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Organizational growth in the IS-function:
Linking Develepment and use of Informantion systems

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**Organizational growth in the IS-function:
linking development and use of information systems**

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The rise of new information technologies has not solved the problems with management of the IS-facility. In this paper it is discussed that a potential cause for these problems is the distinction between development and use of information systems. This distinction is rather unclear. A concept is introduced to make this distinction more clear: the concept of information infrastructure.

Once this distinction is made clear, it is possible to develop a growth model for the IS-facility, consisting of three elements: the specific part for development of systems, the specific part for use of systems, and the common facilities.

Based on the growth model phases for migration towards a more sophisticated level of development, planning and control are discussed. Potential ways of using this model are given.

1. Introduction

The rise of methods, tools and approaches based on information technology (IT) hasn't given a solution for the problems we have in developing and planning for information systems. We can talk for hours and hours about methods, tools, CASE, 4GL, compilers, data bases, information strategy planning, architectures and communication facilities, when to use it, which approach is best, what should be elaborated, without even mentioning what we really want to achieve with all of this. Sure, we want information systems that are free of bugs and are adapted to the needs of the large agglomeration of people we call 'users'. But just like you cannot conveniently drive from city A to city B when there is no road between it, you cannot use proper systems when there is no proper 'infrastructure' for developing and using them.

A great deal of research is carried out in planning for information systems, even strategic planning. But what is the use of planning when we are not capable of ensuring that the planned systems can be developed? The other way around, what's the use of developing high quality information systems when we are not sure we do have the proper planning procedure for these systems? Clearly, the borderline between development and use of information systems is rather fuzzy. There is a lot of research on software engineering and information systems development by people that often have a Tayloristic view on systems development (the software factory). People with organizational or managerial background develop planning procedures based on management accounting theory, but don't even bother to consider the status of systems development. Few models combine both development and use of systems. The Nolan stage model is one of the few examples to attempt a combination of both development and use, but this model is rather vague about the way of developing systems, and it looks like Nolan assumes systems development isn't a big problem after the stages of 'Data' and 'Maturity'.

Only if the link between development and use of information systems is made explicit, it is possible to define a proper management instrument for the IS-facility. In this article the concepts for a growth model for development and use of information systems are discussed. This growth model can be used as a management instrument for the IS-facility. To develop such a model, we need to know which elements of growth are specific for development, which elements are specific for use of information systems, and which elements are common for development and use. The link between development and use (the description of common characteristics) is provided by the recently developed theory on 'information-infrastructure' (Truijens, 1990). In section 2 the concepts of information-infrastructure are discussed, and the link it provides to development and use of information systems. Next, the two dimensions of the growth model are discussed: the development of information systems, and the planning and control of using the developed systems. The dimensions are derived from theories on information management and software engineering (Humphrey, June 1987; Nolan, 1979; Van Schaik, 1985). Then, the dimensions and the infrastructural viewpoint are combined to give a set of phases of growth in development and use of information systems. Finally, it is shown how this model can be used to develop a strategy for organizations to reach a higher level of development and use of systems.

2. The infrastructural view on information systems

The management of information systems, both in developing and planning for their use, is becoming more and more complex. The reasons for this complexity are not only the dynamic environment of most businesses and the rapid development in IT. The problems seem to be more complicated. There are a lot of parties involved in decision-making on information systems. There is the systems-developer, usually with a large body of knowledge in software engineering, methods and tools. There is the information manager, familiar to planning and control issues of information systems and some knowledge on tools and trends in IT. And of course there is the general manager, who has to make the final decision based on advices of people with completely different perspectives on information systems. But these advices don't offer any management instrument for the IS-facility. The organization has to be flexible in use of IT, and must quickly react to developments inside and outside the organization, but with current instruments for developing and controlling information systems steering the IS-facility is hardly possible (Truijens et al., 1990).

Truijens concludes there seems to be a 'mismatch' between managing the IS-function and the creative processes and social innovations occurring in business reality of organizations. This mismatch is largely due to the fuzzy dimensions of the IS-facility. We have only to look at academic world, where IS-research is carried out in both technical environments (the Universities of Technology) with a plain technical background, and economical environments (the Departments of Economics and Management) with an organizational and even behavioral background. Not that one of these environments is better than the other. Both these environments do not seem capable of coping with the problems of managing the IS-facility. Either because of a rather technical orientation, or because of an organizational viewpoint.

No one will object to the statement that the borderline between developing and controlling for information systems is fuzzy, leading to a lot of unpleasant situations. For example who is responsible for managing the common hard- and software and communications facilities of the systems developers and the users of information systems? Systems developers are not likely to take responsibility for current hard- and software facilities (Truijens et al., 1990).

The interaction between the development of information systems, and the controlling of and planning for systems has to be made more explicit. To make this interaction clear we have to know what relates the two dimensions of the IS-function. The link between development and use of information systems occurs at various levels in the organization:

- at organizational level, both occur in the same organizational setting, with a set of common cultural values, and part of organizational processes of change and innovation;
- at departmental level, the link between development and use is visible in the lifecycle process of information systems: first plan, then development, than use and maintain. Both development and use are determined by standards, methods and procedures set at this level;
- at technical level, both development and use are depending on the same complex of infrastructural elements: hardware, software, communication facilities, standard applications and procedures.

