Chapter X
The Theory of Deferred Action: Informing the Design of Information Systems for Complexity

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ABSTRACT

The problem addressed is how to design rationally information systems for emergent organization. Complexity and emergence are new design problem that constrains rational design. The reconciliation of rationalism and emergence is achieved in the theory of deferred action by synthesizing rationalism and emergence. Theories on designing for normal organisation exist but most of them are borrowed from reference disciplines. The theory of deferred action is based in the information systems discipline and is presented as a theory to inform practice to improve the rational design of information systems for emergent organisation. It has the potential of becoming a reference theory for other disciplines in particular for organisation studies. As emergence is a core feature of complexity, the base theory for the theory of deferred action is complexity theory. The theory of deferred action explains the effect of emergence on the rational design of information systems. As a theory to inform practice it provides guidance in the form of design constructs on how to design rationally information systems for emergent organization.

INTRODUCTION

We have been designing, developing, and using information systems in business organizations using computers and lately information technology for nearly sixty years. But what is our understanding of an information system? The practice of information systems has been driven by the invention of digital technology, computers, information technology and lately information technology for nearly sixty years. But what is our understanding of an information system? The practice of information systems has been driven by the invention of digital technology, computers, information technology and lately information technology.
and communication technology. Many advances in our knowledge of how to develop information systems have come from practitioners. Practitioners have also built actual information systems that have become the object of study for researchers. These include transaction processing systems, decisions support systems, expert systems, and recently ebusiness systems and enterprise resource planning systems.

Some advances in our understanding have come from researchers. Early understanding of an information system as a technological system improved with knowledge of information systems as socio-technical systems, acknowledging the human social context in which information systems are developed and used. Researchers now define an information system as composing people, organisation and information technology. Some theories on information systems have been proposed (Walls, et al., 1992). Markus, et al., (2002) propose, a design theory for systems that support emergent knowledge processes, (179-21). But we lack good theoretical understanding of information systems.

What is a simple information system and what is a complex information system? When is it simple to design information systems for a business organisation and when is it complex? It is simple when there is no design uncertainty. Possibly when what is wanted is perfectly known, and when complete and predictable information and knowledge is available to organize the available resources to achieve it. Information on available resources should be complete too. This kind of simplicity is not available to designers because there is much design uncertainty in organizations. Designers do not have complete and perfect information and knowledge about the artifact they design because organizational members themselves lack the knowledge. Designers work with incomplete knowledge of want is wanted, imperfect information about how to design and develop, as well as incomplete information on available resources and how to organize them. The cause of this design uncertainty is complexity.

The predictive capacity of designers is central. Prior to design the purpose of the organisation is knowable to a large extent but it can and does change unpredictably after the organisation has been setup. Commercial companies’ purpose of maximizing shareholder value has changed to consider the impact on the natural environment. Consequently, new information on carbon accounting is obtained by adding new information systems or making adjustments to existing ones. An information system is simple when the organisation and the information required to manage it can be predetermined, its design and development is also relatively simple. When design is predictable there is an absence of complexity. Uncertainty about the information required to manage the organisation arises when aspects of the organisation cannot be predetermined. The core of this uncertainty is highly unpredictable situations that arise in the course of organizational life. The absence of the predictive capacity of designers is the essence of design complexity.

Business organisation as a social system is complex. The functions of information systems for a business organisation are far from simple. Functionality is complex not only because of design uncertainty but also because the social system itself is complex (unpredictable). Structure and resources of the organisation are unpredictable (Feldman, 2000; 2004). Patterns of communication between humans within the organization, and between humans and information systems, cannot be completely predetermined for design purposes. As patterns of human communication within the organization are highly complex it is not simple to determine the necessary information flows. Patterns of information flows between the organisation and its environment are similarly not pre-determinable completely. Also the situations in which information will be used are not pre-determinable exhaustively.

The question of whether the business organisation needs a simple or complex information
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system is important because most information systems projects are thought to be entirely predictable. Simple information systems are those that can wholly be predicted. Credit control and payroll systems are examples. In actuality many projects, especially organisation-wide information systems like enterprise resource planning systems, are complex in the sense that complete knowledge of required functionality over the life of the system is not possible. Such projects are not only unpredictable during development (the design phase) but later too when the information system is in use. The situational use of the information system reveals purposive and functional shortcomings. A corollary of the question is what level of complexity is needed? These questions and the question of how to design information systems that have no predetermined structure and function but when such structure and function takes form in situ is addressed by the theory of deferred action presented in this chapter.

METHODOLOGICAL APPROACH

We propose complexity theory for developing design science theories capable of informing practice. Design is a scientific field of enquiry particularly important for humans. Design scientists can use complexity as a theory of design to advance and improve design quality. The epistemological methodology of complexity can be used to understand emergence in socio-technical systems like information systems and knowledge management systems, and design processes. And it can be used to propose suitable design constructs and design processes for emergent organisation.

Emergence is a defining characteristic of the ontology of complex adaptive systems. The ontology of such a system cannot be predetermined, predefined because of emergence. A particular event affects other events in non-determinable ways in complex adaptive systems, in a chain of events in which initial causes are untraceable to eventual effects. This epistemology is relevant for understanding and designing systems for emergent organisation. Knowledge systems are such complex adaptive systems. The processes for creating knowledge are intertwined in non-determinable emergent paths.

Emergence is the keystone of complexity theory. Complexity is characterized as constant ‘phase change’ arising from emergence. Emergence requires social systems to adapt, resulting in complex adaptive systems (McMillan, 2004). Responses to emergence necessitate ‘self-organizing systems’ that are complex adaptive systems. Complexity in turn requires appropriate concepts and constructs of knowledge. Adaptableness and self-organisation become aspects of organizations that are not generally considered in knowledge and information management theories, strategies and programmes.

SYSTEMS AND COMPLEX ADAPTIVE SYSTEMS

‘Systems are objects with varying degrees of complexity, although they are always acknowledged as containing elements that interact with one another.’ (Bertuglia and Vaio 2005:3). The staying together of the elements is a defining feature of a system. Social phenomena like the scientific enterprise, economy, population, organisation, and information systems, are such systems. The elements of an information system are people, organisation and information technology. Their coming and staying together composes an information system.

A system that self-organizes in response to its environment is a complex adaptive system. It acquires information on its environment and on its own interaction with that environment. This information is structured into regularities and then condensed into a schema or model for acting in the real world. Adaptation of the system to its environment occurs when it changes itself and its
The structure of the internal elements and their relations distinguish a complex adaptive system from its environment and this structure and internal relations is termed complexity. The complexity of information systems is not investigated or well understood. Complexity, self-organisation, emergence and adaptation are features of certain information systems, for example strategic information systems and the Web. Even less well understood is how to design socio-technical systems rationally to cater for complexity.

An organisation, its management, and information systems are examples of complex adaptive systems that are generated (rationally designed) by humans. What is normally termed ‘uncertainty’, ‘change’ and ‘changing organisation’ or ‘creeping requirements’ and ‘information systems failure’ in the literature is better explained in terms of complex adaptive systems. Much instability and uncertainty pervades organizational life, whether it is a charitable, governmental or business organisation. Such uncertainty or indeterminacy is a central feature of complex adaptive systems. It is termed emergence in complex adaptive systems and it is a core feature of complexity.

