On the Nature of Inter-Organisational Information Systems and the Issue of Adaptability

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Abstract

There is sound evidence that the tempo of change in the business world is increasing at an exponential level. Information Systems (IS) as a consequence, are targets of this change and it can be argued that business IS for the '90s and beyond will be judged against not static but highly dynamic goals. They should therefore, be in a sense 'living systems' and offer a level of adaptability. With the environment getting increasingly complex and with Inter-Organisational Information Systems (IOS) on the rise - where the IS is not confined anymore within the context that is defined by a single organisation but spans across many boundaries - this will be a significant issue. Utilising concepts from systems theory, this paper considers the issue of adaptability through a number of questions in an attempt to conceptualise the nature that such systems must exhibit if they are to be successful.

1. Introduction

There is no doubt that the organisations of today are operating in socio-economic environments characterised by dynamism and increased turbulence. As we are progressing into the second half of the 90s, it becomes clear that this instability will continue and the continuum of change as inferred upon the organisation, can affect many of its parts by being evolutionary and/or revolutionary. The organisational ability to cope and adapt to the new operational parameters that this change imposes, has now become a matter of corporate survival. Information systems are at the same time models and subsystems of the business organisation and it can be argued that the dependence of the organisation on their ability to 'safeguard' the core processes and enhance the core capabilities is almost total.

It is unfortunate however, that the approaches and paradigms that characterise Information Systems Development (ISD) today, fall victims of the 'freezing factor' [8] and the mock '*Fixed-Point Theorem*' [15] which both illustrate the fact that although business are dynamic entities that operate through a time continuum, in most cases their information systems are static and largely inflexible to change. Unpredictable change can have devastating effects on the organisational information system due to this inflexibility in following any changes in the business case [11].

The paradigm for the next generation of information systems is said to involve large numbers of systems distributed over large and complex computer/communication networks. This fact prompts us to ask the following question: "If the organisational information system can be so vulnerable and fall victim to an unpredictable and externally induced change, what would happen to a large inter-organisational system when the disrupting effects may be propagated throughout the whole infrastructure in a 'domino-effect' manner?"

It is fairly obvious, we believe, to point out that inter-organisational systems will unavoidably materialise through the employment of various information and communication technologies. We should however, underline one very important fact. The last decade has provided us with a plethora of cases where the indiscriminate computerisation of business information systems, led by a blind faith in information technology (IT), has produced disappointing and often catastrophic results. As Ian Angell [18] noted:

"..organizations are now at the end of that stage of development when in a feeding frenzy, they have bloated themselves in information technology. In the future, they must be more careful in their choice of IT diet. Without coherent ways of thinking about the place of IS in respect of

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the perpetual changes around them, companies can no longer place their faith in technological solutions" [18].

The above set question can therefore double as a warning for undesirable effects that occur when the *how* materialises at the expense of *what*. In the wake of inter-organisational systems, such mistakes should be avoided. Their high cost because of their size, would almost definitely prohibit a 'second chance'. A clear picture of 'what' is required, and this must be formed before we proceed to build such systems.

We begin by offering a definition for inter-organisational IS. A discussion on ISD, and what we perceive to be fallacious is followed by our assumption that what is needed are flexible information systems that can adapt to both evolutionary and revolutionary changes, and could offer a perfect match with successful organisation descriptors such as flexible structures. The final section utilises concepts from systems theory as a means of considering a number of questions that could help us to visualise the nature of such systems. As this paper addresses a knowledgeable audience, and as time and space have been limiting, we have avoided wherever possible detailed descriptions of systems theory concepts. Some familiarity with such concepts is assumed.

2. Defining Inter-Organisational Information Systems

The plethora of available information systems definitions, for example Management Information Systems (MIS), Business Information Systems (BIS), Decision Support Systems (DSS), etc., and the concepts they are trying to project, can be undoubtedly confusing and at the same time a basis for argument [5]. This is primarily due to the fact that even when two observers experience the same phenomena, they may conceptualise them into different systems and environments, assigning disparate meanings. This is particularly true in information systems research where the 'boundary' of the phenomenon observed is inherently 'soft'.

Another confusing factor that becomes apparent, is the fact that the term 'information systems' is linked in most people's minds inexorably with computers. This link is understandable as the vast majority of the current literature is concerned almost exclusively with computer based systems, or fails to explicitly make the distinction between information systems and computer-based information systems. For the purpose of this paper, and in order to delineate and underline the fact that the technical aspects of computers have added a whole new set of problems to the development of information systems, we define an Inter-Organisational Information System (IOS) as

the infrastructure which constitutes of a large number of application and/or organisation-wide information systems, spans over at least two organisations, and is designed to inform. It consists of data, people, and links between the two, where the links comprise of paths along which data is transported, and the processes which transform it into information.

Information can be defined as meta-data, a tangible or intangible entity with the purpose of reducing uncertainty about some future state or event. *Technology* is conceptualised as a set of functional subsystems of the IOS, including for example the database, operating and communication systems. Accordingly, *information systems failure* is a breakdown that occurs anywhere in the infrastructure. *Information technology failure* refers to the inability of technology that fails to support the envisaged IOS for whatever reason.

In the context of this paper, 'Information Systems' will be used as a generic term encompassing all those systems that are used by human beings in organisations, with the purpose of assisting them in improving their performance. Consequently, 'Inter-organisational Information Systems' should not be perceived as a distinct term but should be conceptualised as a subsystem of 'Information Systems'. The term '*Living Information Systems*' (LIS) is utilised so as to explicitly underline the property of adaptability that information systems serving organisations should exhibit, irrespective of their type.