It is important to make the distinction between development and use more explicit because growth in practices of development will affect the way of using the information systems developed, and growth in planning and control for use of systems will affect the quality and way of systems development required. To give an example of the link at departmental level, suppose a very innovative and fast way of systems development is used in the organization. Thus, the organization has the opportunity to solve the problem of backlog (the problem that demand for systems exceeds the capacity of the systems development department). But it is very dangerous to just develop any system you want: the danger of developing an army of systems that is only used for very specific purposes, maybe only once a year. The portfolio of systems developed should be balanced, and only these systems should be developed that offer potential net benefits. At the technical level the impact of development and use on each other is even more clear. The development department usually owns a limited set of hard- and software. The department thus develops systems only for specific environments. Unless new investments in development hardware are made, the hardware on which the developed systems will run is limited by the hardware configuration of the development department.

Given the above examples, it is important to make a distinction between specific characteristics of development and use of systems, and the elements responsible for the interaction between development and use. A recently developed concept, the concept of 'information-infrastructure', seems to be capable to make this distinction. First, this concept will be discussed. Then it will be shown how this concept can be used to make the distinction between developing and using information systems more explicit.

2.1. The concepts of 'information-infrastructure'

When talking about 'infrastructure', we tend to think about highways, railways, transport of gas, oil, electricity, etcetera. But also other facilities may be part of the infrastructure, e.g. the education system. Infrastructure is a kind of basic facility for common use (Truijens et al., 1990). Changing the infrastructure will give a lot of problems. Truijens et al. tried to develop a new perspective on management of the IS-function, and applied the concepts of infrastructure to it.

The 'information-infrastructure', as Truijens et al. call it, consists of *facilities for common use* regarding the IS-facility. A set of five infrastructures together form this information-infrastructure:

- the data-infrastructure;
- the infrastructure of applications;
- the infrastructure of configurations;
- the infrastructure of communication facilities;
- the organizational infrastructure.

The data-infrastructure consists of the organizational data for common use in the organization. Underlying this data are agreements about content, meaning, management, protection and access. The infrastructure of applications consists of the applications that are used by various parts of the organization, such as spread-sheets and word processors. Part of the infrastructure are standards, the way of distribution and the way of acquiring. The infrastructure of configurations has of all common facilities for storage, processing and distributing general data of the data-infrastructure. The infrastructure of communication facilities gives the organization all facilities for (electronic) communication in and between parts of the organization, and with the business environment. Finally, the organizational infrastructure is related to the organization of the IS-function. Of importance to the organizational infrastructure are the procedures and structures for creating and using all the facilities the other infrastructures provide. Thus, the organizational infrastructure encloses the other infrastructures.

2.2. Using the concept of information-infrastructure to link development and use

How can the concept of information-infrastructure be used to make a the link between development and control of information systems more clear? At the beginning of this section it was discussed that the link between developing and using systems occurs at several levels in the organization: the organizational, departmental and technical level of the organization. With the use of the concept of information-infrastructure, it is possible to make clear the link at each of these levels. The organizational infrastructure determines the link at all levels, presenting elements as information plan, training, project organization and the role of the user of the developed systems. The infrastructures of configuration, communication determine the link at the technical level. The configuration, application and data-infrastructure is important for both the technical and departmental level.

At organizational level, the interaction of development and use is determined by the question which facilities to centralize and which to decentralize. In other words, The interaction determines the question which organizational procedures and structures should be used to manage all common facilities. Hence, this is the question of designing the organizational infrastructure. At departmental level, development and use are chained, and as explained earlier, require a balanced portfolio of information systems. But development and use are also constrained by common facilities already available for each department: common software (e.g. spread sheets) but also common access to data. Thus, the link at this level is made explicit by the configuration, data, applications and organization infrastructure. At the technical level, the link between development and use is determined by all common technical facilities (this is in fact the usual interpretation of 'infrastructure'). Thus, most important at this level are the communication and configuration infrastructures.

At each of the levels, the infrastructures define the general facilities in the organization. The management of these facilities is the responsibility of the general management and not of the developers or users of the information systems. What is not defined in the infrastructure, should be explicitly defined for development of information systems, and for controlling and planning the use of information systems. These facilities are the responsibility of the people involved.

What should be clear by now is that growth in development and growth in use are not separate processes: growth in one will affect the other. To control this interaction, at some levels of growth the infrastructural facilities should be defined. The information-infrastructure has to grow with the growth in (specific infrastructural facilities of) development and use.

Now that the link between development and use is made clear, it is possible to develop a model describing the migration path for organizations to reach a higher level of developing and controlling information systems. To achieve this, the dimensions of growth in developing systems, and the levels of growth in using information systems have to be defined, which should then be combined with the infrastructural aspects. The dimension of growth in developing and using systems are discussed in section 3, the combination of these dimensions with infrastructural aspects to form a growth model in section 4.

3. The dimensions in growth and use of IS

Mainly, an organization concerned with the IS-facility wants to realise two objectives with respect to information systems:

- a high level of quality in information systems development;
- a high level of use of information systems.

If well managed, both these objectives will increase the organization's effectiveness and competitive advantage. Quality and high use may realise faster and better performance of operational tasks and increase in (quality of) services provided to customers and other external groups, as suppliers. To achieve these goals, these goals have to be translated into visible characteristics. In systems development this usually means the creation of a phase (evolutionary) model. For each of the two goals phase models exist. Unfortunately, these

phase models are rarely combined to get an overall picture of the status of information systems development in organizations.

Most important phase model for measuring quality of information systems development is the Process Maturity Model of the Software Engineering Institute. Evolutionary models for the spread of systems development in an organization are the Nolan stage model and the MIS growth model of IBM. Each of the models will be discussed, and the problems with these models.