**DESIGN SCIENCE AND COMPLEXITY THEORY**

Design is a scientific field of enquiry particularly important for humans. Herbert Simon defined design as: ‘Everyone designs who devises courses of action aimed at changing existing situations into preferred ones’ (Simon, 1996: 111). The aim of design science is to develop theories of how designers think and work. It also aims to develop methodologies and tools to support designers’ work. Some strands of design science, particularly in information systems, aim to develop ‘IT artifacts’ that are derived from design science investigations (Walls, et. al, 1992). Organisation and its information systems are such ‘artificial’ or synthetic systems.
Takeda et al. (1990) have analyzed the reasoning that occurs in the course of a general design cycle, illustrated in Figure 1. Abduction is used for the creative process and deduction is used for the development and evaluation process. This diagram can be interpreted as an elaboration of the *Knowledge Using Process*. It shows the flow of creative effort and the types of new knowledge that arise from design activities.

Figure 1. Reasoning in the design cycle

Consideration of complexity in design has recently been recognized by researchers and research funding bodies (Johnson et al., 2005). The UK’s Engineering and Physical Sciences Research Council fund research that seeks to ‘embrace’ complexity in design.

Design scientists can use complexity theory as a theory of design to advance and improve the quality of design. The epistemological methodology of complexity can be used to understand social systems like organisation, socio-technical systems like information systems, and the design process. Since information systems need to operate in complex social systems, as they are embedded in organisation, complexity can be used to better conceptualize the design ontology of complex information systems.

The description of a complex system can be done of its structure, function or behavior (Zamenopoulos and Alexiou, 2005). Structurally, a complex system is a set of structured elements and the aim is to describe and explain this structure. To describe an emergent property in the structure of the system an exponential function Power Law, \( P(s) \propto s^{-\gamma} \), is used. It maps the frequency distribution of some quantity (s). The complexity of the World Wide Web can be described using a Power Law. Functionally, a complex system can be modeled as a function that produces an output with given input. In cybernetics a machine is characterized as ‘trivial’ or ‘non-trivial’ depending on the problematic of describing its input-process-output pattern (Von Foerster, 2003). Behaviorally, a complex system can be modeled as a dynamical system.

A complex adaptive system is responsive to its environment. It adapts to sustain itself. When humans design a business organisation and its information systems they are behaving as complex adaptive systems. As complex adaptive systems, humans generate other complex adaptive systems, the organizations and information systems they design and develop. Three out of the...
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five characteristics of complex adaptive systems are to do with information. (Bertuglia and Vaio, 2005: 276-7).

Casti (1986) distinguishes between design complexity and control complexity. Design complexity is concerned with the processes involved in design and how interconnected these processes are. Control complexity is concerned with how control can be maintained in complex designs. Our aim is to include both in developing a theory to support the design of artifacts for emergent organization. To improve control over synthetic complex systems like organisation, its management and information systems. This is possible with deferred action.

Emergence is a central property of complex systems. Emergence is the sudden and unpredictable occurrence of events. As such events cannot be predicted they are said to emerge. Emergent complexity is a characteristic of design too. A particular design is not entirely pre-determinable. Its final form is the result of many iterations until an agreeable from emerges.

The theory of deferred action is a design science theory and draws on complexity as a theory of design. It makes use of the structural, functional and behavioral features of complex systems to understand socio-technical systems like information systems and knowledge management systems. Knowledge management systems particularly have significant emergent properties and they can be better designed if we understand these emergent properties as complex systems. The empirical research leading to the theory of deferred action was from the perspective of information systems development. But because information systems frameworks could not explain the empirical data on emergence in information systems, the deferred systems design and deferred system constructs were proposed. These were further theorized to define the coherence and generality of the theory of deferred action.

OUR DESIGNED ACTIONS AND COMPLEXITY

We rationally determine our designed actions as in the design of purposive organisation. The design and development of information systems is also such designed action. The rational element of designed action is centrally important. Rationality enables us to keep control of our future. Through rationality we can measure our efforts, whether we have achieved our aim, and how well we have performed, as well as other measures.

Aspects of our designed actions can be planned. Such planned action works well in contexts that are stable and predictable. High measure of certainty can be achieved in such contexts. Certain operational information systems can are relatively stable and predictable, for example the central purchasing organisation in a manufacturing business (but over the very long term this can become unstable too). But design by planned action solely is unable to cater for emergence in social systems.

Our designed actions however meticulously planned are not simple to enact. Simple here means an absence of complexity. They are not simple because they are not entirely predictable, and unpredictability (emergence) is a major feature of complex systems. Designed actions are not simple to enact because new organizational situations emerge, requiring new information to act, that could not have been predicted for design purposes. Consequently, the information systems we require to complete our designed actions are not simple too.

Is it possible to design rationally the kind of complex adaptive systems that humans (themselves complex adaptive systems) generate? How can emergence be factored into the rational design of complex adaptive systems like certain information systems? In general, how can emergence be factored in the design of socio-technical systems like information systems and ebusiness systems? The Theory of Deferred Action is proposed to
cater for emergence in rationally designed information systems that are characterized as complex adaptive systems.

**Complex Organisation**

Empirical evidence supports the thesis of emergent organisation. Emergent organizations experience frequent, unpredictable change because of fluctuations in the organisation itself and in the external environment. The change commonly is sudden and unexpected resulting in structures, processes, and resources becoming unstable and difficult to predict. Therefore the efficacy of planning is limited (but it is still necessary). The impact on information systems development projects is therefore logically complex as the challenge of successful definition, adoption, and diffusion is exacerbated. Consequently, emergence clearly has an effect on the generation, distribution and application of information to improve products and services with a direct impact on the efficiency and effectiveness of organizational performance.

Emergent organisation is ‘a theory of social organisation that does not assume that stable structures underpin organizations’ (Truex et al, 1999: 117; Truex and Klein 1991). Emergence affects structure, processes, and resources. Empirically, organizational structure and processes are emergent. Feldman (2000) studied organizational routines to reveal that even routines are a source of continuous change. Feldman (2004) later revealed that organizational structure is emergent and, importantly, it effects organizational resource allocations. Emergent organisation assumes that organizational structure and processes are fluid (Baskerville et al., 1992). It assumes that ‘organizations are always in process; they are never fully formed.’ ‘Emergent’ acknowledges the ‘possibility of a current state being a stage to a possible outcome and always arising from a previous history and context.’ (Truex et al, 1999; 117) Emergence affects actors’ need for information and knowledge of organisation and organizing (Truex et al., 1999; Markus, 2002; Patel, 2002).

Emergence has implications for information systems where information is characterized as contextually dependent. It becomes problematical to structure information in emergent organisation. Truex et al (1999), referring to information systems development, state that there are limited means to address information management in emergent organisation. Similarly, given emergence, our ontological understanding of information and its use to design and support business processes needs revising. As knowledge processes in organisation are effected by emergence (Truex et al. 1999; Patel, 2005), emergence must be considered theoretically as a dimension of information and knowledge. Patel’s (2005) study of sales and client relationships in an insurer’s company reveals that emergence results in deferred action in ‘situations that are confusing, unclear, lacking knowledge or unfamiliar’ (p.356).

Emergence is intrinsic to social systems (organization). It has non-repeating patterns that arise from interactions and communications between actors, between actors and knowledge management systems in situ, and located in various organizational settings over time. Its prime characteristic of unpredictability makes it un-specifiable and therefore problematical to manage. ‘Emergence is an unpredictable affect of the interrelatedness of multifarious purposes and the means to achieve them that is characteristic of social action. By implication, emergence is the non-specifiable constraint on rational design because it cannot be determined as design objects, it is off-design’ (Patel, 2006:12). An emergent organisation is a complex adaptive system and its enabling and supporting information systems are complex adaptive systems.

For analytical purposes an organisation, processes and information systems, can be divided into two parts. Normal organisation has definable structure, processes and resources, and therefore its data and information can be pre-determined for
design purposes. This is termed predictable design in which the artifact to be designed is completely knowable in advance. A manufacturing production process and credit control process are examples. Emergent organisation has indefinable structure, processes and resources, and therefore its data and information cannot be pre-determined for design purposes. This is termed unpredictable design in which the artifact is not completely knowable in advance. Industrial innovation processes and strategy formation are examples. Any organisation is both normal and emergent, and as a whole it is emergent.

