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Fischer, S.

1992

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citation for published version (APA)

Fischer, S. (1992). *A control perspective on information technology*. (Serie Research Memoranda; No. 1992-13). Faculty of Economics and Business Administration, Vrije Universiteit Amsterdam.

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A Control Perspective on Information Technology

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Research Memorandum 1992-13
april 1992

vrije Universiteit

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A CONTROL PERSPECTIVE ON INFORMATION TECHNOLOGY

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A lot of problems with respect to use of IT and development of information systems stem from the lack of proper control of the IT function of organizations. Just like other business functions, a control system has to be developed for the IT function. This paper discusses control aspects of IT, and how these aspects can be used to build a control system for the IT function. This control system has to be flexible, and growth towards such a system should take into account all levels of control, not just one level.

INTRODUCTION

Planning for and use of information technology (IT) are still key problem areas for management. The rise in methods and techniques has not changed this. This lack of success is visible, for example, in the still existing software crisis (see Vinig [1991], McClure [1989]), the need with measuring the potential benefits of use of new IT and developing information systems (see, for example, CASE Strategies [1991], EDP Analyzer [1991]), and the notion that IT "is a two-edged weapon which may prove a blessing or a bane to the user depending on the skill and insight with which he handles it" (Van Waes [1991], see also Darton and Giacoletto [1989]).

A great deal of research is carried out in planning for IT, also strategic planning. But what is the use of planning when we are not capable of ensuring that the planned IT is properly used? The other way around, what is the use of introducing high quality IT in the organization when we are not sure we do have the proper planning procedure for IT? Based on the statements above, it can be concluded that planning for and controlling information technology are related, and proper management of the IT function requires this inter-relationship to be made explicit.

The concept of control systems, as described by Anthony [1965, 1984] allows the inter-relationship to be clearly defined. Thus, these concepts offer the possibility to overcome the problem areas of the IT function. Whatever business function is to be performed, it should be managed and controlled, even if it is the IT function.

In this paper the IT function is discussed from the perspective of management control systems. This allows a critical look at theories regarding the IT function. It also allows the definition of a control system for the IT function, and the definition of a model for implementing such a control system. Because this control system deals with IT, it should not only be formal, but also flexible to allow the control system to adapt to the rapidly changing field of IT. Section 2 of this paper discusses the concepts of control based on the work of Anthony [1965, 1984]. Section 3 analyses research literature based on these concepts. Aspects of control are visible in literature on information systems research (see Van Schaik [1965], Nolan [1974, 1978]), but also in literature on computer science and software engineering (see Humphrey [1987]). Viewed from the control perspective these models contain some serious flaws, that can be extinguished by taking into account all levels of planning and control. Section 4 defines a control system for the IT function and, more important, how an organization should grow towards such a system. In order to survive in a dynamic environment, organizations need to build a control system for the IT function, which addresses the task control aspect and aspect of management control and strategic planning. Organizations must follow a parallel growth path that addresses the aspects in order to implement a flexible control system. Flexibility requires that organizations must pay attention to new organizational structures, simulation new technology and simulation of new information systems. Finally in section 5 research recommendations will be given.

CONCEPTS OF CONTROL SYSTEMS

Organizations need to know what to do and what not to do. This is a task for management of the organization, resulting in *strategies* for attaining the goals of the organization. These strategies consist of *policies* to guide ways of action and broad *programs* of activities to pursue goals. But management also needs to know if the people in the organizations do what they are supposed to: this is the process of *control*. Control refers to guiding a set of variables (machines, people, equipment) towards an objective or goal (see Anthony [1984]).

Three different types of control processes exist, corresponding to different levels in the organization: strategic planning, management control and task control. Strategic planning is the process of deciding on the goals of the organization, and the formulation of broad strategies to be used in attaining these goals. Management control is the process by which management ensures that the organization carries out its strategies. The third type of control process, task control, is the process of assuring that specific tasks are carried out effectively and efficiently.