3.1. SEI Process Maturity Model

The Software Engineering Institute at the Carnegie Mellon University was the first institute to define stages regarding the level of the software process. The software process was defined as a process to develop, maintain, support, and enhance software. It consists of five phases, as shown in figure 1.

Level	Characteristic	Issues	Results
5 - Optimized	Improvement fed back into the process	Automation	Prod. Qual.
4 - Managed	Measured process	Problem analysis and prevention	
3 - Defined	Institutionalized process	Process metrics	
2 - Repeatable	Intuitive process Success depends on individuals	Process standards reviews, testing	
1 - Initial	Ad hoc, Chaotic Success depends on luck	Project and configuration management	RISK

Figure 1. Software Engineering Institute Process Maturity Model (source: Humphrey, June 1987)

The maturity model is based on an ideal software process. The principle behind this ideal process is measurement. Not surprisingly, the model is based on the concepts of statistical process control (based on the works of Deming and Juran). The five levels of process maturity which have been defined are (Humphrey, June 1987, 1989, July 1991):

- **Initial** - until the process is under statistical control, no orderly progress in process improvement is possible;
- **Repeatable** - a stable process with a repeatable level of statistical control is achieved by initiating rigorous project management of commitments, costs, schedule and change;
- **Defined** - definition of the process is necessary to assure consistent implementation and to provide a basis for better understanding the process;
- **Managed** - following the defined process, it is possible to initiate process measurements;
- **Optimized** - with a measured process, the foundation is in place for continuing improvement and optimization of the process.

The SEI provides a detailed description of the characteristics of each of the phases, and the key actions required to move from one level to another. Although the model is considerably sophisticated, it suffers from a number of limitations:

- it is strongly oriented towards development of real-time systems, not towards development of business information systems. The Software Engineering Institute was founded with money of the American Department of Defence, and most of the research (including the research regarding the process maturity model) is carried out on request of the DOD. Since most of the systems development that is critical for Defence is real-time (e.g. the missile control systems) the maturity model is heavily oriented real-time systems development;
- more seriously, it is based on the assumption that there exists an ideal model of systems development, the software-factory model (Bollinger et al., 1991). History has proved there are several ways to achieve a goal, and correct systems development may require different arrangements for different organizations;
- the model emphasizes collecting measures for the software process, but doesn't take into account the fact that most of the measurements can be automated, even before phase 5.

These limitations can be overcome by redefining several stages of the maturity model (maintaining the basic growth in quality of the software process that is fundamental for this model). Most critical assumption of this redefinition of the stages is that there is no such thing as 'an ideal development process'. Current technology offers various approaches to successful and fast systems development. Thus, it isn't useful to watch 'tiny' spots of the software process, as the maturity model states. It is possible to automate most parts of the technical development tasks: the 'measuring' is part of software-technology automating the development. With the current state of technology, we don't even have to talk about bugs in and testing of programs (on syntax) anymore, since technology is capable of performing syntactically correct code.

It is important to realize that with the growth in technology as 4GL, database technology and CASE-technology, the 'technical' aspects of systems development as writing code, documenting the system and creating various reports can be carried out by the hard- and software itself. Together with the increased possibility of reusability of not only code, but also specifications and models of the logical activities of systems development, the fastest and most correct way depends on the situation. E.g., when logical models exist of similar systems, these can easily be modified, the modified models being used to generate a new system. But when no similar models are available, it may be necessary to conduct analysis from the start. Systems development is becoming more 'creative', more flexible. When an organization is capable to develop information systems, and the process of developing that system is based on aspects as reusability, reengineering, existing development models, but not totally forced by a standard approach to systems development, the organization has achieved the real maturity level. But this not only requires installing all technical facilities. Reaching the level of flexible systems development requires changes in the way of working in the organization, and organizing and planning for systems development. Thus, this change process is more a process of

innovation than a process of installing the right hardware and software. There is little attention for this process of change in the theory of the Maturity Model, although the in last version of the model the level 5 is characterized by 'innovative systems development' (based on the theory of diffusion of innovations).

It was discussed that the Maturity Model should be redefined to overcome its limitations. Since the limitations are due to the technical perspective of the model, redefining the model only requires the addition of a more organizational perspective on systems development. Adding this organizational perspective, the following phases occur in systems development:

- **Initial** - there is no control over the software development process;
- **Experience** - the organization gains experience in the software process by initiating project management;
- **Control** - the organization achieves control over the development process by carefully defining a formal way of developing systems. Any system to be developed must be constructed by these formal standards;
- **Integrate** - a lot of information is generated during the development and exploitation of information systems. In this stage, the various departments of an organization start to use the information of other departments. Decisions are made which data is shared between departments and business units. Based on these decisions, an architecture of application and development databases is developed. Attention shifts from developing software to maintaining software;
- **Flexible** - all conditions are available to treat systems development as a flexible development process. Technical aspects are carried out by sophisticated hard- and software. Consequently, formal standards for development are reduced, building various opportunities to think of innovative ways to develop software. Attention shifts to planning the way of developing systems.

3.2. The evolutionary models for growth in information systems use

The second dimension of the IS-function is the use of information systems, particularly the control and planning of the use of information systems. Various models exist that describe the evolution in use of information systems in organizations. The most widely known of these models is of course the Nolan stage model (Nolan, 1973, 1979, Gibson et al., 1974). The last version of the model (Nolan, 1979) identifies six phases of use of information systems: initiation (adopting and beginning of growth), contagion (rapid and uncontrolled growth in use and cost), control (computing expansion greatly restricted, missed opportunities), integration (combination of improved management technique and planning results in 'fine tuning' controls), data (DP role changes to management of organizational resources) and maturity (application portfolio 'complete' and 'mirrors' organization and data flows). Although the model has been criticized of lacking both an empirical and theoretical foundation (Kling et al., 1984; Lucas et al. 1977), it is still one of the most often used models for information strategy development and information planning.