Data, Information and Knowledge in the Context of Emergent Organisation

Our understanding of data, information and knowledge is that it has stable properties that are predictable. In applying complexity theory to data, information and knowledge, we ask what is the effect of emergence on data, information and knowledge?

Data are facts about the world and are relatively stable. Data can be identified, structured and processed. The effect of emergence on data is relatively less. Names of customers, their address or the product manufactured do not change often.

The effect of emergence on information is relatively greater. Information is normally defined as processed data (Data + algorithm = information). The meaning that humans attach to data is here interpreted as ‘algorithm’. Some kinds of managerial information depends on emergent situations. We re-define information as processed data in the context of emergence. (Data + emergence + [contextual] algorithm = information). New and unpredictable organisational situations arise in the course of organisational life which make information dependent on emergence.

Applying complexity theory to information systems, we learn that information and knowledge have emergent properties. These emergent properties make information dynamic. Emergence affects the kind information managers need. In emergent contexts information is changeable. Where does the customer live now? Not at the address shown in the company’s database but somewhere else. In emergent contexts information has the qualities of uncertainty and unpredictability.

We assume the phenomenon of organisational information has elements that are static and emergent. The static elements are knowable and predictable and therefore they can be specified for design purposes. Transaction processing systems are examples. Information required to manage a motor cycle production process can be predetermined. It can be specified to design and develop the appropriate module for an enterprise resource planning system.

The emergent elements are not knowable, emergent events occur suddenly and unpredictably. Information required to manage sudden announcement of companies merger cannot be predetermed. It cannot be specified in advance. Information systems that are affected by emergence include strategic information system and decision support systems. At the societal level they include the World Wide Web.

The dichotomy of knowledge as explicit knowledge and tacit knowledge is established (Polanyi, 1966). We add as a core third element emergent knowledge. Emergence affects the kind of knowledge managers need in purposive organisation. Knowledge and the processes used to generate knowledge have emergent properties.

INFORMATION SYSTEMS IN EMERGENT ORGANISATION

A source of conceptual models of information system is business and management. Earlier applications of computers in business were in business operations. Routine procedures like inventory control, sales and accounting were automated using
computers. Reports produced by these systems were used by management to manage business operations. Additionally, computers were applied to support management decision making resulting in decision support systems. The transaction processing systems and management information systems were designed for normal organisation. Therefore, the concept of information system was that it was predictable.

A strand of information systems research exposed deficiency in the concept of information system as predictable. Researchers applied social science theories such as Actor Network Theory and Structuration Theory to interpret organisational information systems. A prime outcome of this research added the notion of ‘meaning’ to concept of information system. Humans attach meaning to information in order to make sense of it in particular organisational contexts. What meanings humans will attach to information cannot be predicted.

Other subtle sources contributing to the concept of information systems are science and engineering. A focal conceptual model is inadvertently based on physical ‘linear system’. The idea of a linear system is that the phenomenon of interest is represented as a mathematical model to demonstrate casual relationships and therefore to make predictions. Cause and effect and predictability are core features of physical linear systems. Information systems design and development too is broadly conceptualised in terms of cause-effect and predictability. The ‘cause’ being tools, methods and methodologies for designing and developing information systems and the ‘effect’ being the information systems product. This is essentially the approach of engineering design.

This evolved concept of information system is suitable for normal organisation. It needs further enhancement to be useful for emergent organisation. Little attention has been given to the effect of emergence on information systems. The ‘system’ in the term ‘information system’ is presumed to be a stable and predictable. These are strong features in conceptualisations of information system and in its development process. It is presumed that an information system is a stable and predictable entity (it has known data items and information outputs) and that it operates in a stable environment (the knowable organisation). It is also presumed that the information systems development process is stable and predictable. Predictability in the information systems development process is the expectation that by following some method of development, usually a information system development methodology, the result will be the expected information system product.

Stability, cause-effect and predictability are problematical in the rational design of information systems. Designers and developers encounter problems with stability and predictability in the early stages of information systems development. So-called ‘users’ are expected to state the functions for a new information system as ‘requirements’, but often they can only give broad indications, and they tend to change their minds during the development process. Information systems development methods and methodologies become less predictable in the actual context of development. User participatory and prototyping methods have been developed as a response but they too retain the essential core elements of linear systems – stability, cause-effect and predictability.

Being developed for human use and by being placed in human organisation, an information system is a socio-technical system. Stability, cause-effect and predictability are not characteristic of socio-technical systems. A better characterisation of socio-technical systems is complexity. Complex systems are unstable, unpredictable, and adapt to their environment over time. Such systems are termed complex adaptive systems.

Our problem is how to design rationally information systems for emergent context. Emergent contexts include emergent business processes, emergent knowledge processes, emergent organisation structure, and emergent resource needs. We are concerned with the design of information systems with emergent properties. Such complex
information systems are embedded in social bodies like organisations and society. Organisation-wide information systems should be designed to have emergent properties (functions). Since aspects of organisation like structure, processes and procedures are emergent, information systems that enable or support them should also be capable of adapting to emergent situations. ERP systems should have emergent properties.

**DESIGNING EMERGENT ARTEFACTS RATIONALLY**

The problematic of designing information systems rationally by necessity was recognised early (Parnas and Clements 1986). An information system, its development process, and the use of the information system, are all construed to be objects that are created entirely rationally. By rational is meant that designers are expected to be able to explain satisfactorily their design activities. Such rational design assumes explicit purposive action, specifiable business processes, data and information. This is termed information systems specification formalism in the theory of deferred action. The quintessential example of specification formalism is information systems development methodologies.

As noted the meaning that humans attach to information is central to information systems. An information system is much more than rationally specifiable objects. As a socio-technical system, an information system is embedded in a social system (organisation). Since the social system is a complex adaptive system it responds to its environment by changing in an emergent way. Such emergent change is unpredictable. Therefore, information in an emergent organisation cannot be accounted for solely by specification formalism.

Specification formalism fails to recognise emergence and how people, information systems designers and developers and organisational members who make use of the information system artefact, behave relative to emergence in purposive organisations. Emergence constrains the degree to which an information system can be specified. The scope for designing specification formalism itself is constrained by emergence.

**DEVELOPING THE THEORY OF DEFERRED ACTION**

Some background leading to the development of the theory of deferred action is discussed in this section. Principles and frameworks for developing information systems conceptualise an information systems as a product and recommend that the product should be developed systematically as phases of an information systems development project. Such phases are well embodied in information systems development methodologies. As no credible alternatives are available, the actual practice of information systems development attempts, rather unsuccessfully, to implement these principles and frameworks. Their success varies greatly but in the main so-called ‘users’ of information systems are disappointed.

The term ‘system’ in information systems is not emphasised in the conceptualisation or development frameworks for information systems. Design science research was designed (1) to investigate how an information ‘system’ is developed and used in organisation and (2) to propose information ‘system’ design concepts and principles. Four information systems development projects were studied using the case study method in different organisations. When the collected data was analysed it was found that the actual practice of developing information systems differed from the extant principles and frameworks. In some cases and situations the actual use of the information systems by organisational members differed greatly from the intended use. The data could not be interpreted in the available frameworks. The important construct that the data revealed which could not be explained by the frameworks is emergence.
To make sense of this emergence data complexity theory was invoked. A core tenant of complexity is emergence. The emergence data was interpreted in terms of complex adaptive systems. The interpretation resulted in conceptualising the information system development process as deferred systems design and an information system as a deferred information system (deferred system). The design principle of deferred design decisions was proposed to implement deferred systems. This principle is designed to raise the level of abstraction of the software artefacts to enable people who use the information system in context to tailor its functions. This reduces the need for an elaborate specification of functionality during design and development. A deferred system is an emergent system. Its systems architecture is designed by reflective designers (professional IT systems developers) but its operational functionality is determined by active designers (people who use the information system) in actual organisational situations.

