic forms of management. This shift in emphasis corresponds to a shift away from the use of the machine metaphor and towards the use of the organism and mind metaphors for organizations.

A change in the use of organization metaphors

Using the organism metaphor for organizations, bureaucracy, for example, is seen as being opposed to the flexibility in an organization. A bureaucracy is an organization with a medium steerability and a small management strategy repertoire. A flexible organization is seen as a highly steerable organization in which the management repertoire of strategies for adapting to the environment is large. Steerability is the degree to which it is possible to change the organization to meet the requirements of a specific strategy within an acceptable period of time. With an adequate strategic repertoire and steerability an organization is able to influence its environment and to react adequately to impulses stemming from its environment. The FARSYS project is mainly based on the organism metaphor.

Using the mind metaphor for organizations, the bureaucratic organization is contrasted with the pluralistic organization. Bureaucracy is here seen as an organization whose decision-making is essentially that of a single-agent the management of the organization. As a result of this, the availability of a variety of interpretation frames and the strategies of other agents within the organization in severely limited. In contrast, the pluralistic organization is characterized by its multi-agent network of communication and decision-making, and by a relatively high variety of interpretation frames and strategies. The pluralistic organization stimulates initiative and change. As a result of the pluralistic decision-making network, the overall strategy of the organization adapts easily to changing circumstances. This means that, over a period of time, multiple strategies will be followed. The MAGSYS project is mainly based on the mind metaphor.

The observation, interpretation and analysis of change in organizations, using metaphors other than the traditional machine metaphor, requires new, carefully-developed methods and instruments. In the following paragraph, we explain the role of the background theory (symbol system theory) and the use of the metaphors in the development of these methods and instruments.

PROBLEM SOLVING AND THE USE OF METAPHORS

Problem solvers as seen by the symbol systems theory

Organization analysts and consultants can be seen as solvers of problems to which general theories about symbol systems are applicable. Symbol systems theory is based on the functional similarity of the human mind, computer systems and organizations. Their common characteristics correspond to a more general concept - the symbol system concept. Pylyshyn (1981: 68) observes: "*History may well record that around the middle of the twentieth century many classical problems of philosophy and psychology were transformed by a new (and not yet well understood) notion of mechanism, specifically in the form of a computational mechanism*".

In their Turing lecture, Newell and Simon (1976: 40) define the concept of a "symbol system" as follows: "*A physical symbol system consists of a set of entities, called symbols, which are physical patterns that can occur as components of another type of entity called an expression (or symbol structure). Thus a symbol structure is composed of a number of instances (or tokens) of symbols related in some physical way (such as one token being next to another). At any instant of time the system will contain a collection of these symbol structures. Besides these structures, the system also contains a collection of processes that operate on expressions to produce other expressions: processes of creation, modification, reproduction, and destruction. A physical symbol system is a machine that produces through time an evolving collection of symbol structures. Such a system exists in a world of objects wider than just these symbolic expressions themselves*".

They also state a general scientific hypothesis about symbol systems: "*A physical symbol system has the necessary and sufficient means for general intelligent action*".

A general characteristic of symbol systems is that they solve problems by generating solutions and testing them. A solution can be seen as a set of successive operations in a problem space, leading from a starting point to a goal. Solutions are represented by symbol structures.

"*The solutions to problems are represented as symbol structures. A physical symbol system exercises its intelligence in problem solving by search - that is, by generating and progressively modifying symbol structures until it produces a solution structure*", according to Newell and Simon (1976: 51).

Metaphors as instruments for complexity reduction

Because physical symbol systems have limited processing resources, and because they have to solve problems within a reasonable time, only a limited number of possible solutions can be generated and tested. An exhaustive search of the problem space for possible solutions is impossible. Exhaustive search requires an exponentially expanding number of search steps: "*Thus, if from each expression it produces, the generator creates B new branches, then the tree will grow as BD, where D is its depth*" (Newell and Simon 1976: 56).

This number of search steps is known as the complexity of the problem. Therefore, most practical problem solving requires complexity reduction. For complexity reduction, two general strategies can be used:

- using a limited interpretation frame (the strong methods), and
- controlling search by heuristics (the weak methods).

The strong methods for complexity reduction are based on the prevention of exponential search expansion by choosing the right problem space. The weak methods are general heuristic methods for controlling the search based on the selection of the most probable route to an optimal solution, and thereby avoiding exhaustive search.

The use of strong methods is well known in organization and management theory. Based on the specific characteristics of the problem, a viewpoint is chosen, and that process can be described as selecting a metaphor for interpreting the state of the organization. Therefore, limited interpretation frames in organization and management theory can be described in terms of organization metaphors (see Morgan 1986). These interpretation frames can be analyzed as formal grammars defining the symbol structures producible by them (see Gazendam 1991); and the organization metaphors described by Morgan (1986) have been described as such (see Gazendam 1990). For problem solving by organization consultants, an approach based on the use of multiple metaphors is advocated in Morgan (1986) *Organization and Management Theory* (321). Well-known metaphors are the machine metaphor and the organism metaphor. Because of the fact that organizations, information systems and the human mind have been used as metaphors for each other, we distinguish a third main organization metaphor: the mind metaphor. Symbol systems theory is the theory underlying the use of the mind metaphor. The methods of analysis using the mind metaphor are especially interesting from a semiotic point of view because then interpret the organization as a symbol system consisting of communicating agents. In the next paragraph, we describe these metaphors by outlining the development of thought about organizations.