Another interesting stage model is the growth model of IBM, part of its 'Information Systems Management Architecture' (Van Schaik, 1985). See figure 2. The phases look similar to the phases of the Nolan model, but are more specifically oriented to the level of use of information systems, and the management of the use of information systems (controlling and planning). The model of IBM consists of five phases: startup, growth, control, planning and strategic planning. The characteristics of each of the phases are as follows. During the startup phase, typical applications are clerical or labour saving functions. In this phase, usually there's a single user or user department that owns both the technical solution and clerical function. I/S management is aligned with user management.

In the Growth phase, a separate organization tends to grow to deal with new applications, hardware and software, and facilities. Standard project structures begin to emerge, and user dissatisfaction greatly increases. In order to overcome the problems of the growth phase, change and resource control becomes more disciplined, service control is instituted to ensure consistent level of availability and increased financial accountability is ensured. In this Control phase, users migrate toward simple startup type of solutions (e.g. PCs and departmental minicomputers).

In the Planning phase, the control over applications to be developed is even more rigorous. Tactical IS planning is initiated, in which new applications are compared to the ongoing services. A way of achieving acceptable levels of service and reliability is ensured. The management shifts from being reaction-driven to being plan-driven, e.g. development of systems is not based on symptoms visible inside and outside the organization, but is based on the careful planning of applications to be developed. During the strategic planning phase, the control over and use of information systems reaches a maturity level. The IS becomes more business oriented, key architectures are developed for data, applications and technology, and time frames are established for implementing the architectures.

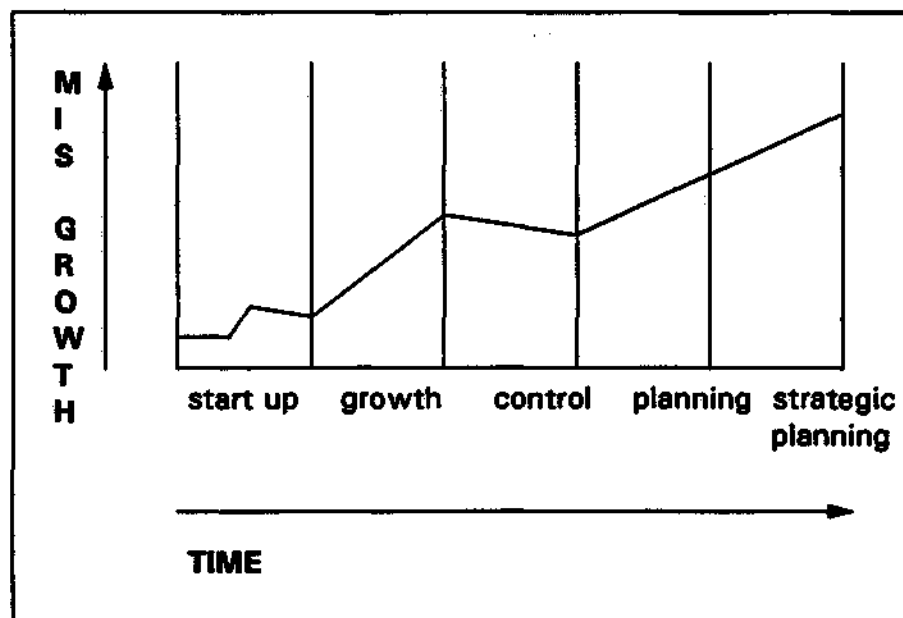


Figure 2. The MIS Growth Model (source: Van Schaik, 1985)

The limitation of the Nolan model and the MIS Growth model is that these models try to gather several different aspects in one model: development as well as use, information services as well as administrative services. Such models tend to lack the dynamics of each of the aspects they try to describe. E.g. systems development is discussed in the initial and growth phase, but in the later stages it somehow disappears. Thus, the model should concentrate more on the control and planning aspects of information systems use, not on the development aspects of information systems.

The limitation of the two models is similar to the limitation of the SEI Maturity model. The Maturity model is developed from a technical perspective and lacks the organizational perspective, the model describing the use are developed from organizational perspective and weak from technical perspective. Thus, again, it is necessary to redefine the phases of a growth model. In the following, the MIS Growth model will be used. In this case, it is not necessary to add the technical perspective. Controlling and planning of IS is an organizational problem. So the technical perspective, the attempt to incorporate aspects of development of these systems, should be deleted. This redefinition results in the following MIS Growth phases:

- **Initial** - startup phase of information systems use. Yet, there is no need for planning and control;
- **Experience** - due to the increase in development of information systems, simple control measures are introduced. The organization gains experience in controlling the use of information systems;
- **Control** - control of use of information systems is institutionalized. Financial accountability increases;
- **Planning** - tactical IS-planning is introduced. Management shifts from being plan-driven to being reaction driven;
- **Strategic Planning** - IS strategy planning is introduced. Key architectures for data, applications and technology are defined.