The deferment construct is a “rich insight” or “second order concept”. It is a concept that emerges from the data but through the interpretation of the researcher. It explains how to design information systems rationally for emergent environments like business organisations. The generalisation power of deferment is great. It has been extended to other areas like organisation design (deferred organisation) and to learning in education (deferred learning technology). The generalisability of the deferment construct for designing artefacts that are embedded in social systems was further developed as the Theory of Deferred Action.

THE THEORY OF DEFERRED ACTION

The theory of deferred action (Patel, 2006) is a generic artefact design theory. In Gregor’s (2006) terms, it is a theory for action and design. Nomer-thetically, it explains and suggests effective models of information and knowledge management for emergent organization, by accounting for IT-based information and knowledge systems as embedded in social systems. Its applied aspect helps to explain and improve informational and knowledge artefact design in emergent organization. How can such artefacts cope with organizational change and the uncertainty much characteristic of emergent organization? How can it cope with ‘emergent business processes’ found in innovation work, jobbing, unit and one-off processes? What kind of taxonomy of knowledge has greater generalisation power and can cope with scaling up? What is an effective model of knowledge capable of accounting for emergent organization? Such questions are addressed by the theory.

The theory assumes business organisations rationally seek and pursue some purpose and plan to attain it. A plan is any devise or artefact whose purpose is to construct the future. However, it also assumes actual human and organisational behaviour is determined by emergence and sociality in the context of complexity. Therefore, rational behaviour is tempered by emergent behaviour that needs to be catered actively in the rational plan. A further assumption is that actuality takes precedence over plans. Actuality is affected by emergence. Therefore, plans need to be evolving to cater for actuality. The main constructs of the theory are: planned action, emergence, and deferred action. A construct in social science refers to an idea that is invented for specific research or theory-building. Constructs are built from other concepts. Normally, constructs are not directly observable but are deduced from relevant empirical observation.

Theorising requires ‘creative inspiration’ (Rosenthal and Rosnow, 2008). How can the effect of emergence on information and knowledge not only be explained but the theoretical explanation also used to prescribe what action should be taken? This is the design science problem. Given emergent organisation, how can the design of
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informational and knowledge artefacts be accomplished rationally? The theory of deferred action seeks an answer to this question. It explains emergence in information systems and proposes how to design rationally for emergence. It contributes significant knowledge of how to design socio-technical systems for emergent organisation and improves our understanding of information systems as complex adaptive systems adapting to an emergent environment.

The base theory for the theory of deferred action is complexity theory as expounded previous sections. Emergence is characteristic of complex adaptive systems. The deferment construct explains courses of rationally design human action (organisation to achieve collective purpose and its information systems) suitable for emergent environments. The theory permits analysis of the context of information system to determine the kind of information systems suitable for predictable and unpredictable contexts.

Meta-Design Dimensions

The pre-determined (rational) designability of information systems is affected by emergent organisation. Emergence is a non-specifiable constraint on rational design. It cannot be determined as design objects - it is off-design. When designing and developing information systems, emergence cannot be specified because it is unpredictable. So, what is the rational design of information system for unpredictable environment? Planned action, emergence, and deferred action constructs are meta-design dimensions for designing informational and knowledge artefacts for emergent organisation.

Planned Action

Planned action looks at future states of knowledge. But plans make use of existing available information and knowledge bases. Drawing on established information and knowledge bases is necessary to undertake any planned action aimed at developing future states of knowledge. The innovation of a new electronic product draws on existing electronic information and knowledge bases such as circuit gates, modularisation, and limits to miniaturisation.

Planned action (design) is necessary but not sufficient. Planned action is organisational behaviour devised from some formalism, ‘it prescribes actual action as predetermined moves’ (Patel, 2006:73) and, therefore, assumes stable organisational structure and processes. Planned action is undertaken centrally. It may be some plan, design, or strategy. Planned action is prescribed action by design and enacted regardless of actuality. For example, a three-year strategic plan or formal systems design for a knowledge management. Planned action characterises human action and organised activity exclusively as rational act and results in specification formalism – formalism used to obtain requirements for and design some IT artefact. Action is rational, purposeful and intentional. It is useful for design problems that can be well-structured based on explicit knowledge and declarative knowledge.

Emergence

Emergence is concerned with the locale - present, contextual, and situational aspects of information. The process of creating future states of knowledge (new knowledge) from information is subject to emergence. While working from an existing electronics information database (planned action), new problems need to be solved that requires new know-how (knowledge). Such information and knowledge has an emergent element. The innovation of a new electronic product draws on the existing knowledge base, but how existing knowledge components are combined while solving new problems is emergent information and knowledge, resulting in some innovative design.

Emergence is ‘the occurrence of unplanned and unpredictable human events out of bounds of
rational analysis and therefore off-design.’ (Patel, 2006: 116) Emergence is the patterns that arise through interactions of actors, and interactions between actors and artefacts, and their environment. Emergence is a becoming aspect of design. It is intrinsic to social organized action. It is an affect of interrelatedness of multifarious purposes and means to achieve them characteristic of social action. In complexity science, emergence is ‘the phenomenon of the process of evolving, of adapting and transforming spontaneously and intuitively to changing circumstances and finding new ways of being.’ (McMillan, 2004:32). Most examples of emergence are in the natural sciences. There are few concrete business and management examples and no information systems examples. One example relevant to knowledge management is self-organising learning teams. Emergence causes self-organising. Such teams are found in strategic management, where open-ended issues are identified, clarified, and progressed by self-organising networks in an organisation (Stacey, 2003).

In design, planned action prescriptions need to cater for emergence. We postulate that the root of ‘wicked problems’ (Rittle and Weber, 1984) or wicked information and knowledge problems is emergent organisation. It is necessary to relate by synthesis planned action and emergence to design informational and knowledge artefacts for emergent organisation. Planned action and emergence are related design dimensions when designing for emergent organisation.

Deferred Action

Contextual information happens within a plan (planned information systems) but it cannot be entirely dictated by details of the plan. The electronic product innovation programme (plan) is the goal, but since the actual process of innovation is subject to emergent factors an adequate response to local working situations is necessary – deferred action. Such deferred action is within the programme but enacted in the emergent, rich context of the knowledge generation process, using existing information systems and catering well for creativity. Adaptableness and self-organisation characteristic of complex systems, are aspects of knowledge that are facilitated by deferred action.

Deferred action is the synthetic outcome of relating planned action and emergence. Deferred action results in emergence, space (location), and time being represented in planned action. It enables the enactment of some pre-determined planned action (formal design) by contextualizing it in unpredictable, emergent situations. Deferred action is actual, situational action within some formal design. The formal design is the context in which actual (deferred) action happens. Since emergence is unpredictable actors should be enabled to respond to it in particular organizational situations. Deferred action is the synthesis of planned action and situated action. It enables actors to modify an information system within the context of its use. So an information system is conceptualized as a continuous design and development process, rather than a time-bound product.

Deferred action formally relates emergent actual action with planned action or formal design (Patel, 2006: 96). Deferred action is undertaken locally in the emergent context. It is derived from natural design – what humans do naturally to achieve some natural purpose such as sustain and house themselves. Natural design assumes mind and body holistic human action. It is not entirely subject to rationality (planned action or rational design). The three meta-design dimensions and deferred constructs are related and depicted in Figure 2.