Changes in Thought About Management and Organization as Expressed by Metaphors

The machine metaphor: the classical management perspective

During this century, thinking about management and organizations has been largely dominated by the normative propositions of classical theories. There are four bodies of literature that provide both the intellectual substance for and the legitimacy of this classical management perspective. They are (1) scientific management (Taylor 1911), (2) classical organization theory (Fayol 1949), (3) classical economics (Smith 1957), and (4) bureaucratic theory (Weber 1925).

Taylor (1911) was a crusader for a new and "scientific" management. Management's function was to determine "scientifically" the best procedures for perform-

ing every task, to select and train workers in following these procedures, and to provide financial rewards for compliance (Taylor 1911: 59- 60). However, it was not only, or even primarily, the lot of the workers that was to be altered by the introduction of scientific management; the role of management itself was also to be transformed, according to Scott (1987: 36). Taylor's aim was to replace the arbitrary and capricious aspects of management with analytical, scientific procedures (Taylor 1947: 211, 189). The activities of both managers and workers were to be rationalized; both were to be equally subject to the regimen of science. The resulting contribution to the classical management approach was a perspective on job design that separates thinking from doing, focuses on the individual worker as opposed to the group and stresses economic incentives as the sole source of motivation. Unlike scientific management, classical administrative management was concerned with the macro aspects of organization design -as the process of dividing the organization into departments, coordinating the departments, managing the hierarchy, and so on (see Kilmann 1977: 20). Fayol (1949) suggested that managerial processes such as planning, organizing, directing, coordinating, and controlling are requirements for efficient and effective task fulfilment (see Kilmann 1977: 19-20). He and his followers sought to develop principles of rational organization, such as "unity of command", "span of control", "exception", "departmentalization", and the "line-staff" principle. These principles increasingly came under attack for being mere truisms or common sense pronouncements, and for being based on questionable premises. Their main fault, however, was not so much their inadequate theory of motivation, or the prescriptive cast of their contributions, as their failure to develop conditional generalizations - that is, statements that include the limits of their applicability to particular situations or types of organizations.

While scientific management and classical administrative theory have had a lasting effect on management practice, it is classical economic theory and Weber's theory of bureaucracy that have provided intellectual legitimacy for the classical management perspective. Classical economic theory had its origins in the ideas of Adam Smith (1776), who set forth the principles of specialization *An Inquiry into the Nature and Causes of the Wealth of Nations*. Classical economics views the firm as having a single purpose - the maximization of profit.

The firm is seen as the instrument of the entrepreneur, with all other organizational participants being supplied by the market at the going rate. This view of the organization as a solitary actor with a single objective or goal is a key part of the classical economic theory. However, it is Weber (1925) who provided the greatest insight, and, perhaps unintentionally, did most to legitimise the classical management perspective. He suggested that all organizations were moving towards an ideal type of structure - a bureaucracy characterized by a high degree of specialization or division of work at all organizational levels, a hierarchy of authority, the use of a set of rules and procedures for conducting daily organizational functions, and impersonality in decision making (see Kilmann 1977: 18). The emergence of this "rational-legal" ideal form of management and organization was seen as a response to the problem of the traditional and charismatic forms of management. Rational-legal authority rests on a belief in the "legality" of patterns of normative rules and the right of those elevated to authority under such rules to issue commands. By contrast, charismatic authority is too transitory to result in the formation of a permanent organizational structure, and traditional authority leaves an organization subject to the arbitrary and capricious act of its leader. By comparing bureaucracy based on rational-legal authority with a capricious traditional structure, Weber provided the most sophisticated argument for the legitimization of the classical management perspective.

Taken together, the ideas of scientific management, classical administrative and economic theory, and bureaucratic theory, provide the theory and rules for the practice of the dominant management perspective of this century. Scientific management provides the rationale for job design. Classical organizational theory provides the guidelines for overall design. Classical economic theory provides the rationale for pursuing the single goal of maximization of profits, which deals with employees as variable costs and deals with other firms on a transactional basis. Bureaucratic theory provides the rationale for hierarchical authority relations. In this classical management perspective, organizations are considered as machines - single-purpose mechanisms designed to transform specific inputs into specific outputs, and capable of engaging in different activities only if explicitly modified or redesigned for that purpose, says Morgan (1986: 35). This machine-metaphor has dominated the practice of management and organization.

According to Scott (1987: 99), the classical management perspective is a closed rational approach which portrays organizations as tools designed to achieve preset ends and ignores or minimizes the difficulties and opportunities posed by connections to a wider environment.

The organism metaphor: a modern management perspective

Around 1930, the human relations movement founded by Elton Mayo emphasized the importance of social relations among organizational participants (see Khandwalla 1977: 133). By illustrating the inhuman aspects of classical concepts, the human relations movement challenged scientific management's basic assumptions about job design and motivation. In the mid forties, Herbert Simon expounded his view of the administrative decision maker whose reasoning, perceiving and information-processing abilities were limited: the bounded rationality concept. This was an attack on the perfect rationality concept of traditional economists and the universalistic prescriptive character of classical organization theory. For the "economic man", motivated by self-interest and completely informed about all available alternatives, Simon proposed to substitute a more human "administrative man", who seeks to pursue his own interests but does not always know what they are, is aware of only a few of the possible alternatives and is willing to settle for an adequate solution instead of an optimal, Scott (1987: 45-46) states. In 1950, Eric Trist of the Tavistock Institute of Human Relations brought the socio-technical systems viewpoint to bear on organization behaviour. He stressed that a work group is subject to social, psychological, technical, and economic forces. In 1958, Joan Woodward founded contingency organization theory based upon the observation that differences in the structures of organizations depend on differences in the technology they employ. She revealed the inappropriateness of universal principles of organizations. In the mid fifties, Chris Argyris and Douglas Mc Gregor developed their models of desirable organizations in which human needs would be more fully satisfied and a fuller use made of human capital. While human relationists sought only to modify classical organizational theory (see Mayo 1933), the behavioral humanists have been inclined to seek radical change (*cf.* Kilmann 1977: 21). In reaction to

numerous revisions of the classical approaches to the design and management of organizations, they began to emphasize change in social systems processes for improving organizational effectiveness. All these different schools of thought combine to provide the basis of modern organization theory. Their new insights into management and organization resulted in a new management perspective which recognizes:

- that an organization possesses properties of a natural system (Human Relations and Human Resources School) as well as of a rational system (Bounded Rationality School): each approach leads to some truth, but neither alone provides an adequate understanding of complex organizations (see Thompson 1967: 8);
- that an organization is an open system, indeterminate and faced with uncertainty (Contingency Theory and Sociotechnical Systems School);
- that an organization is at the same time subject to criteria of rationality and hence in need of determinateness and certainty (Bounded Rationality School; see Thompson 1967: 10).

However, this modern management perspective still views organizations as multi-purpose mechanisms designed to achieve predetermined goals in different environments. The organization is viewed as an organism that strives to survive. To survive it has to adapt to its environment. This adaptation, however, is based on the prediction of changes and is therefore rational. The rationality underlying this revised perspective is what may be described as organizational rationality.

The Mind Metaphor: a Post-Modern Management Perspective

The organizational rationality of the organism metaphor contrasts with the substantial rationality of organizations in which people are encouraged to determine whether or not what they are doing is appropriate, and to adjust their actions accordingly (see Morgan 1986: 37). Substantial rationality implies that organizational participants are able to perceive or to experience reality as a meaningful and coherent whole, giving sense to their actions within the organization (see

Frissen 1989: 70-71). Whereas under the control ethos actions are rational because of their place within the whole, substantial rationality requires actions that are informed by intelligent awareness of the complete situation. Whereas organizational rationality is in its roots mechanical, substantial rationality is reflective and self-organizing. It is possible to develop this substantial rationality by using the mind as a metaphor for organization. To the extent that we build organizations on classical or modern principles, we develop technical or organizational rationality respectively, where people are valued for their ability to fit in and contribute to the efficient operation of a predetermined structure. This is sufficient for performing a fixed task in stable circumstances or changing tasks in predictable circumstances. When these conditions are violated, however, organizations designed along these lines encounter many problems. In these situations, it is necessary to improve the organization's ability to organize in a way that promotes flexibility. Under changing circumstances, it is important that participants of the organization be able to question the appropriateness of what they are doing and to modify their action to take account of new situations. "*This requires an organizing capacity that is "substantially" rational, in the sense that action manifests understanding of the relations within which the action is set: substantially rational action is not undertaken blindly but in an awareness that it is appropriate*", says Morgan (1986: 78).

The considerations above require a post-modern management perspective. In this perspective, the question as to whether organizations are closed or open systems is not important. Instead, organizations tend to maintain their existence by responding in particular ways to the environment. The sharp dichotomy between organization and environment is misleading. Environments are as much part of the organization as production technologies, organizational structures, and cultures. If we put ourselves inside such an organization we may come to realize that we are within a closed system of interaction consisting of the organization and its ecological environment, an environment that is chosen or even created by the system and depends on it as much as the system itself depends on its environment (see Maturana and Varela 1984).

Table 14.2: ***Changes in Perspectives of Management and Related Metaphors***

Dominant perspective of management	Rationality concept	Environmental approach	Organizational approach	Dominant metaphor
Classical management	Technical rationality	Closed system approach	Rational system approach	Machine
Modern management	Organizational rationality	Open system approach	Rational/natural system approach	Organism
Post-modern management	Substantial rationality	Open/closed system approach	Natural approach	Mind

Instruments Based on Organization Metaphors

The necessity of new instruments for observation, analysis and change

The emergence of the organism metaphor and the mind metaphor as important organization metaphors requires new methods and instruments for observation, analysis and change. Fundamental aspects of the design of these methods and instruments are the methods of breaking down and analyzing the problem area, and the judgements on which optimization will be based. Metaphors guide the processes of breaking down and analysis, and of designing and implementing the methods by which optimal solutions can be reached. The organism metaphor stresses the fitting of the organization as a whole into the dynamically changing environment. Both the machine metaphor and the organism metaphor take the viewpoint of the (top) management of the organization, and see the organization as a whole as one which is managed by this (top) management. The analysis and optimization instruments focus at the description of the environmental turbulence, the resulting organizational stress and the organization's adaptation processes. Advice is generated which is based on contingency characteristics and rules emerging from consultancy practice. The mind metaphor stresses the communication network of interacting agents, of which some are within the organization and some are outside, in the environment. The breaking down creates or identifies a

multi-agent system in which each agent behaves according to an interpret-choose-act-learn cycle. The analysis is focused on the perception of the problem by each agent in the organization and the mechanisms for problem solving and coordination of agent strategies. Advice is generated which is based on a pluralism profile. The variety of agent interpretation frames can be analyzed further using a grammar-based description method (see Gazendam 1991). The emergent dominant strategy of the organization, and its time-stability, have to be explained through the interactions of the problem-solving and communicating agents in an agent network. The network-like structure of communication and control channels can be analyzed by mathematical techniques. A further analysis of the dynamics of the organization, and the patterns emerging from these dynamics, can be carried out by using intelligent multi-agent simulation models (see Gasser and Hill, 1990; Gazendam 1990, 1991). The FARSYS instrument is based partly on the organism metaphor and partly on the mind metaphor. It sees an organization as a whole, and as a single-agent system as seen from the mind metaphor. The MAGSYS instrument is based on the mind metaphor, but uses aspects of the organism metaphor as well. It sees an organization as a multi-agent system existing in a multi-agent world. These differences in break-down, and in metaphor emphasis lead to differences in the FARSYS and MAGSYS instruments.