3. The Process-Use matrix

In the second section two dimensions were defined regarding the status of information systems in an organization: the development of the information systems, visualized in the process maturity model, and the use and control of information systems, represented by the Nolan stage model and the MIS Growth model that elaborates the Nolan model. Both the dimensions were redefined for MIS development and use. It is obvious to combine these models, to form a matrix, but this is only possible if the dimensions have the same level of analysis (Markus and Robey, 1989). Markus and Robey describe three levels of analysis: micro (level of individuals), meso (level of groups) and macro (departmental and organizational level). The two dimensions (i.e. development and use) have the same level of analysis, so the dimensions can be combined to form a matrix: the process/use matrix (PU Matrix). See figure 3.

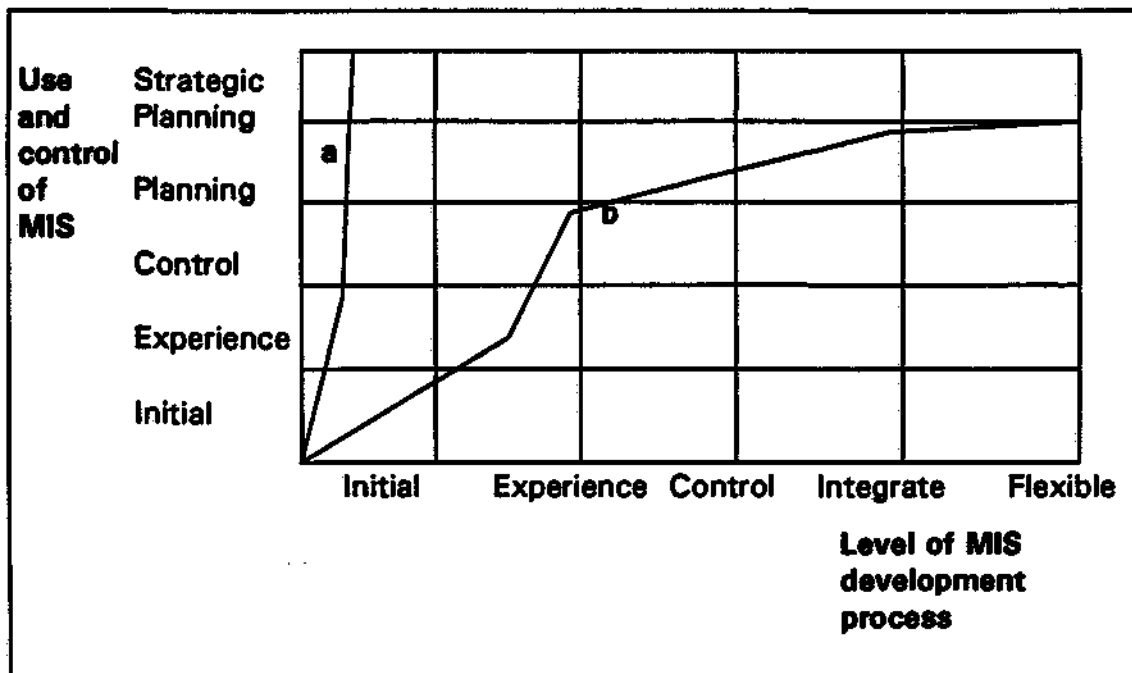


Figure 3. The Process/Use Matrix

With the help of this matrix, it is possible to assess the 'experience' of an organization in information systems. In addition, based on this matrix, a strategy can be developed to move from one level to a more sophisticated level of use and development of business information systems. Also based on this matrix, an organization can decide whether to adopt new technologies as 4GL and CASE, and when to adopt these technologies.

The horizontal axis of the matrix shows the phases of the development process maturity, based on the SEI process maturity model. The vertical axis shows the stages in control and planning of business information systems, based on the MIS Growth model. This gives a total of 25 quadrants. The lines 'a' and 'b' in the diagram are border lines in organizational adoption of MIS use and development in practice. Research on the state of software engineering practice shows that most organizations are at levels 1 and 2 of the Maturity model (and thus at levels 1 and 2 of the dimension of developing IS, because the redefinition only added the organizational perspective) and almost none at the higher levels (Humphrey, february 1989). On the other hand, research on the current IS profile of U.S. companies shows that most organizations are at the Integration and Data phases of the Nolan stage model, and thus at the Control and Planning phases of the MIS Growth model (Li et. al., 1991). Thus, companies tend to grow in developing and controlling IS somewhere between lines A and B in the matrix. Progress of organizations outside these borders is not unlikely or impossible, but based on current research no organizations tend to grow beyond these borders.

3.1. Defining phases based on the PU-matrix

Figure 3, the PU Matrix and the lines A and B in it, shows various quadrants representing experience of an organization in information systems development and use. The quadrants however are not very good representations of the phases through which an organization passes in the development and use of information systems. Several quadrants can be taken together to represent a phase.

But how can these phases be defined? To define them we have to know what links the development and use of information systems. This link was discussed in paragraph 2: the information-infrastructure. The information-infrastructure defines the common elements of developing and using information systems in data, communication facilities, configurations, applications and organizational context.

At the initial levels of growth the configuration infrastructure, common hardware and software, usually is installed. At the Initial and Experience levels it is unlikely that the data, communication and organizational infrastructures are installed, either because information development and use is ad hoc at these levels (data and organizational infrastructure), or because there is no use for installing common facilities (communication infrastructure). At the control level, the organization has shown considerable growth in application systems. Thus, at this level, the applications infrastructure is in the process of being created. Once the organization has achieved some level of Control of developing and using information systems, it is time to make decisions about communications facilities to acquire, and data to share between various departments or business units. When these decisions are made, and (strategic) planning of information systems is in place, the organization infrastructure will also be complete, because it encompasses all other infrastructures. The only thing to be done to reach a flexible level of systems development is to design and construct models (architectures) describing the infrastructures. With these architectures in place, it will be more easy to plan for the most flexible way of developing systems, because the architectures describe the constraints applied to development and use of systems.