The relationships among these constructs, or dimensions of information and knowledge, are stated in Table 1. The dimensions and their inter-relationship model actuality. Actual situations are never sympathetic to plans or purely rational. They are subject to emergent factors which require an adequate embodied and situational response. In
rational design, this response is deferred action. Deferred action differs from *situated action* as propounded by Suchman (1987) because the latter negates plans, while deferred action is the synthesis of planned action and emergent situations. In situated action the situation itself is a given but in deferred action the situation is emergent. Also, situated action lacks enduring structures while planned action builds enduring structures within which deferred action takes place.

**Ontology of Information Management**

The deferred ontology of data, information and knowledge is determinable, emergent and tailor-able. Determinable things are explicitly known to reflective designers, such as stock, costs, and prices. Emergent things are unknown as when competitors bring out new products or when consumers’ preferences change. Data, information and knowledge is tailorable in the sense that active designers can tailor operational functionality to suite actual action required in context. They ascribe meaning to it in context. Tailorability enables operationalisation of tacit knowledge and other deep human traits.

Application of the theory to information management results not only in additional dimensions of information but a new construction of information that contributes to our existing understanding discussed in the introduction. Information can be interpreted in terms of the three constructs and their interrelationships. To illustrate with the example of industrial innovation:

Most usefully, the theory may be used for interventions to inform knowledge-based competition strategy. An example of knowledge-based competition strategy that is well explained by the theory is Google. Knowledge and its creation are important for Google’s pre-eminence as a technology leader. Google’s mission is to organize the world’s information and make it universally accessible and useful. In terms of the theory of deferred action, Google’s organisation has the three deferred action dimensions of knowledge. Google has an IT infrastructure (planned action) that is ‘built to build’, providing the flexibility needed in emergent context. This infrastructure is designed to enable further building by expan-
The Theory of Deferred Action

The Theory of Deferred Action

Deferred Design

A deferred system contains design uncertainty and cannot be completely pre-specified because of emergence - the rich human and organizational context in which it functions. Operational needs emerge in this context. Deferred systems contain specifiable and non-specifiable operational design. Systems functionality cannot be completely pre-defined because of emergence. Deferred systems are significant for modern organizations exposed to constant change.

A deferred system is characterised by high emergence, high level of deferred action, and low capacity to plan system functionality and information needs centrally. The operational functionality of a deferred system is a function of its environment. Its form is not predetermined but evolves in response to emergent factors. It exhibits emergent functionality that is not pre-specified (planned) but arises from the intentions of individuals or groups who interact with it in context. Therefore, a deferred system is deferred until the

<table>
<thead>
<tr>
<th>Construct</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned action</td>
<td>Rational planning is necessary for effective and efficient organisation to build enduring structures and processes that result in some quality product or service for consumption.</td>
</tr>
<tr>
<td>Emergence</td>
<td>Emergence creates emergent situations or locale. It makes situations unpredictable. Emergence affects KMS design. Emergence requires KMS design and organisation design to be continuous.</td>
</tr>
<tr>
<td>Deferred action</td>
<td>Deferred action is the synthesis of planned action and emergence. Deferred action takes place within planned action in emergent locale.</td>
</tr>
</tbody>
</table>

The synthesis of these constructs results in four system types: deferred systems (point A), specified systems (point B), autonomous systems (point C), and real systems (point D) in Figure 1. These types can also be generic design types and organisation types.

The theory contains other theoretical categories summarised in Table 2. These terms arise from application of the theory to the use of IT in business organisations to manage data, information and knowledge. The diffused management category in the table is the logical consequence of emergent organisation. Since emergence is organisation-wide its management in relation to knowledge needs to be diffused in the organisation as in Google’s case. The result of the synthesis of the dimensions of knowledge and the categories is the production of informational and knowledge IT artefacts.

**GENERIC DEFERRED ACTION DESIGN TYPES**

Based on the synthesis of planned action and emergence, organisational action can be mapped in terms of four generic design types: specified design, real design, deferred design and autonomous design depicted in Figure 3 (also explained in Table 1). Each quadrant names the generic design type, gives example of type of knowledge management best suited for that design type, names the type of organisation and system design, and names the type of work best suited for the design type.

Table 1. Deferred action dimensions of knowledge

<table>
<thead>
<tr>
<th>Construct</th>
<th>Description</th>
</tr>
</thead>
<tbody>
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Deferred Design

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A deferred system is characterised by high emergence, high level of deferred action, and low capacity to plan system functionality and information needs centrally. The operational functionality of a deferred system is a function of its environment. Its form is not predetermined but evolves in response to emergent factors. It exhibits emergent functionality that is not pre-specified (planned) but arises from the intentions of individuals or groups who interact with it in context. Therefore, a deferred system is deferred until the
The Theory of Deferred Action

Table 2. Categories from applying deferred action to IT

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human (behaviour)</td>
<td>Humans use IS and KMS in context. (They are distinguished from professional IS developers but in a sense they design the systems).</td>
</tr>
<tr>
<td>Organisation design</td>
<td>Organisation is composed of people, structure, processes, IS and KMS. Organisation is emergent. Organising is normal.</td>
</tr>
<tr>
<td>IT artefact</td>
<td>IT artefact is any information or knowledge artefact created with the use of information technology. IS and KMS design depends on people, organisation, and emergence. IS and KMS design requires deferred action.</td>
</tr>
<tr>
<td>IS and KMS design</td>
<td>IS and KMS design depends on people, organisation, and emergence. IS and KMS design is affected by emergence. IS and KMS design requires deferred action.</td>
</tr>
<tr>
<td>Diffused management</td>
<td>Diffused management of local situations is necessary because of emergence. It caters for self-organisation and adaptive behaviour. Centralised management of local situations is ineffective in emergent organisation.</td>
</tr>
</tbody>
</table>

Figure 3. Deferred action taxonomy

actor decides what the system will become. The actors design decisions are taken through the operational principle of deferred design decisions. An operational principle is ‘any technique or frame of reference about a class of artifacts or its characteristics that facilitates creation, manipulation and modification of artifactual forms’ (Dasgupta, 1996; Purao, 2002).

The dominant property of deferred system is emergence which requires the use of deferred design decisions principle. A deferred system is deferred until active designers (actors) decide what it becomes in actuality. Deferred systems are co-designed by reflective designers (professional designers) and active designers (actors). Reflective designers make structural time-specific design decisions and active designers make design decisions that are influenced by emergence. They decide the operational functionality as revealed by emergence. Deferred design is not constrained by prior design decisions of reflective designers. Active designers make design decisions in pursuit
of objectives and come to own systems. Deferred decisions happen in context in the situation where they are imperative and necessary. Table 3 lists properties of exemplar deferred systems.

Ontologically, data, information and knowledge in deferred systems are tailorable. Data structures and data processing algorithms used to produce information can be tailored to suite particular emergent organisational situations. Deferred systems are suitable for design domains where specification of operational functionality is ineffective and complete requirements gathering is not possible because of emergence. An example is a knowledge management system to support innovation.

**Real Design**

Real systems are co-designed in real-time by reflective designers (professional designers) and active designers (actors). Reflective and active designers’ design decisions are effective in real-time. Real systems architecture and functionality is not pre-determined design but designed during use in actuality. (This may be required in deferred systems too, but it is not necessary.) Active designers determine design of real-time deferred structure and details of operational functionality. Deferred architectural form and operational functionality is shaped in real-time in context by active designers’ deferred design decisions. Such decisions determine much of the operational system architecture.

A real system is enacted in the situation by active developers with the overall objectives set as plans by reflective developers. It acknowledges high emergence, high level of deferred action, and high need to plan. Its overall design is planned to achieve specific objectives but active developers determine the details of these.

Active designers enact a real system. It is not used as a delivered product like other systems types. They come to own the system. Real systems exhibit high emergence, deferred action, and importance of central planning and local action. Therefore they contain much structural and operational design ambiguity. Structure and operational functionality are minimally designed.