A control system covers all three processes of planning and control. The three control processes are related, and therefore a control process can only function properly when all control processes are functioning. More specifically, a strategic control system is only useful when management control and task control are functioning. It can be argued that a task control can be efficient even without management control and strategic control, but identifying new ways of performing task control and performing tasks clearly will not take place. So without management control and strategic planning a task control system can be efficient, but not effective.

THE CONTROL SYSTEM PERSPECTIVE IN LITERATURE ON IT

The concept of control system and levels of planning and control in organizations stems from management accounting literature. In this section, it is discussed that it is almost never applied to the IT function. Most of the levels are addressed in literature, but combining and analyzing the levels based on the control concept has not yet occurred.

The Management Control and Strategic Perspective in literature on IT

The body of research on management control and strategic planning for IT is extensive. Not only are numerous articles written concerning the issue of information planning and strategic information planning, research with respect to implementing information systems (which is part of management control of IT) is also elaborate (see, for example, Theeuwes [1990], Van Schaik [1985], Martin [1982], Hopstaken et. al. [1990]). Although the planning concept of Anthony sometimes functions as starting point for frameworks for information planning, the link between information planning and the concept of Anthony tends to deteriorate very rapidly (see for example, Theeuwes [1990], Martin [1982]). Of the frameworks for information planning, only Van Schaik [1985] stresses the importance of planning and control of the IT function just like other business functions.

Van Schaik developed a model for a management system for the IT function. The focus of the model is on the aspects of management control and strategic planning. One of the interesting features of the model is that it describes the relation of Nolan model to the concepts of Anthony. By relating the concept of planning and control to the Nolan stage model, the process of implementing the system becomes visible. Task control is the first process to be implemented, then management control, and finally strategic planning. So, the implementation process of the management system is a bottom-up process.

Nevertheless, the model of Van Schaik still suffers from a serious flaw. As can be concluded from figure 1, growth in task control, management control and strategic planning is assumed to be sequential. But since task control for the IT function is concerned with development and maintenance of information systems and services, Van Schaik assumes that strategic planning and management control can only be used when we have systems development, maintenance, and services under control.

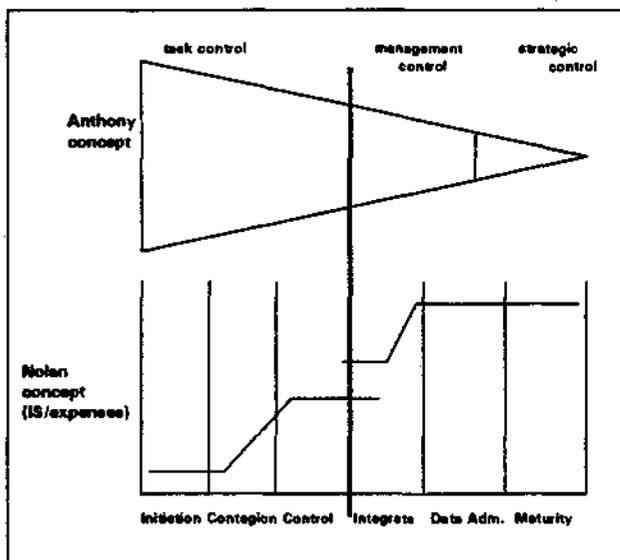


Figure 1. Anthony/Nolan overlay (source: Van Schaik [1985])

As discussed at the end of section 2, strategic control can not be implemented when management control and task control are not functioning, because there is no mechanism to introduce the defined strategy. Also, a task control system without management control or strategic control is likely to be ineffective. For the IT function, this is even more important, because the environment is so dynamic that once new technology is installed, it already is not the most effective any more. Trends in IT are too dynamic to make the assumption of installing a task control system for the IT facility based on one type of technology. Task control is under continuous pressure of changes in technology, and its dangerous to try to install a formal task control system when the way of developing and maintaining systems may be out of date once it is installed. IT changes the nature of planning and control (see Rockart and Short [1989]).