From the development in installing infrastructures, and ideal trajectory can be defined for organization to grow from the initial levels of developing and controlling information systems to a sophisticated and flexible level of systems development. This ideal trajectory is based on the following assumptions:

- the trajectory has to be a process of 'steady' growth, and not a process of fast growth in one dimension and then growth in the other dimensions. It is not practical to have a high level of developing systems and not knowing which systems to develop (e.g. a low level in controlling and planning for use of systems). The other way around, it is not practical to rigourously control and plan (strategically) for information systems when we are not sure we can control systems development itself;
- the ideal trajectory must present the growth in control of the information-infrastructure of the organization. As described above, attention paid to each of the infrastructures tends to shift from application infrastructure, via application and communication infrastructure to

data-infrastructure and controlling of and planning for all of these infrastructures (the organizational infrastructure).

Considering the assumptions, the ideal trajectory will consist of the following phases:

- **Control Startup (CS)** - this phase represents the organization that is starting to use computer technology. The organization isn't much interested in the development of the 'new' technology, the priority lies with the control over of service and resources. The configuration and communication infrastructures are built.
- **Control Experience (CE)** - after the organization has gained experience in control of resources and services, the next step is to extend control to the information systems development process itself. The organization reaches the 'repeatable' level of process maturity: a stable process with a repeatable level of statistical control is achieved by initiating rigorous project management of commitments, cost, schedule and change. IS planning is started. The application infrastructure is built and defined, the configuration and communication infrastructures are extended.
- **Define Experience (DE)** - during this phase, the organization gains more experience in IS planning. The organization reaches the defined stage of process maturity: definition of the process is necessary to assure consistent implementation and to provide a basis for better understanding of the process. As the organization reaches this process, it has achieved a considerable level of control and planning of the use of information systems in the organization. The organization starts up to build its data-infrastructure, and defines its communication infrastructure.
- **Integrate (I)** - key architectures for data, applications and technology are being developed. Since the organization has achieved a considerable level of control and planning of use of information systems, its focus shifts to enhancing the way of developing the systems itself. The data-infrastructure is extended and defined, and decisions are made which data are available for common use. Based on these decisions, an architecture of databases is installed to share the common data among departments and business units.
- **Flexible (F)** - with a measured information systems development process and considerable experience in control and planning of information systems, the organization is capable of performing flexible software development, which means it can adapt quickly to any new circumstance that affects the development process. By now, all infrastructures are considerably defined, and attention shifts to plan for and enhance these infrastructures.

Above an outline was given for the ideal trajectory for organizational growth in the IS-function. However, it was also discussed that based on empirical evidence we can conclude that most organizations are at a considerable sophisticated level of planning and control of information systems, and even strategic planning, whereas there are almost no organizations at the Integrate and Flexible level of the Maturity model (Li et. al. 1991;

Humphrey, february 1989). Thus, organizations usually are more concerned with control of computer resources than the control over the way these resources are used to develop information systems. Even if the organization does reach some level of statistical control, by initiating project management of costs, schedule and change of the systems development process, it still tends to get stuck in this phase of software development and pays more attention to control of resources and services and IS planning. Thus, the usual trajectory for growth in use and development of information systems is:

- **Control Startup (CS)** - as above.
- **Overly Controlled (OC)** - after the organization has gained experience in control of service and resources, it is too fixed on getting more control over its use of information systems, it forgets to start controlling the software development process itself. IS Planning is initiated and worked out. Resources are planned. Key architectures for data, applications and technology are designed, but no key architecture for the software development process is designed. The organization still can develop in the right direction, to the CE-phase, but this will take a major effort in changing its view from use of information systems to development of information systems.
- **Overly Planned (OP)** - the organization realises it has taken to much attention to service and resource control and to planning, and that it has to shift its focus to the development process itself: it tries to achieve a stable information systems development process with a repeatable level of statistical control, by project management of change, costs etcetera. But still, it is too much oriented to IS planning.

Once an organization is in the OC-phase or in the OP-phase, it is very difficult to attain a considerable level of software development because the organizational structure, task structure and culture are too fixed on using information systems, and planning for these systems, resources and services. It is difficult to shift attention to 'technical' issues of systems development. Planning, competitive advantage and business opportunities are the key words, and there are no time or resources for measuring the software process. In crisis of software development, time is so critical that the organizations reverts to coding and testing, and abandons the established procedures. Development is 'planned' and delay in delivering systems will result in 'missed competitive advantages' or 'more costs'.