<table>
<thead>
<tr>
<th>Deferred System Properties</th>
<th>Spreadsheet</th>
<th>World Wide Web</th>
<th>eXtensible Mark-up Language (XML)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reflective Developer</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>System-System Environment Interface (S-SEI)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Deferred Design Decisions (DDD)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Action Developer</td>
<td></td>
<td>✓ (Partially, if trained (Extradaferment))</td>
<td>✓ (Intradaferment)</td>
</tr>
<tr>
<td>Tailoring Tools (Tools)</td>
<td>✓ (micro-Ttools)</td>
<td>✓ (micro-Ttools &amp; Meso-tailoring)</td>
<td>✓ (meso-Ttools)</td>
</tr>
<tr>
<td>Non-SDLC Developed</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

The Theory of Deferred Action

because they are enacted, rather than placed, in context. Real systems take shape, form and change by deferred action.

Systems architecture is divided into specified structure and deferred structure. Like building construction design process, deferment of structure is possible in real design. The architecture of real systems emerges. Requirements for deferment structure can be determined by specification. Structure too does not have to be specified it can be deferred. Reflective designers design specified structure. Specification design is to achieve specific objectives as planned action. Reflective designers cannot predict all the structural form and no operational form because of emergence. The capability to design for real-time by specification is minimal in emergent organisation.

The dominant property of real systems is emergence requiring the principle of real design decisions. Real systems are enactive. Active designers enact real systems during action. Reflective and active designers jointly make structural and functional design decisions. Reflective designers make initial structural design decisions based on requirements specification. When the system is live active designers make structural and operational functionality design decisions by deferment design in real-time.

Real systems data, information and knowledge ontology is similar to deferred systems. It differs because it emerges and it is determined and implemented in real-time. Design issue in real design decision is the same as in deferred design. The difference is that real design decisions need to be implemented in systems in real-time, using technology that delivers real-time data, information and knowledge. The same design principle as for deferred systems applies to reflect deferred action in formal systems design.

Real systems are suitable for design domains where specification of real-time structure and operations is not possible, where they emerge and need to be realised in context in real-time. So they require deferred action. An example is ‘computing on-the-edge of network’ military systems and aspects of learning systems. Real systems are of interest to military organizations, educationalists and companies. Modern theatre of war poses new problems for military strategists to achieve objectives because strategy alone cannot account for the actual field of operation. Central planning becomes redundant in actual contexts because of unknown variables and emergent situations. Understanding interrelations among specification design, emergence, and deferred action and deferred design can provide a framework for designing appropriate action to achieve aims.

Specified Design

A specified system is designed and shaped prior to operation in actuality. It is assigned artificially to design domains by reflective designers. Complete design knowledge is assumed. Specified systems admit no emergence and assume high capability for specification design. So systems architecture and operational functionality is specified with specification formalism. Operational functionality is assumed to be knowable, specifiable by ‘users’ prior to use and assumption of stable systems ‘environment’ is made. The dominant property of specified systems is predetermined structure and functions resulting in the dominant design principle of specified design decision.

Specified systems are imposed. Reflective designers are exclusive designers. Design is based on specification of information and knowledge needs ‘captured’ from potential ‘users’. Such design requires complete ‘requirements gathering’, ‘specification’ and ‘engineering’ by reflective designers. Specification formalism is used to develop elaborate systems models to represent reflective designers. Formal specification details systems architecture and operational functionality. Reflective designers then design systems models and implement them. Such designing is presumed capable using information systems development methodology or other practice conforming to SDLC main phases.
A specified system has predefined functionality designed into it by reflective developers who ‘capture’ requirements from potential users. Systems strategists and system designers assume that system functionality is knowable and the system environment is stable. Consequently, specified systems admit low emergence and low deferred action, and assume high capacity for system planning. Specified systems are suitable for application domains that are unambiguous and completely specifiable, and do not require deferred action. They assume perfect knowledge, stable system functionality and system environment. Early applications of IT to business were of this type, and most strategic system planning is in this quadrant.

Reflective designers only make specified design decisions. Only they can design systems. Design of large-scale software particularly relies on specified design and is termed ‘software engineering’. Reflective designers make all the design decisions in metaphorical ‘clean rooms’ detached from experiences of ‘users’ and actual context of use. The design issue is how to determine formal systems specification for reflective designers’ use to code systems.

Business workers simply use designed systems. Deferred action necessary for contextual information needs from systems is constrained by prior reflective designers’ specified design decisions, which explains research that finds systems are not used or tend to disappoint. Changes required to systems to make them relevant to context are relayed and managed by reflective designers as ‘change control’.

Ontologically, data, information and knowledge are objects existing independently. They are knowable, determinable, stable, fixed and independent of ‘developers’ and ‘users’. Specified design decisions are based on ontology of information as mechanical artefact (Shannon, 1948). Specified systems do not admit meaning attribution to information.

Specified systems are suitable for completely specifiable, certain and unequivocal design domains. Emergence is not present. So, they do not require deferred action. Early applications of computers to business were of this type, and most strategic system planning is done as specified design.

**Autonomous Design**

An autonomous system makes use of intelligent software to redefine system design choices for users. The autonomous agent is the autonomous software. Emergence is not explicitly acknowledged in autonomous systems design. Two types of autonomous systems can be distinguished based on control given to ‘users’. Reflective designers predefine systems functionality embedded in intelligent agents enabled to make design decisions autonomously and independently of business workers and reflective designers. Some designs are based on formalism derived from the situated action thesis. Intelligence inside machines is dominant design principle. Presently they admit low emergence, low capacity for specification design and low deferred action. There are no real examples of such systems, but researchers and designers are exploring multi-agent systems for many organizational processes. Autonomous systems have potential as aspects of other generic design types in organized action not as a separate entity.

The other type is context scenarios or patterns used to suggest design solutions to ‘users’ during system use. Autonomous systems suggest embedded predetermined design choices. Design choices are predefined scenarios created by reflective designers, and active designers only have choice to accept or reject context-sensitive design offered. Design choices are inferred from observed user behaviour actions. Context scenarios are akin to business best practice. Context scenarios and patterns are distinct from actual contexts that
deferred systems and real systems active designers encounter.

Reflective designers determine predefined systems functionality in autonomous systems, which may be based on requirements specified by ‘users’. Operative design principle is autonomy in context. System effectiveness is improved through autonomous design decisions.

Ontology of data, information and knowledge is objective and specified. It is predetermined and does not permit tailoring. Character of knowledge in expert systems is explicit and declarative knowledge. In general, artificial intelligence systems characterise knowledge as explicit knowledge, fixed and knowable. Data and information are similarly characterised. At present, scope for emergent information is theoretical in multi-agent systems.

The autonomous designer is the intelligent agent embedded in autonomous systems, who makes or recommends autonomous design decisions based on pre-determined context. ‘The autonomous designer is the artificial intelligence embedded in a system.’ (Patel, 2003: 5) Autonomous designer is enabled by reflective designers to recommend design decisions to ‘users’, for example in office applications. In more sophisticated example, multiple agents collaborate to determine design decisions. They determine what operational functionality or service to perform in situations.

Autonomous systems are suitable for completely knowable and predictable design domains. In the Internet, a completely knowable routing policy is determined for a collection of IP networks and routers and placed under the control of one entity (or sometimes more) making an autonomous system. A prime facet of autonomous systems is artificial machine intelligence. Autonomous systems are the physical embodiment of machine intelligence.

Different levels of synthesis of planned action and emergence result in these four design types for normal organisation and emergent organisation. The design types are generic and equally applicable to designing organisations and information systems. Rational strategy formulation, central planning, and information systems development methodologies are examples of specified design. Emergent strategy formulation and sustainable business and education are examples of deferred and real design. Technologically enabled battle-field action and civil air traffic control are examples of real design.