It can be concluded growth in task control and growth in management control and strategic planning are related growth processes, parallel processes, and should not show a sequential growth process. Of course, an organization must start to built a task control system because starting to built management control is useless. But even before this task control system is installed, the organization should be aware of the importance of management control and strategic planning for the IT facility. Thus, once a task control system is completely installed, the management control and strategic planning already have to be mature enough to adapt to changes in IT (see figure 2). The ideal growth path for managing the IT function should be a path in which all levels of planning and control have the same importance, or in which strategic and management control is one step ahead of task control. When strategic planning and management control get too much attention, the total control system is ineffective because developing and maintaining systems are not controlled, and thus, not properly functioning. When the emphasis is on task control, the control system is likely to become static, resulting in missed strategic opportunities, and the danger of relying on outdated IT.

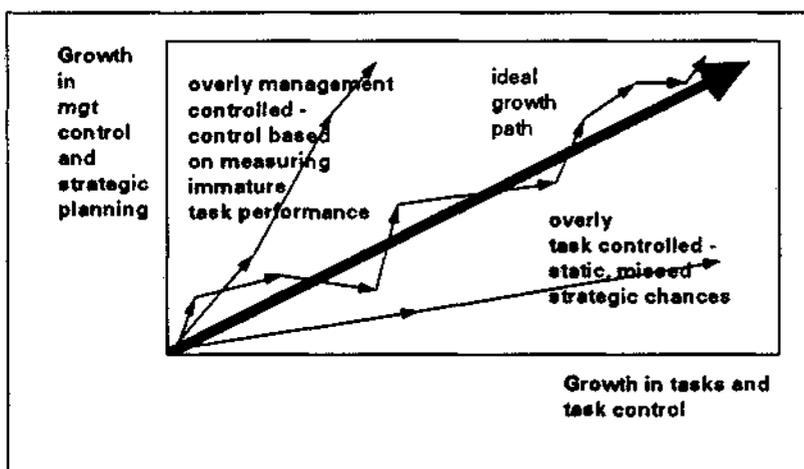


Figure 2. Parallel growth in the three levels of planning and control

The Task Control Perspective in literature on IT

The task control perspective focuses on operational level processes. This level is directed towards planning and control of individual activities and tasks within the framework of given resources. According to the model of Van Schaik, this level deals with development and maintenance, administration services, information services and the daily and weekly control of these operations (information services include the production and distribution of information). Of these activities, development and maintenance get the most attention in literature (see, for example, Humphrey [1989], Thompson [1991]).

Although the aspects of task control largely belong to the domain of computer science, installing a proper task control function until recently has not received much attention. With the introduction of new software technologies like CASE, the first attempts to describe the installation of task control were made. Of these attempts, the Maturity Model (see, for example, Humphrey [1987, 1989], Paulk et. al. [1991], Weber et. al. [1991]) is the most generally known and widely accepted. The following discussion will focus on this model, but similar discussions can be held for the other models (for example, ISO standard EN29001). The Maturity Model holds two basic assumptions: the process of developing and maintaining software can be defined, managed, measured and progressively improved, and the quality of the software products produced is largely determined by the quality of the process which produces them (see Thompson [1991]). The model describes five phases of growth organizations must pass to attain a 'mature' level of performing tasks and task control.

The Maturity Model is widely used in practice for technology assessment. Nevertheless, just like the model of Van Schaik, the Maturity Model has some serious limitations. Most of the limitations are related to the assumptions of use of software technology itself: an example is the assumption that CASE-technology should not be used before phase three of the model (for a discussion of these types of limitations, see Bollonger and McGowan [1991], Thompson [1991]). But beside these inherent problems, there is another serious limitation. The Maturity Model is heavily influenced by factory models and measurement of processes, based on the theories of Juran [1988, 1989] and Deming [1986]. Thus, the 'mature' phase of the Maturity Model is based on a 'software factory' model: in which every aspect of the software process (development and maintenance) should be measured. Only after such a control systems is installed, an organization can become 'innovative'. Just like the model of Van Schaik, the assumption makes the Maturity Model too static, in that radical changes in IT, as they occur nowadays, can not be coped with. The model lacks the link to the organization: management control and strategic planning. The Maturity Model demands a formalized and documented task control system, not a flexible control system. Flexibility requires proper mechanisms to assess impact of new systems developed, and impact of new technology. Although the issue of new technology is addressed in the 'Mature' phase of the Maturity Model, when issues of management control and strategic planning are not addressed, tasks and task control remain flexible only to a limited extend. Strategic aspects and aspects of impact of new IT remain unaddressed. Also, with the rise in software technology, the software process can be automated to a large extend. This should result in a shift towards the problems surrounding the systems that are developed and the use of IT itself: thus, the *service* aspect instead of *development and maintenance of systems* should be addressed. But the Maturity Model doesn't address this issue.