The FARSYS Instrument

Aim of the FARSYS instrument

The Flexibility Audit and Redesign System (FARSYS) is a result of a joint research effort of the Faculty of Management and Organization of the University of Groningen and GITP/management consultants. The principal aim is to develop an instrument for the development and improvement of organizational flexibility. This instrument is based on the organism and mind metaphors for organizations, as opposed to the machine metaphor. In the machine metaphor, flexibility is restricted to the machine design phase. Management is characterized as a highly rational process that involves activities such as establishing goals, searching for

and evaluating alternative actions, and developing an integrated plan to achieve the goals. Whereas in a stable environment we can allow such a deliberate formulation and execution of plans, nowadays many situations comprise strategic surprises that do not give sufficient warning to permit deliberate planning (see Ansoff 1978; Burton 1984). Integrated, comprehensive planning requires unrealistic stability in the environment (see Mintzberg 1973). In many situations, managers have to compensate for the one-sided tendency of bureaucratic organizations to produce highly formalized and ritualistic planning procedures. In this context, Pennings (1983) and Starbuck (1981) warn against the institutionalism and routine of formal planning systems that lead their own life, regardless of relevant strategic events. Numerous examples of these formalized planning systems can be found in the public sector and in large private corporations. Considering these arguments, we might conclude that planning and analysis are necessary elements of the management task which need to be understood as mechanisms for problem and opportunity identification rather than for radical change (see Johnson 1988). Indeed, in situations of radical change, attempts to adopt comprehensive and ritualized planning would only paralyse the organization (see Burton 1984). In such a situation, the obsession of rationality would probably lead to a further refinement of the planning mechanism that is the cause of the problems. In the organism metaphor, flexibility is considered as an essential strategic asset for facilitating responses to unanticipated surprises. The focus is not on deliberate planning and control, but on developing the organizational capability for strategic thinking and learning, which means being open and responsive. As a result, patterns or consistencies are realized despite, or in the absence of, intentions (see Mintzberg 1985). In this context, flexibility is essentially a question of organizing: "*How do we have to organize ourselves in order to facilitate the process of adapting to or influencing the environment?*" In the mind metaphor, a flexible organization is an organization with a core belief set that is broadly shared among the organization members, permitting additional sets of beliefs that are rather heterogeneous. The cultural system must have mechanisms for encouraging strategic initiatives as well as for suppressing counterproductive actions. There must be a "constructive tension" between that which is necessary to preserve and that which must be changed (see Moss Kanter

1983). This view is supported by Meyer (1982), who argues that organizations are more likely to adapt strategies that are divergent from their previous strategies if they have a heterogeneous organizational "ideology", as manifested in terms of organizational images and symbols. In the same line, Friedlander (1983) states that organizational learning in a "reconstructive" mode takes place more readily where there is such heterogeneity.

Breaking Down of the Object System in FARSYS

In the light of these metaphors, organizational flexibility can be seen as an indicator of management competence, as well as an organizational characteristic.

Flexibility and management competence

As an indicator of management competence, flexibility is concerned with the ability of management to influence the organization and its environment, and to react adequately to disturbances and signals stemming from the organization and its environment. Core components of this management task are:

(a) the existence of actual and potential procedures for influencing the organization and its environment, for reacting to events in the organization and its environment and for enhancing flexibility itself;
(b) the variety of these procedures in the organization, which must be attuned to the possible disturbances in the environment (see Ashby 1956); and
(c) the rapidity by which an organization can implement these procedures.

Time is a very essential factor of organizational flexibility.

The degree of management competence with regard to the core components of the management task described above is expressed in the organization's "flexibility-mix". The flexibility mix refers to the collection of flexibility increasing procedures that an organization possesses, and the rapidity by which an organization can implement these procedures. The flexibility mix comprises of

three types of flexibility: operational flexibility, structural flexibility and strategic flexibility (see Ansoff and Brandenburg 1971; Eppink 1978; Volberda and Van der Stelt 1988).

Operational flexibility consists of routines based upon the existing structures or goals of the organization. This most frequent type of flexibility relates to the volume rather than the nature of activity undertaken within the organization. The routines, which are primarily directed at the operational activities, are largely reactive in nature. The time limit involved is often short-term. Structural flexibility or adaptive manoeuvring capability is the ability of the management to adapt the organization structure, and its decision and communication processes, to suit changing conditions, and the rapidity with which this can be accomplished (see Krijnen 1979). Strategic flexibility or non-routine steering capability involves procedures related to the goals of the organization or the environment (see Aaker and Mascarenhas 1984). This radical type of flexibility is much more qualitative, and goes together with changes in the kind of organizational activity, such as the creation of new product market combinations (external strategic flexibility) or the application of a new technology (internal strategic flexibility). Strategic flexibility is, by definition, unstructured and non-routine; the scarce information is very inconclusive. Totally new values and norms are required and past experience is more of a disadvantage than an advantage (see Newman *et al.* 1972). The creation of new activities in new situations has great importance.