Invoking systems theory, the taxonomy is further analysed into open information systems and closed information systems (depicted in Figure 3 by the horizontal line). Open systems of information are deferred and real information systems because their boundaries are open and variable. These tend to be self-organising systems that require complex adaptive behaviour undertaken by local actors. Crucially, they are evolving information systems and knowledge bases. An example is the World Wide Web and in knowledge management similar to the joint UK, Australian and New Zealand governments’ effort to construct a knowledge base for teaching and research. (e-framework, 2008). Closed systems of information and knowledge are specified and autonomous because their boundaries are closed and fixed. Changes to such systems require re-design and re-engineering centrally. Most organisational information systems are closed systems.

The deferred action analysis is applicable to any design problem in which humans are an integral part of the designed artefact. Humans and information technology are in symbiotic relationship. Many such design problems are necessarily open systems because organised action occurs in the political, economic and social environment that is subject to emergence.

**PROPERTIES OF EMERGENT ARTEFACTS**

Structure, Emergence, Space and Time (SEST) are a set of design constructs applicable for de-
signing artefacts that are affected by emergence. SEST are attributes of rational design conducive to actuality. A construct in social science refers to an idea that is invented for specific research or theory-building. Constructs are built from other concepts. Normally, the construct is not directly subject to observation but is deduced from relevant empirical observation. These constructs were created to inform the design of information systems in emergent organization.

An organisation has a structure (hierarchical, flat, network). The unplanned and unexpected events are emergent aspects. The space is the locale in which action takes place. The period over which the action takes place is the time.

The World Wide Web has a dual structure. It is mounted on the Internet and so limited by the structure of the Internet. But it has its content structure which is very complex. The physical structure of the Internet does emerge as more nodes are added, but the content structure is highly emergent. The geographical space covered by the Internet nodes is the space property and the period of time the Web exists is the time property. Similarly, an ERP system has a physical structure its architecture. It is located in the organisational space of a company and operates over time from the time of its inception. Although its functionality is largely pre-specified, aspects of emergent organisation require enhancement to the functionality over the life of the organisation.

Complex adaptive systems can also be characterised as possessing the SEST properties. An ecosystem has the structure of trees, species of birds and mammals, insects and fauna, which compose the structural elements of the system. The emergent property of an ecosystem is the new structure or order resulting from some change like extinction of an animal or plant species, or possibly deforestation, in the system. The geographical area that the ecosystem covers is the space property and the period of time over which the ecosystem exists or changes is the time property.

Environment is the significant factor affecting the system. The SEST properties are determined in the context of the environment. By gaining knowledge of the environment the system adapts itself. Knowledge is an important determinant of the structure and functions of the system.

DEVELOPING DEFERRED SYSTEMS

Deferred system is the deferred information system and deferred system design is the process for developing a deferred system continuously. The development of a deferred system requires a continuous development process. This is termed the deferred systems design process (DSDp). The development process is necessarily continuous because of the emergence effect. The continuous development process is composed of two types of systems design decisions.

Specified design decisions and deferred design decisions are two types of design decisions stemming from normal organisation (predictable) and emergent organisation (unpredictable) respectively. The pre-determined knowable architecture and functions of the system can be specified and these are specified design decisions. These decisions occur at a specific point in time. These are the predictable aspects of the deferred system. The need for new information in new organisational situations is catered for by deferred design decisions. Actors take the deferred decisions in particular organisational situations. These decisions occur over time.

A deferred system is a model driven architecture and it is modelled as an active model. An active model maintains a synchronised link with the domain of the application (Warboys, et al., 1999). They are models of information systems that are linked and synchronised with actuality. The active model enables deferred design decisions.

The architecture and functions of deferred systems should be capable of adapting and, as Tim
Berners-Lee (1999) states for the Web, there should be no single point of failure. The basis of adaption is systemic deferment point analysis in which deferment points are determined. A deferment point is the juncture at which purposeful human action that is formalised in some sense encounters actuality. A formally designed decision support system meets a deferment point when it fails to provide information that decision makers require. The shortcoming is usually the consequence of pre-programmed rigid data processing algorithms. It is the systemic equivalent of deferred action that arises when purposeful human action encounters emergence (Patel, 2005).

In terms of the deferred action analysis, ERP systems are designed and developed as specified systems. However, they are better conceived as deferred systems. Admittedly, in a manufacturing organisation much of the processes and operations can be pre-determined and specified to develop known system functionality. As noted earlier, there are however unknown events that give rise to emergent processes which cannot be pre-specified. For such reasons ERP systems are better modelled as deferred systems (with elements of specified systems).

**APPLICATIONS OF DEFERRED ACTION BASED DESIGN**

The theory of deferred action and the principle of deferred design decisions are used and applied by researchers in research systems and applied business systems. Various types of knowledge work benefit from the deferred analysis including legal arbitration and organisational learning. This work tends to be of the semi-structured problem type. Two exemplars are given. Both these systems are in the domain of knowledge management.

**E-Arbitration-T System**

Elliman and Eatock (2005) developed the online E-Arbitration-T system capable of handling workflow for any legal arbitration case, thus meeting the emergence criteria. The project aimed to develop an online system for European SMEs seeking fair dispute resolution in an international forum. The system would be used by many different organizations offering arbitration services but the cost of adapting E-Arbitration-T to local priorities, including emergent factors, had to be kept low as some organizations had low case loads making high cost unjustifiable. Elliman and Eatock applied the deferred analysis, particularly the

**Table 4. Deferred technology implementations**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deferred-action-list; deferred-action function</td>
<td>Used in emacs-development.</td>
</tr>
<tr>
<td>Deferred Execution Custom Actions</td>
<td>Used in scripts for Windows installer.</td>
</tr>
<tr>
<td>Deferred Procedure Calls</td>
<td>Microsoft uses DPCs to manage hardware interrupts At micro-processor level: Microsoft’s response to this problem is to use Deferred Procedure Calls (DPCs). <a href="http://www.nematron.com/HyperKernel/index.shtml">http://www.nematron.com/HyperKernel/index.shtml</a></td>
</tr>
<tr>
<td>Client side deferred action with multiple MAPI profiles</td>
<td>This is a patent at: <a href="http://www.patentalert.com/docs/000/Z00002860.shtml">http://www.patentalert.com/docs/000/Z00002860.shtml</a></td>
</tr>
<tr>
<td>Java deferred classes</td>
<td>Used in the Java computer programming language.</td>
</tr>
</tbody>
</table>
deferred design decisions principle, to manage the open and changing system requirements, making their system an open system. This enabled users to make design choices rather than the system developer.

**CoFIND System**

The deferred action construct is reflected in deferred learning systems. Dron (2005) invokes deferred systems to design systems that have ‘emergent structure’, allowing the system to have changing functionality. He developed a self-organised e-learning web-based system called CoFIND. Self-organisation in CoFIND results in emergent structure which the system needs to reflect. It is not designed from requirements but takes shape in response to the actions of the people that use it.

**EXPLAINING SYSTEMS PRACTICE AS DEFERRED ACTION**

More generally, the theory can be applied to explain the invention of much deferred technology shown in Table 4. These independent inventions serve to cater for emergence in digital applications of information and communications technologies. It is because fixed technological functions are inadequate in emergent situations that the deferred technology is invented. The function of the deferred technology takes form in actual contexts, contexts which could not be pre-determined by designers and developers.

**Open Source Software as Deferred Systems**

Open source software is well explained by the theory of deferred action. Open source software is a complex adaptive system that is a deferred system. It has a planning core that determines the direction in which open source software will develop. This is the planned action element of the system. But the actual problems addressed by open source software are determined locally (emergence) by individual software coders (deferred action). This is the emergent aspect of the system. The Linux operating system is an exemplar.