Solving problems by use of the control concept

Several limitations were identified in models describing task control as well as in models describing strategic and management control. The main flaw of the models addressing strategic and management control is the lack of concepts of task control. Task control isn't worked out completely, and even when it is worked out, it is assumed that problems of task control can be easily solved. For example, Van Schaik [1985] assumes that after the first three phases of the Nolan stage model, the problems of task control, i.e., systems development, are solved.

On the other hand, models describing task control are limited to the systems development and maintenance process, not to the services based on IT. The main model describing task control with respect to systems development and maintenance, the Maturity Model, shows the most serious flaws of these models: the models are very static and do not make any assumption on organizational growth in strategic problem solving or management control. A lot of models are based on the principles of 'software factory' (see Bollonger and McGowan [1991], also for a discussion of the concepts of software factory).

Thus, the main problem of all models is that interrelationship between, on the one hand, strategic planning and management control, and on the other hand, task control, is not taken into account. And even when it is taken into account, it is assumed that growth in each of these control processes is sequential, but the dynamic aspects of software technology require a parallel growth in each of these levels of planning and control. In addition, aspects of flexibility, as described in management literature (see for example, Rockart and Short [1989], Malone and Rockart [1991], Dichter [1991], Drucker [1988], Reich [1987], Hauptman and Allen [1987]), and services based on IT are not addressed. No attempt is made to extend management concepts on flexible organizations, characterized by for example adhocracy, decentralized responsibility, and team responsibilities, to the IT function. This issue will be discussed in depth in the next section.

TOWARDS A CONTROL SYSTEM FOR THE IT FUNCTION

Because the IT function has to be controlled just like any other business function, a control system for the IT function is needed (see Van Schaik [1985]). When a control system for the IT function is implemented in an organization, an organization is capable of planning, controlling and using IT and information systems in a better way. Planning, controlling and using IT improves when all aspects of control are taken into account (see the discussion in the former chapter). By taken all aspects of planning and control into account, not only each of these aspects is improved, but also attention is paid to the interaction of these aspects. In this chapter, the outline of a control system for the IT function is discussed. This control system is characterized by four aspects of flexibility. Next, it is shown how to implement such a control system, by taken all three aspects, i.e. the three levels, of planning and control into account.

The mature level of IT function

The IT (EDP) organization should become a responsibility center (see Van Schaik [1985]). As a business, it should provide a high-quality service to a customer at a fair price. Thus, the IT organization should cover all levels of planning and control. These levels range from strategic planning, management planning and control to task control and the tasks itself. In other words, the levels range from information strategy planning, project and service planning, short term project planning, control of information systems development and services, to developing and maintenance of information systems and services (See Van Schaik [1985]).

However, becoming a responsibility center is not enough. With current state of technology, and the strategic nature of IT, the control system should not only be formal, but also flexible. Flexibility requires at least the formalization of four key issues, issues that address all three levels of planning and control:

- simulating possible use in IT, not only for the IT organization, but for the organization as a whole.
- simulating possible use of new information systems for the organization as a whole (i.e., workplace simulation).
- shift in attention towards IT Services instead of IS development and maintenance.
- incorporating a flexible organization structure for the IT (EDP) organization, e.g. delegation of responsibilities, teamwork, flexible tasks instead of documented procedures.

At the strategic level, simulating possible uses of IT and information systems allows for a flexible information planning process. Flexible management control can be initiated by restructuring the IT organization to allow for a flexible organization structure. This aspect also allows for flexible task control, as does the aspect of IT Services. A control system for the information business that has flexible strategic planning, flexible management control and flexible task control will be called a Flexible IT Control System (FICS).