Besides these three different types of flexibility, we can distinguish the meta-flexibility of an organization - that is, the ability of the organization's monitoring and learning system to enhance the flexibility mix. Meta-flexibility involves the processing of information to facilitate the continuous adjustment of the composition of the organization's flexibility mix to the changing characteristics of the environment.

Flexibility and Organizational Characteristics

The success of the procedures for proactively influencing, or reacting to, events in the organization or in its environment is dependent upon the degree to which the organization's technology, structure, and culture are changeable within the time

required by the repertoire of management procedures. This steerability determines the boundary conditions which are imposed on the procedures underlying the managerial flexibility mix. The creation of specific organizational conditions for changeability constitutes an important organization design task. This second dimension of flexibility is aimed at creating the organizational conditions which are necessary for the effective realisation of certain procedures. Paradoxically, core aspects of this organization design task are concerned with stability and preservation as well as with changeability. There cannot be flexibility without some stability or preservation. Stability provides certainty for organizational members and preservation facilitates steerability of the organization. Changeability as well as stability and preservation are conditions for steerability measured with respect to three aspects of the organization: operational technology, organizational structure, and organizational culture. The operational technology refers to the hardware (means of transformation, such as machinery and equipment) and the software (knowledge) by which the organization transfers materials and/or information. The characteristics of the technology can range from routine to non-routine. The organizational structure is not only the actual distribution of responsibilities and authority among the organization's personnel, but also the planning and control systems, and the processes of decision-making, coordination and execution. The former is related to the construction of the organization in functions and divisions or units (organizational form or "Aufbau" (see Kieser and Kubicek 1978). The latter is related to the organizational regulations of processes ("Ablauf"). The structure of the organization can range from mechanistic to organic (Burns and Stalker 1961), corresponding to the opportunities for adaptive procedures. The organizational culture can be defined as the shared interpretations about the kind and usefulness of work and co-operation (see Hofstede 1980). This means that culture is in our conception something different from the explicit behaviour, which is an effect of the organizational structure. This culture can range from conservative to innovative, depending upon the slack within the existing norms and value systems. As an indicator of management competence, flexibility measures the quality of the steering capability of management in a changing environment. As an organizational characteristic, flexibility is concerned with the steerability of the organization under different conditions. These

two dimensions define the way FARSYS will measure the organizational flexibility: as a degree to which an organization possesses a variety of actual and potential procedures, and the rapidity by which it can implement these procedures in order to increase the steering capability of the management and improve the steerability of the organization.

Practical Application of FARSYS

After developing the conceptual model described above, twenty-two interviews with management consultants were conducted in order to examine the process of diagnosing and improving flexibility, and the organization of this process of change. The resulting clinical understanding of the change process, together with the conceptual model, was integrated in a process model. With the checklists developed next, the former activities resulted in a method for diagnosing flexibility and for guiding the transition process. Subsequently, the method was applied in a multi-case longitudinal study consisting of three different organizational units in different, changing environments: an administrative unit, a production unit, and a professional service unit. In each case we scanned the environment on the three headings of dynamism (frequency and intensity of changes), complexity (number of factors and relatedness) and unpredictability (predictable, unpredictable as a consequence of ignorance of data, fundamentally unpredictable). The results were presented in a turbulence profile. We also measured the flexibility mix, and this resulted in a flexibility profile indicating the relevant types of flexibility. Finally, we measured those characteristics of the organization which are relevant to flexibility: the organizational technology (routine/non-routine), the actual organizational structure (mechanistic/organic) and the specific idea-system or culture of the organizational unit (conservative / innovative).

On the basis of the conceptual model described above we predicted that:

- an administrative unit, formerly functioning in a relatively stable environment (static, simple and predictable), would have a very limited flexibility-mix and possess a routine technology, a mechanistic structure and a conservative culture.

- a production unit, formerly functioning in a reasonably turbulent environment (dynamic and/or complex, but largely predictable) would have a more extensive flexibility-mix, dominated by operational flexibility, and possess a more non-routine technology, a mechanistic structure and conservative culture
- an R&D unit, formerly functioning in a very turbulent environment (dynamic, complex and fundamentally unpredictable), would have a very broad flexibility-mix, dominated by structural and strategic flexibility, and possess a totally non-routine technology, organic structure and innovative culture.

The diagnosis by FARSYS of these organizational units gave the following results. The administrative unit possessed a very small flexibility-mix and the steerability of the unit was low. The flexibility-mix, as far as it existed, was dominated by simple routines. The choice and variation possibilities were limited; improvisation was taboo in this unit. The mature technology, the functionalized and centralized structure with many hierarchical layers, and a monotonous and narrow-minded culture resulted in a fragile and vulnerable organization. The administrative unit resembles what is commonly understood to be a bureaucratic organization at present - that is, a large, inefficient, role-bounded organization, constrained by red-tape and multiple procedures (very different from the bureaucracy conceived by Max Weber). The production unit also had a limited flexibility-mix, but the composition was less limited than the administrative unit and the steerability was much higher. The flexibility-mix mainly consisted of routines and specific rules and detailed procedures, which were very sophisticated and complex in nature. For every possible change the production unit had developed a certain routine (operational flexibility). In comparison with the administrative unit the mix was much more sophisticated. The rigidity of this organizational form was not so much a result of the primary structure as an outcome of the strong process regulations of the structure, such as standardization, formalization and specialization, and very detailed planning and control systems. Also, the shared beliefs and assumptions which were a part of the culture gave very little leeway for deviant interpretations of the environment. Dissonance within this idea-system was potentially threatening to the organization's integrity. This organizational form resembles the "ideal-type"

bureaucracy of Weber (see Perrow 1972). The R&D unit possessed a very large and extensive flexibility-mix, but was totally unsteerable. In this organization the possibilities of variation were unlimited; there was no anchorage. There were innumerable initiatives for innovation, but it was impossible to implement them. Administrative structures and some "shared values" in the culture were missing. A lack of administrative stability was caused by "strategic neglect" (see Burgelman 1983).