Extant information systems and information technology can be mapped in terms of the four design types, shown in Table 5.

**FUTURE DEVELOPMENTS OF THE THEORY**

Deeper empirical investigation of the effect of emergence on the rational design of organisations and its information systems is planned. The purpose of the empirical work is manifold. It is necessary to collect data on aspects of the theory that are still tentative such as determining deferment points and converting them into systemic deferment points. There is also a need to

**Table 5. Classification of extant systems in terms of deferred action**

<table>
<thead>
<tr>
<th>Deferred System</th>
<th>Real System</th>
<th>Autonomous System</th>
<th>Specified Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Wide Web</td>
<td>Internet</td>
<td>Intelligent agents</td>
<td>Payroll</td>
</tr>
<tr>
<td>CoFIND</td>
<td>Semantic Web</td>
<td></td>
<td>Sales</td>
</tr>
<tr>
<td>ViPre</td>
<td>Air traffic control</td>
<td></td>
<td>Product databases</td>
</tr>
<tr>
<td>Dallas Capital</td>
<td>Modern military systems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Theory of Deferred Action

better define the operational principle of deferred design decisions supported with empirical data, which would provide better scientific basis for the principle. The other purpose is to generate new theoretical constructs from the data to improve our understanding of how complexity can be catered for in rational design.

The empirical data will also support further research into developing a design complexity scale for information systems. What is the design complexity of a proposed information systems project and what is the design complexity of the information systems itself? What is its intrinsic complexity? Such questions can be addressed with a design complexity scale based on empirical data.

Measuring complexity is a critical issue in rational design. Empirical data will enable consideration of items of measure, such as count number of data types and data items, number of data retrievals from database, or number of interactions by users with the information systems. Some measure of complexity is necessary to do rational design properly. It is not the intention to measure complexity per se, as this is theoretically not possible. The purpose is the define measures of complexity suitable for rational design of information systems. In physics, a complex system is measured as the length of the description of the system. In general, a system is more complex if the length of its description is longer.

CONCLUSION

This chapter has addressed how to design rationally information systems for emergent organisation. Complexity and emergence are new design problem that constrains rational design. The Theory of Deferred Action is proposed to reconcile rationalism and emergence in information systems design and development. The theory is a synthesis of rationalism and emergence producing the deferred action design construct. Theories on designing for normal organisation exist but most of them are borrowed from reference disciplines. The Theory of Deferred Action is based in the information systems discipline and is presented as a theory to inform practice to improve the rational design of information systems for emergent organisation. As emergence is a core feature of complexity, complexity theory was invoked as a base theory for developing the Theory of Deferred Action as a design theory. The Theory of Deferred Action explains the effect of emergence on the rational design of information systems. As a theory to inform practice it provides guidance on how to design rationally information systems for emergent organisation.

The theory has the potential to be applied to any kind of artificial systems designed by humans in which humans are an integral design element. This includes cities, organisations, information systems, and knowledge management systems among others. It is a general theory for the artificial sciences where the system to be designed interacts with humans and the interaction causes the system to be re-designed by actors in the context of the interaction.

Theoretical physicists and experimental physicists both have exalted places in physics. Theories generated by theoretical physicists inform the experiments that experimental physicist set up. Data produced by experimental physicists lead theoretical physicists to support their theories or revise them. If we are to improve the discipline of information systems then the same should happen in our discipline. The status of theoretical researchers of information systems should be acknowledged and valued.

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methodology (N. Cross ed.) (pp. 135-144). New York: Wiley.


KEY TERMS AND DEFINITIONS

Action Designer: Action designer is someone engaged in organised action, needs scope to design within bounds of specified design of formal organization or system design. Has knowledge of actual action, determines design in actual space and time. They come to know and have procedural knowledge, which is stronger than declarative knowledge.

Actuality: The domain of empirical. Present time.

Autonomous Design: Design capability afforded to intelligent machines by reflective designers that becomes autonomous of humans.

Autonomous Design Decisions: Design decision made by intelligent agents or systems.

Autonomous Designer: Intelligent agents or systems.

Autonomous System: Systems behaving independently of its human reflective designers.

Deferred Action: Deferred action is concerned with enabling actual action as interrelation design within formal design. It is synthesis of planned action and actual (deferred) action.

Deferred Design: Deferred design is design by action designers within formal design to cope with unknowable emergence, space and time, ‘equivocal reality’.

Deferred Design Decisions: Design decisions enabled by reflective designers but made by action designers in context.
Deferred Organization: Structure designed by reflective designers whose actual operations take shape in context through behaviours determined by action designers.

Deferred System: Systems architecture designed by reflective designers whose actual operational functionality takes shape in context through behaviours determined by action designers.

Design Domain: The planned action notion of an actual organizational problem demarcated for systems design by specification.

Emergence: A term to describe unknowable and unpredictable social action in all its multifarious aspects. Philosophically, it is instrumental in determining being.

Emergent Organization: Social action that is organised but subject to emergence.

Enacting: Enacting is the act of putting design in social action with interrelations design capable of real-time structural and operational functionality design. Enacting enables action designers to make design decisions in response to Complete SEST.


Formalism: Prescribed methods containing precise symbols and rules for creating structural forms to achieve set objectives.

Individual Deferment Points: Junctures in purposeful action within existing formal structures where next steps are indeterminate.

Natural Design: The conscious and unconscious determination of objectives and action leading to its achievement by conscious or unconscious determination of structure and responses to emergence in actual space and time.

Off-Design: In terms of SEST structure is designable by specification. Off-design is the emergent, spatial, temporal aspects of organized action that cannot be specified for design. Off-design is the universal set of natural design. Some structural properties of action cannot be specified either.

Organization: Determination of goal-directed actions leading to structural forms whose actual form is the result of responses to degrees of emergence.

Organizational Deferment Points: Junctures in purposeful organised action within existing formal structures where next steps are indeterminate.

Planned Action: Planned action is prescribed action enacted by design regardless of actuality.

Problem Space: Metamorphic space where human concern is progressively systematised and formalised to derive a solution.

Rational Design: Rational design is conscious event at some point in organized social action to determine the future. It is abstract design because the design objects are some orders removed from actuality.

Real Design: Design of structures and operations by rational design for enactment in emergent actuality and responsive to it in real-time.

Real Design Decisions: Real-time design decisions by action designers in response to emergent events in actuality.

Real Organization: Organizational structure and operations designed and enacted in emergent actuality and in real-time.

Real Systems: Systems architecture and operations designed and enacted in emergent actuality and in real-time.

Reflective Designer: Designers of structural forms containing deferment mechanisms for de-
ferred operational design. Teams of professional organization and systems designers.

**SEST:** The attributes of rational design conducive to actuality.

**Situated Action:** Action that is rich in phenomenological attribution.

**Specification Formalism:** Prescribed methods for creating structural forms and operational detail to achieve set objectives.

**Specified Design:** Design by reflective designers from specification obtained from users.

**Specified Design Decisions:** Design decisions by reflective designers separated spatially and temporally from actuality.

**Specified Organization:** Organizational structure and operations designed by reflective designers for business workers.

**Specified System:** Systems architecture and operations designed by reflective designers for business workers.

**Systemic Deferment Points:** Junctures within existing formal systems where operational design (and for real systems structural design) are deferred to action designers.

**Systemic Deferred Objects:** Representation of real things in systems by deferred design.

**Systems Deferment Point Analysis:** Technique to determine structural and operational design deferrable to action designers.

**Technological Deferment Points:** Junctures within technology where operational design (and for real technology structural design) are deferred to action designers.