Growth towards a flexible control system

Not only the ideal situation (a flexible control system) is important. It is also important to know how to reach it. A growth model has to be defined, phases corresponding to the level of maturity of the information systems control system. This growth model should make clear the growth in task control and in strategic planning and management control. As discussed in the former section, sequential growth (first task control, than management control and strategic planning) is not possible due to the dynamic aspects of IT, and the dynamic business environment.

Thus, the model describing how to implement a FICS should assume a parallel growth path as discussed earlier. To describe two parallel growth processes the interrelation between the two should be defined very carefully. Phases of growth in task control and phases of growth in management control and strategic planning should be defined. The phases of the Maturity Model can be used for phases of task control, and the phases of growth in the model of Van Schaik can be used for the other dimension. Both these dimensions should include the aspects of flexibility as mentioned in the former paragraph.

Figure 3 shows the model resulting when growth in task control, management control, strategic planning are combined. Based on each of the aspects a set of 7 phases can be identified, which organizations may pass to arrive at a FICS. The lines 'a' and 'b' in the diagram are border lines in organizational adoption of strategic planning, management control and task control. Research on the state of software engineering practice shows that most organizations are at levels 1 and 2 of the Maturity model and almost none at the higher levels (see Humphrey [1989], Thompson [June 1991]). 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. This implies that most organizations have installed a proper management control system. Thus, these organizations are at the Control and Planning phases of the MIS Growth model (see Li et. al., [1991]). From this it can be concluded that companies tend to grow in developing and controlling IT 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.

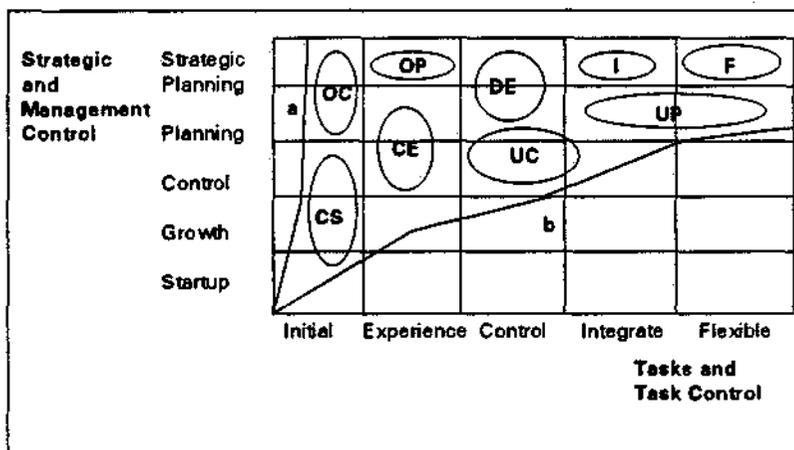


Figure 3. A model describing growth in levels of control of the IT facility

A proper trajectory, based on the parallel growth in task control, management control and strategic planning, will consist of the following phases:

- **Control Startup (CS)** - this phase represents the organization that is at an initial level of use of IT. The organization isn't much interested in the use of the 'new' technology, the priority lies with the control of resources.
- **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 control is achieved by initiating project management of commitments, cost, schedule and change (see, for example, Humphrey [1989]). Control of resources and services is extended (see Van Schaik [1985]).

- **Define Experience (DE)** - during this phase, the organization gains more experience in 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 (see Humphrey [1985], Paulk et. al. [1991]). As the organization reaches this process, it has achieved a considerable level of control and planning of the use of information technology in the organization, including services and resources.
- **Integrate (I)** - key architectures for data, applications and technology are being developed (see Van Schaik [1985]). Since the organization has achieved a considerable level of control and planning of use of information systems, its focus shifts to enhancing the infrastructure of the organization, and monitoring the control system itself (this concept, called management system monitoring, is discussed by Van Schaik [1985]). Decisions are made which facilities and organizational data are centralized in corporate data bases, and which facilities are decentralized.
- **Flexible (F)** - with a controlled information systems development process and considerable experience in control and planning of information systems and services, the organization is capable of performing flexible information technology control, which means it can adapt quickly to any new circumstances affecting the control process.