The empirical findings suggest that different organizational forms can be identified. On the basis of the two aspects of organizational flexibility - the management competence expressed in the flexibility-mix, and the steerability of the organization - a typology can be constructed consisting of the rigid, the bureaucratic, the flexible and the chaotic organization (see Table 14.3).

Table 14.3: ***FARSYS Typology of Organizations***

	Steerability		
	Low	**medium**	**high**
Low flexibility mix	Rigid	bureaucratic	
High flexibility mix	Chaotic		flexible

The administrative unit fully corresponds with the rigid form, while the production unit resembles the bureaucratic form. In both cases there was a lack of structural and strategic flexibility caused by a preference for preservation over change. The R&D unit is close to the chaotic form. The surplus of structural and strategic flexibility indicated a preference for change. Our theoretical sample did not contain a flexible form because the FARSYS project focuses on the engineering of flexibility. In this typology, however, the "flexible organization" possesses a large and rich flexibility-mix and a reasonably high steerability. A variety of innovation stimuli can be observed and also implemented with some supple adoptions within the existing structure (see Ansoff and Brandenburg 1971).

The paradox between change and institutionalization or preservation is well managed here.

The MAGSYS Instrument

Aim of the MAGSYS instrument

The Multi-Agent Grammar-based Organization Analysis and Change System (MAGSYS) is a mind-metaphor-based instrument for organization analysis and change, related to information technology. The aim is to develop an instrument for describing, analyzing, and understanding organizations as networks of interacting agents in which each agent has his or her own interpretation frame. For describing organizations, taxonomy, typology and an observation approach are used. For analyzing and understanding organizations, MAGSYS uses a grammar-based interpretation frame analysis method and multi-agent simulation models. In the taxonomy, attention is paid to technical infrastructure, technical innovation, agent topology, organizational reflection and change, agent interpretation frames, and agent strategy dynamics. The taxonomy is based on symbol systems theory, complexity reduction and grammars, as well as on the idea of developing coordinated problem solvers (see Gasser and Hill 1990). The taxonomy has been elaborated to a typology in which bureaucracy and pluralism are distinguished. The observation approach is action research and systematic observation based on the triangulation principle. The triangulation principle (see Jick 1983) is a policy evaluation approach using several information sources, data acquisition methods, and knowledge elicitation methods. Grammar-based interpretation frame analysis is based on the interpretation of the agent's mind as a symbol system (see Newell and Simon 1976). At the symbol system level, complexity reduction can be seen as a central phenomenon. This phenomenon is studied using grammars describing interpretation frames (see Gazendam 1991). Morgan's (1986) metaphors have been described by grammars (see Gazendam 1990, 1991).

Table 14.4: ***Typology Distinguishing Bureaucracy and Pluralism***

No	Indicator	Bureaucracy	Pluralism
1.1.1	Technical infrastructure variety	Standardization	Diversity
1.1.2	Technical infrastructure topology	Concentrated	Deconcentrated
1.1.3	Technical infrastructure control	Centralized	Decentralized
1.2.1	Technical infrastructure change method	Blueprint planning	Incrementalist development based on supply and demand
2.1.1	Agent topology	Hierarchy	Network
2.1.2	Coordination instrument	Central comprehensive planning	Markets, goals, and behaviour rules
2.1.3	Control goal	Coordination	Learning
2.1.4	Control enforcement	Following the plans and rules	Foster initiative and learning
2.1.5	Agent strategy	Agents have one strategy	Agents have more strategies to be prepared for contingencies
2.1.6	Dominant aspect of decision-making	Resource allocation	Result-based task allocation
2.1.7	Dominant target of decision-making	Internal control and efficiency	Adaptation to external markets and changing circumstances
2.2.1	Structural change based on	Formal reorganization	Informal project teams
3.1.1	Agent variety	Functionally determined agent variety	High variety of agents dependent on probabilistic factors

3.1.2	Interpretation frame variety of an agent	Functionally determined variety of agent frames	High variety of agent frames
3.1.3	Agent tolerance	Agents see their strategy as good for everyone	Agents see their strategy as good for themselves or for their own group
3.1.4	Dominant knowledge in communication	Formal positions, structures, procedures, and plans	Informal opinions, strategies and capabilities
3.2.1	Cultural diversity and change potential	Uniform culture with low change potential	Pluralist culture with high change potential
4.1.1	Interaction patterns with environment	Low diversity of interaction patterns for each agent	High diversity of interaction patterns for each agent
4.2.1	Dynamics of interaction patterns with en-vironment	Changes in legislation or procedures are followed by changes in interaction patterns	Entrepreneurial initiatives of agents change interaction patterns

Multi-agent simulation models (coordinated problem solvers) are used for gaining insight into the dynamics of communication and co-operation in networks of intelligent agents.

Breaking Down of the Object System in MAGSYS

Taxonomy and typology

The taxonomy for describing organizations is based on five main aspects of the organization: the technical infrastructure, the organizational (human) structure, the organization culture, the interaction with the environment, and the emergent coordination and stability of the organization's strategy. Each aspect has static

characteristics as well as dynamic characteristics and each aspect has its specific methods for observation and analysis. These aspects can be used for a typological description of bureaucracy and pluralism. The main characteristics are depicted in Table 14.4.