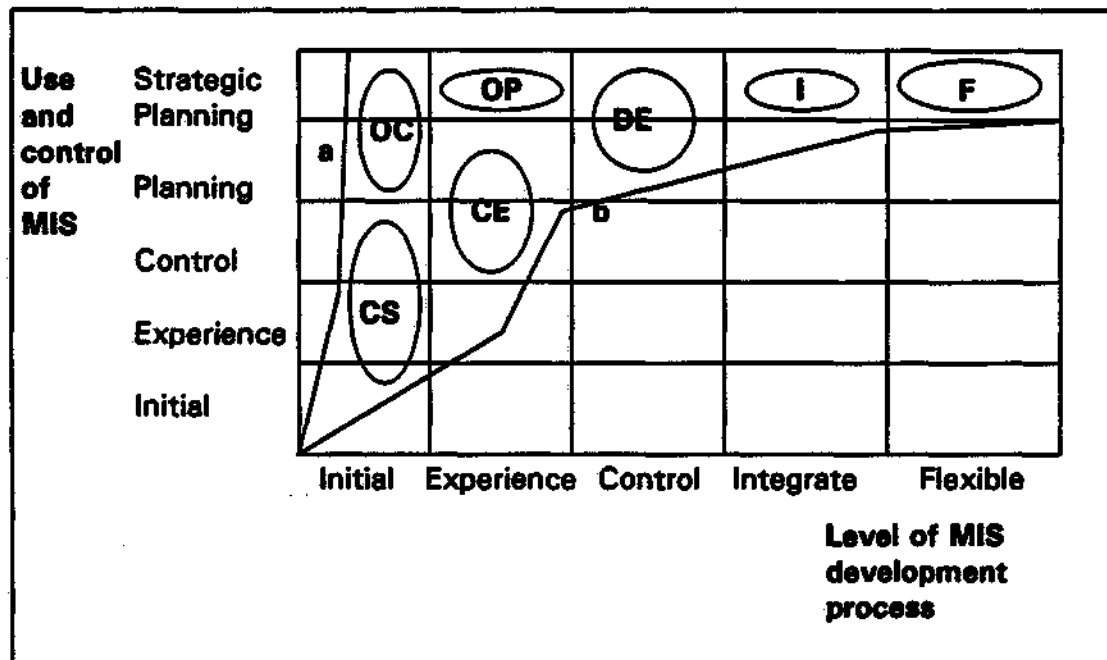


Figure 4. Phases visualized in the PU-matrix

As discussed, the phases of growth are determined by growth in development, use and growth in common infrastructure. In the PU-matrix, the essential growth in common facilities and procedures is not visualized. Because growth in information infrastructure is necessary for growth in the two dimensions, table 5 shows each of the phases of growth with corresponding growth in this infrastructure.

Level	Growth in development	Growth in use	Growth in common facilities
Control Startup	/	control of resources, services	/
Control Experience	project management	tactical IS planning	define application infrastructure
Define Experience	definition of software process	strategic IS planning	define communication infrastructure
Integrate	integrated use of development information	architectures for data and technology	define data and configuration infrastructure
Flexible	planning for software development	/	complete organizational infrastructure

Table 5. Growth in information infrastructure related to growth in development and use

4. The PU-matrix as a management instrument

The PU-matrix discussed in the former section identified several possible phases of growth of organizations in the IS-function. The concepts of the matrix are very simple, and because of its separation between the aspects of development and use, the matrix can be used as a management instrument. There are many possibilities for using the matrix as a management instrument. In this section a brief discussion will be given on four possible uses of the PU-matrix:

- the PU-matrix as a general growth model (with the objective of reaching a higher level of development and planning for information systems);
- the PU-matrix as means of planning for new technologies;
- the PU-matrix as a tool for SWOT-analysis;
- the PU-matrix as a basis for managing processes of change, especially the management of innovations.

4.1. Attaining a higher level in developing of and planning for IS

The obvious use of the PU-matrix is its use as general growth model for organizational development. The starting point is to assess the current state of development and use of information systems. The assessment answers the question which phase the organization is currently in. Surely most organizations want to reach the next, more sophisticated phase in the growth model. Based on the description of each of the current level and the next level to be reached, a strategy can be defined to reach that level. We will give an example.

Suppose the organization has conducted an assessment to determine its level of development and use of information systems. It assessed itself at the Control Experience level in the growth model. Based on the model, the organization knows it must reach the Defined level. What are the actions to ensure it will reach this phase? To assess which actions are to be taken, the basic distinction between development and use, and the link between development and use has to be taken into account. Just like the characteristics of the phases, the actions can be partitioned into three groups:

- actions specific for an increased level of development of systems;
- actions specific for an increased level of controlling of and planning for systems;
- actions with respect to infrastructural concepts.

Suppose the organization already has characteristics of higher levels: it plans strategically and has developed architectures for data and technology. Thus, to reach the Defined level it must plan for changes in development and infrastructure. The Defined level is characterized by definition of the software process and communication infrastructure. Key action to be taken to incorporate a defined software process is to develop an architecture for the software process. Infrastructural decision to be taken is the definition of the architecture of the communication infrastructure.

For each phase the organization is in, it is relatively easy to develop an strategy to move to a higher phase. A technology assessment seems to be the proper instrument to develop such a strategy.

4.2. Planning for new technologies

The field of IT is becoming more and more complex. Trends in IT are hardly predictable anymore. This doesn't prove to be a problem from point of view of planning, when we realize most businesses are very slow in adopting new technologies. Common examples are CASE, 4GL, reverse engineering and EDI. Corporations are careful in planning for new technologies, not surprisingly: the benefits (e.g. productivity increases) are hard to quantify, different business units usually want different technologies, different technologies are hard to compare.

The PU-matrix offers the possibility to plan for the use of new technology. It will not solve the problem of quantifying the benefits of new technology, but nevertheless makes it easier to compare different technologies on usefulness or compare different alternatives based on the same technology.

Just like when using the PU-matrix as a model of growth, the preliminary action is to assess the current state of the IS-function. The next step is to assess the functionality of the new technology, and question its suitability for the assessed phase and the next phases. For example, an integrated CASE-environment isn't very useful at the Flexible Level because it is very strict in describing the way of software development. On the other hand, it is also not useful in the Control Startup or Define Experience phases because it requires a careful description of the software process, and the planning facilities these environments offer are obsolete. Integrated environments are more suitable for the Control Experience and Integrate phases. To give another example, 4 GL is very flexible and requires a careful definition of its use. Thus 4 GL seems an interesting opportunity for the Integrate and Flexible phases of growth.