Note that the ideal trajectory is slightly upward bended: strategic and management control is one step ahead of task control. This allows an organization to plan for, and thus be aware of, the changes needed to attain a flexible task control system.

Above an outline was given for a proper trajectory for organizational growth in the IT function. However, it was also discussed that based on empirical evidence it can be concluded that most organizations are at a considerable sophisticated level of planning and control of information systems, also strategic planning, whereas there are almost no organizations at the Integrate and Flexible level of the Maturity model (see Li et. al. [1991], Humphrey [1989], Thompson [June 1991]). Thus, organizations may be concerned with control of computer resources than the control over the way these resources are used. 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 technology control and pays too much attention to control of resources and services and IS planning. This less desirable trajectory for growth in control of IT consists of the following phases:

- **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, and forgets to start controlling the software development process itself. IT planning is initiated and worked out. Resources are planned. 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)** - because too much attention is paid to service and resource control and to planning, the organization 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.

When organizations pay too much attention on performing tasks and using state-of-the-art technology, another undesirable trajectory becomes visible. This trajectory is less likely to occur because most organizations have problems in controlling their systems development and maintenance processes. This trajectory consists of the following phases:

- **Control Startup (CS)** - as above.
- **Underly Controlled (UC)**- just like an organization may pay too much attention to planning and control, it may take too much attention to performing activities instead of controlling and planning for these activities. The organization forces itself to introduce and use state-of-the-art technology, but forgets what to use the technology for. Planning for new information systems or new technology is limited.
- **Underly Planned (UP)** - the organization has improved on planning for IT and information systems, but the level of strategic planning and management control does not correspond with the level of performing and managing activities in the short term, i.e. the task control. The organization is too much focused on using technology 'just because it is technology'. Planning for new technology may be overruled by the urge to use state-of-the-art technology.

Once an organization is in the OC-phase, OP-phase, UC-phase or in the UP-phase, it is very difficult to attain a considerable level of IT control. The organizational structure, task structure and culture are too fixed on using IT or on planning for these systems. In phases OC and OP, too much attention is paid to planning and controlling resources and services. It is difficult to shift attention to 'technical' issues of IT control, in this situation the IS development process and IT services. Planning, competitive advantage and business opportunities are the key words in phases OC and OP, and time and resources for measuring the software process and services are not available. The other way around, it is difficult for organizations in phase UC or UP to shift attention from performing excellent activities and using the state-of-the-art technology, to thoroughly planning and controlling for technology and information systems. Organizations in phase UC and OP tend to use new technology just because it is state-of-the-art, not because the technology may be practically useful.

5. Conclusions

In this paper, it was shown that just like any other business function, management of the IT facility should be based on management accounting principles. By applying this perspective organizations can arrive at a proper IT facility. However, the era of specialization has given researcher of the IT facility more problems than solutions. Levels of planning and control are components of different research areas, and until now there is no model to combine the several levels of planning and control. In this paper a model was presented that tries to combine these levels of planning and control, based on a flexible information systems control system (FISC). This flexibility can be attained by focusing on four issues:

- simulating possible use of information technology in the organization as a whole;
- simulating possible use of information systems;
- shift in attention towards services, instead of systems development and maintenance;
- incorporating a flexible organization structure, e.g. teamwork, delegation of responsibility, less documentation by group control.

Further research is necessary to elaborate the model, to verify its use in practice: the position of organizations in the model, the way of growth of organizations based on the model, the two dimensions of growth and its characteristics, the use and impact of IT based on the model, and the characteristics of the phases identified in the model for both the optimal and sub-optimal paths.

Although many researchers in IS-studies stress the importance of multi-discipline research, results from multi-discipline research are very limited. For individuals, acquiring knowledge of many disciplines is hardly possible in an increasingly complex and dynamic society. Thus, the only way to get results from multi-discipline research, and this type of research usually gives the most interesting and promising results, is to allow researchers in related fields to carry out joint research program.

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