A main research question for MAGSYS is the extent to which the bureaucracy/pluralism dimension influences the coordination and stability characteristics of an organization by the interaction patterns of agents. These coordination and stability characteristics are shown in Table 14.5.

Table 14.5: ***Coordination and Stability Characteristics***

No	Indicator	Value 1	Value 2
5.1	Agent strategy coordination	Agents coordinate their strategies	Agents have parallel or conflicting strategies
5.2	Time stability of the dominant strategy	The organization's dominant strategy is stable in the long run	The organization's dominant strategy is cyclic or chaotic in the long run

Analyzing Instruments

The analysis component of MAGSYS aims at the investigation of the macro properties of an organization, such as strategy coordination and stability of the dominant strategy, as emergent from the dynamic interaction of agents in a multi-agent network. The characteristics of agents and their interactions, as well as the macro properties, can be observed using the taxonomy and typology described above. For the investigation of the relationship between macro-level properties and micro-level characteristics, an approach based on intelligent multi-agent models (coordinated problem solvers) (see Gasser and Hill 1990) has

been chosen. To be able to investigate the effects of the variety of agent interpretation frames (for example the use of a variety of metaphors as interpretation frames), a method for building these multi-agent simulation models, based on the representation of interpretation frames as grammars, has been developed (see Gazendam 1991). The resulting architecture is called the pluralistic problem solver architecture. Thus far, two prototypes of this pluralistic problem solver have been built: the Information Strategy Model (ISM) and the Multi-Agent Grammar-based classifier system (MAG).

Characteristics of Intelligent Multi-Agent Simulation Models

Theory development about the complex processes of organizational decision-making can gain from computational research - that is, research based on building simulation models of organizations. Especially intelligent multi-agent simulation models (see Masuch 1990; Gasser and Hill 1990; Gazendam 1991) offer interesting possibilities. They combine the more traditional, process-based, multi-agent simulation with modelling techniques from artificial intelligence. They are called "coordinated problem solvers" by Gasser and Hill (1990). These models offer possibilities for a deep understanding of task allocation, multi-agent problem solving and co-ordination mechanisms as related to agent goals, agent knowledge, and communication channel topology. Gasser and Hill (1990: 216) report the progress in the field of coordinated problem solvers. They identify six basic problems for engineering the latter:

1. description, decomposition, distribution, and allocation of tasks;
2. communication: interaction languages and protocols;
3. achieving coherent collective behaviour;
4. modelling other agents and organized activity;
5. recognizing and resolving interagent disparities;
6. implementation languages, frameworks, and environments.

The description, decomposition, distribution, and allocation of tasks is determining the basic task topology of a coordinated problem solver. It determines

implicitly which agents have to co-operate. With respect to the communication topology, the choice of the communication channels (centralistic, multi-black-board, or agent-to-agent) is a basic choice. Furthermore, the communication process and language have to be specified in terms of standard protocols with vocabularies and syntax. There may be different types of message an agent wants to communicate - standard messages of a descriptive nature, for example, and announcements of plans or intentions. Speech act theory describes these message types (see Searle 1969). Related to the choice of communication topology is the choice of co-ordination forms. There may be highly centralistic and hierarchical control and communication structures in addition to market-like structures, of which is the pluralistic community is a special type. Furthermore, control can be imposed by plans or by behaviour rules. Plans tell agents what to do; behaviour rules provide the parameters within which agents are free to discover a "*[...] best way to proceed*", according to Gazendam, Ter Heegde, Sturkenboom and Zwier (1987).

The Pluralistic Problem Solver Architecture

The pluralistic problem solver architecture is based on multiple intelligent agents using multiple interpretation frameworks, communicating by channels that have a network-like architecture. Dominant coalitions of agents can change, and dominant strategies for the organization can change also. Technically speaking, the PPS architecture is an object-oriented architecture in which the communication is free, but can be restrained by binding message-passing to (possibly multiple) blackboards or communication channels (see Piersol 1985). The agents in the pluralistic problem solver have the "interpret-choose-act-learn" cycle as their basic behaviour. In the "interpret" phase, a grammar is used for the production of symbol structures enriching the mental model. Holland, Holyoak, Nisbett, and Thagard (1986) give a description of intelligent systems focusing on the "interpret" phase. Their use of the category concept fits well in the grammar approach (see Gazendam 1991) to symbol systems, and seems suited for the implementation of this phase in the pluralistic problem solver. Laird, Rosenbloom, and Newell (1986) describe symbol systems and, in that description,

focus on the "choose" phase of the problem solving process. Because of that, their main interest is in heuristics, and they describe the multi-heuristic problem solver Soar. The Soar architecture can be used as an example for the use of multiple heuristics in the pluralistic problem solver. In the "act" phase, a grammar is used for message production. This message production can - for simulation purposes - be reduced to the filling in of a protocol that seems most suitable in the given situation (see Searle 1969; Charniak and McDermott 1985: 581). In the "learn" phase, the apportionment of a credit algorithm - as in classifier systems (see Holland, Holyoak, Nisbett, and Thagard 1986) - and a chunking algorithm - as in Soar (Laird, Rosenbloom and Newell 1986) - can play an useful role.

The ISM Simulation Model

The Information Strategy Model (ISM) is a multi-agent organization model based on the Smalltalk simulation shell (Goldberg and Robson 1989). In this model, some agents use a personal knowledge base to fulfil their tasks. These knowledge bases are approached through HUMBLE, a Smalltalk expert system shell with MYCIN-like features (Piersol 1985). The agents communicate by sending messages to each other. The communication is partially regulated by using a central blackboard and some secondary blackboards. The model simulates the choice and implementation of information strategies (see Gazendam 1990).