4.3. Identifying strategic opportunities and threats

Like every growth model, each phase of growth is characterized by vital issues and problems. The phases of growth in the PU-matrix also are characterized by specific problems: e.g. the Define Experience phase has as problem the definition of the software process and the lack in identifying critical information systems (because the software process isn't defined yet and strategic planning is not initiated). On the other hand, an organization in the Define Experience phase has the strength of experience in software development and tactical planning for the developed systems. Thus, the PU-matrix may be used to identify possible strengths and weaknesses of the organization in IT, and incorporate these factors in the business plan of the organization.

4.4. Managing change processes

The last potential use of the PU-matrix to be discussed is its use as an instrument in managing changes in the organization related to IT. The PU-matrix is easy to understand, making it suitable as a instrument to make employees aware of the direction the organization is going. Awareness building is an essential factor for success of (large) change processes, especially the change processes that have a large impact in the way of working of people. People aware of what the organization really wants to achieve tend to be more eager to cooperate. When employees discover the organization tries to achieve a higher level of development and use of information systems, it will be possible for them to evaluate the impact of the change and perhaps even make recommendations in the direction of the change.

5. Research considerations and conclusions

In this paper a growth model was presented for the IS-function. The growth model consists of three essential elements: growth in developing information systems, growth in use (planning and control) of information systems, and a corresponding growth in common facilities and procedures for both development and use (the information infrastructure). The last element is the 'linking pin' of the model: growth in development and use are not separate processes, but interacting processes. The concept of information infrastructure makes this interaction more clear by requiring specific design of five different types of infrastructure.

The ease of use of the model developed shows the potential for research. Nowadays, with rapid changes in technology and increased specialization, linking technical and organizational aspect of the IS-function doesn't receive any attention. But perhaps this is the reason why so little improvement in quality of the IS-function is gained.

So far, a lot of people are talking about IS-research as a multi-discipline research area. Inreality, this multi-disciplinary perspective is often lacking, resulting in interesting *perspectives* of problem areas, but usually not resulting in *practical theories*, capable of solving problems in these problem areas. IS-research has resulted in 'cook-book' approaches to information planning (e.g. ISP), without realising that introducing ISP is a process of change and thus requires an incremental approach rather than a large number of steps as described in ISP.

Researchers have to overcome the bias in looking at problems from a narrow perspective. Regarding a problem area from many perspectives may give far more interesting and practical results. As Nietzsche described in his theory of perspectivism, the value of a theory depends on its perspectives. The more perspectives you take, the higher the value. Taking only one perspective will give the lowest possible value to a theory being developed.

References

1. Bollinger, T.B., C. McGowan, "A Critical Look at Software Capability Evaluations", *IEEE Software*, july 1991, pp. 25-41.
2. Gibson C.F., R.L. Nolan, "Managing the Four Stages of EDP Growth", *Harvard Business Review*, january/february 1974, pp. 76-88.
3. Humphrey W.S., Characterizing the Software Process A Maturity Framework, Software Engineering Institute, Carnegie Mellon University, CMU/SEI-87-TR-11, ESD-TR-87-112, june 1987.
4. Humphrey W.S., W.L. Sweet, A Method for Assessing the Software Engineering Capability of Contractors, Software Engineering Institute, Carnegie Mellon University, CMU/SEI-87-TR-23, ESD/TR-87-186, september 1987.
5. Humphrey W.S., Managing the Software Process, Software Engineering Institute, Addison-Wesley Publishing Company, 1989.
6. Humphrey W.S., CASE Planning and the Software Process, Software Engineering Institute, Carnegie Mellon University, CMU/SEI-89-TR-26, DTIC Number ADA219066, may 1989.
7. Humphrey W.S., T.R. Snyder, R.R. Willis, "Software Process Improvement at Hughes Aircraft", *IEEE Software*, july 1991, pp. 11-23.
8. Humphrey W.S., B. Curtis, "Comments on 'A Critical Look'", *IEEE Software*, july 1991, pp. 42-46.
9. Humphrey W.S., D.H. Kitson, T.C. Kasse, The State of Software Engineering Practice: A Preliminary Report, Software Engineering Institute, Carnegie Mellon University, CMU/SEI-89-TR-1, ESD-TR-89-01, february 1989.
10. Kling J.L., K.L. Kraemer, "Evolution and Organizational Information Systems: An Assessment of Nolan's Stage Model", *Communications of the ACM*, 27(5), may 1984, pp. 466-475.
11. Li, E.Y., J.C. Rogers, "An information systems profile of U.S. companies", *Information & Management*, 21, 1991, pp. 19-36.
12. Lucas H., J.A. Stutton, "The Stage Hypothesis and the S-Curve: Some Contradictory Evidence", *Communications of the ACM*, 20(4), april 1977, pp. 254-259.
13. Nolan R.L., "Managing the Computer Resource: A Stage Hypothesis", *Communications of the ACM*, 16(7), july 1973, pp. 399-405.
14. Nolan R.L., "Managing the Crisis in Data Processing", *Harvard Business Review*, march/april 1979, pp. 115-126.
15. Schaik Van, A Management System for the Information Business: Organizational Analysis, New York: Prentice Hall, 1985.

16. Truijens, J., A. Oosterhaven, R. Maes, H. Jagers, F. van Iersel,
Informatie-infrastructure, (information-infrastructure; in dutch), Kluwer
Bedrijfswetenschappen, 1990.