The MAG Simulation Model

A simple Multi-Agent Grammar-based classifier system prototype MAG has been built (see Gazendam 1991). This system operates similar to Cohen's (1991) model of cooperating agents. An important difference with Cohen's model is that the intelligent agents within MAG build a mental model based on a grammar. MAG's major components are two agents and an object simulating their environment called "reality". When an agent is faced with a new problem, nothing specific is known about that problem.

Table 14.6: ***Comparison of Main Aspects of FARSYS and MAGSYS***

Aspect	FARSYS	MAGSYS
Theory	Contingency theory, strategic management theory, learning theory, innovation theory	Symbol systems theory, entropy theory, classifier systems theory
Main subject of theory	Proactive adaptation to, and influencing of, the environment	Perceptions of reality, problem solving, and communication
Observation method	Structured questionnaires	Knowledge elicitation
Recommendation is based on	Flexibility profile	Perception, knowledge, and communication profile
Computer-based analysis method	Expert system	Intelligent multi-agent simulation (coordinated problem solver)
Change method	Idealizing approach	Learning-oriented

Every new problem has to be explored by trial-and-error; only the associations between categories, actions, and goals are remembered. In interpreting, the agent's categories all try to translate the information returned by the environment in symbol structures using their interpretation rules - which is a way of operation resembling the way classifier systems (see Holland, Holyoak, Nisbett, and Thagard 1986) work. The agent uses multiple heuristics in problem solving.

When a specific problem is addressed, rules are created which are based on experience (and forgotten after the problem is left). In this way, an agent can demonstrate short-term learning. As long-term learning mechanisms, the "success of prediction" algorithm described by Cohen (1991) and an algorithm that apportions credit after the goal is reached by remembering the path to the goal without loops are used. By separating short-term learning from long-term learning, the agents can adapt to a gradually changing environment. In solving a problem, the agents co-operate by acting alternately. Model experiments (see

Cohen 1991) indicate a specialization of each agent - caused by chance as well as the long-term learning mechanism -, which leads to a better performance of two agents as compared to the performance of a single agent.

The Practical Roots of MAGSYS

The development of MAGSYS thus far can be characterized as theory development supported by computer models. MAGSYS emerged from an information management policy review in a Dutch Government Agency (see Gazendam and De Jong 1991).

In this policy review, the organization was analyzed as a system of multiple interacting agents. The roles and interpretation frames of these agents were investigated in addition to their interaction patterns. Special attention was paid to the so-called policy theory - that is, the cause-and-effect mechanisms supposed to be true in the formulated policies. This policy review was mainly descriptive and verbal. MAGSYS was developed at a later stage as a more formalized account of the policy review approach. The most interesting result of the policy review was the success of an innovative approach to information management. This approach which can be characterized as flexible and pluralistic, had been followed by four of the seven organization units that were studied, and proved to lead to a more effective [...] of organization and to a significantly lower cost level as compared to the more bureaucratic approach followed by three other organization units. [...] our statistical calculations, we found - with 95% confidence - that the innovative approach had an average cost level that was 5 to 29 times lower than the cost level of the bureaucratic approach. These results could not be explained by the machine metaphor organization models that information systems theory uses. On the contrary, these models predicted a lower cost level for the bureaucratic approach. This triggered our interest in the development of an explicit theoretical framework (MAGSYS) based on the insights obtained in the information management review.

Comparison and Perspectives for Further Research

The FARSYS instrument can be used for observing firstly the flexibility mix, which is a mix of flexibility indicators of management competence, secondly the turbulence profile of the organizational environment, and thirdly the steerability of the organization based on several indicators concerning the technical infrastructure, the organization structure, and the organization culture. Organization theory predicts optimal combinations of these three aspects. The FARSYS instrument can be used for testing these hypotheses, and for investigating possible trajectories of change. The MAGSYS instrument can be used for the observation of the variety, topology and control characteristics of the technical infrastructure, the organization structure, the organization culture, and the environment. Furthermore, strategy co-ordination and strategy stability, which are considered emergent properties at the agent-network level, can be observed. Organization theory has not yet generated much hypothesis about the relationships between the agent-level characteristics and the agent-network-level properties. Therefore, MAGSYS has set up analysis instruments (a.o. multi-agent simulation models) for the investigation of these possible relationships, and for producing clear theories and hypotheses about them. In combination with the observation instruments, these theories and hypotheses can be tested.

In Table 14.6 the main aspects of the FARSYS instrument and the MAGSYS instrument are compared. FARSYS and MAGSYS both aim at the construction of an observation and analysis instrument in the field of organizational stability and flexibility. Their application areas, however, are different. FARSYS has been designed as an instrument for general managers of organizational units; MAGSYS originated from an information management review, and aims at the development to an instrument for organization theorists as well as general managers. FARSYS has been tested in several organizations. It is used by management consultants. At this moment, it is transformed to a knowledge system that can be used to render recommendations based on the observed flexibility profile, turbulence profile and organizational characteristics. MAGSYS is an instrument that is still in the development phase. It is based on five years of practical consultancy and research in the field of information management, and

parts of it have been used during this practice. The development of a sound theoretical basis, and of explicit organization models based on this theory, is stressed. Therefore, the first phase of the research in the MAGSYS project is aimed at the further development of multi-agent models that can be used as an environment to develop and test theoretical statements, the taxonomy and the typology. In a second phase, the developed instrument will return to the consultancy practice for further testing and further development.