3. 'Frozen' Information Systems Development for 'Living' Organisations

While both closed and open systems exist in the real world, the organisation which the IOS will serve is open and dynamic in the sense that it has an environment with which it interacts. Changes in one or more of the environment's structural and utilitarian properties must initiate a response, and be accommodated by appropriate organisational changes. Accordingly, the importance of organisational change for information systems cannot be overemphasised. Ignoring this factor, or inadequately preparing for it, is a recipe for failure.

Information Systems Development refers to the analysis, design, technical implementation (construction), organisational implementation (institutionalisation) and subsequent evolution (enhancement maintenance) of information systems. Some hindsight as to how the practices employed in ISD, and in particular the role of design within this framework which currently results in most, if not all information systems being a disappointment, is clearly needed. In his report on Fourth Generation Languages, Grindley [8], identifies amongst many others the '*Freezing Factor*' as being responsible for the current state of affairs in total integrated systems development. He notes that because of the systems' complexity and interdependencies, it is extremely difficult

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to change the design once programming has commenced.

As a direct result, system requirements have to be defined as accurately as possible beforehand, and also in one go so that all likely future demands can be catered for in the design. The consequence is that an 'artificial freeze' has to be imposed on the 'getting agreement' exercise after a while, "...partly to enable a start to be made, but mainly to ensure that no new requirements are introduced while project development is under way" [8]. This freeze results in systems that are built for one (hypothetical) point in time - a fallacy - as they must work over some time continuum.

The implication of the above in leading to a variety of false paradigms for ISD is amply demonstrated by Paul's [15] mock Fixed-Point Theorem which states that

There exists some point in time when everyone involved in the system knows what they want and agrees with everyone else [15].

Because of our attempts to build a system to an exact specification, the theorem is assumed to be true. There is no theoretical or empirical proof, however, that the theorem is true. In contrast, a look into case studies of information system failures could reveal numerous counter-examples. The extension to the theorem is that the fixed point remains fixed for the project duration or even longer. As there is no proof that the theorem is true, it is inferred that the extension cannot be true either. Building information systems with the implicit, or sometimes even explicit assumption that the theorem is true, is guaranteed to cause problems [15].

In order to conceptualise how information systems can fail due to the inability to adapt to unforeseen change, consider the notion of 'identity' and any subsequent loss of it [12]. [20] notes that IBM is not the same as it used to be. "Once a supremely powerful, confident, [and] complacent organisation, it is now undergoing uncertainty and downsizing. It has lost its 'identity'" (ibid.). Has IBM survived? In one sense, it has not! An organisation therefore survives just as long as it maintains its identity. The same is true for IS. From the moment a decision is made to put a formal IS in place, an identity is imposed upon it by stating the characteristics that it should have, which are then translated into a requirements definition. Current design approaches strive to maintain this identity, and although may allow for iteration and evolution in the design process, *fail* to allow for any shifts in the business case. IS do inhabit a time continuum from their inception to their final demise (intentional or otherwise), and any notion of failure should be tried and explained within this time parameter as it can occur at any point and can take any form.

Addressing this, we argue that an IS is said to have disappointed when (a) the system no longer meets its specific design objectives (*internal failure*), or (b) the system objectives no longer meet the information needs (*misfit failure*) [3]. These two types of failure are not mutually exclusive, but a direct relationship exists with the dependent variable of change in its core [12]. Change is perceived here as an element that has a destabilising effect on a system that has no adequate response for it. IS as organisational models are constantly required to meet the information needs of an organisation operating in a dynamic mode. The inability to do so results in misfit failure. As the information needs dictate the system objectives - if the system is built to an exact 'identity' specification as a result of a requirements 'freeze' at a certain point in time - the unavoidable inability to meet them as they will with no doubt change, results in internal failure. Hence, the system eventually dies.

If the barometer we are seeking for information systems failure is to be effective, it should be sensitive enough to pick out the slightest change that can be considered an aberration contributing to system performance [7]. This has an even more serious implication on organisational performance, as a 'dead' information system will be a malfunctioning cog within the IOS infrastructure. If one wishes to take this one step further, one could argue that as information systems are closely interrelated and interdependent with all the other organisation components like tasks, structure, people and culture, a change in one will affect all the others, leading ultimately to organisational incompetence within the environment that is operating.

Change and our inability to provide for it by persistently adhering to a Fixed-Point Theorem mentality in developing IS, has inadvertedly led to a variety of false paradigms with the consequent creation of static systems which are designed to meet the needs of the business at one point in time. In retrospect, the concept of 'lost identity' implies a paradigm shift in ISD where the systems designer will no longer be required to foresee every contingency or articulate every requirement of a design. IS will not be given a pre-determined identity but rather they will be developing this themselves, having been brought in existence as infants with the ability to grow and adapt, rather than as 'set-in-their-views' adults.

4. A Primer on 'Adaptability'

The concept of adaptation from systems theory, can aid in helping us to break away from this false mentality in developing information systems, by conceptualising on the property that they should exhibit - adaptability. Systems can be classified into 'reactive', 'responsive' and 'autonomous' based on considerations of what brings about changes in them. A system's *reaction* is a system event that is deterministically caused by another event that occurs to the same system or its environment, whereas a *response* of a system is an event for which another event is necessary *but not* sufficient. An *act* of a system is a system event for the occurrence of which no change in the system's environment is *either* necessary or sufficient. These system events determine the *behaviour* of the

system and have both antecedents and consequences.

A *state-maintaining system* is one that (a) can *react* in only one way to any one internal or external event but (b) it reacts differently to different internal or external events, and (c) these different reactions produce the same internal or external outcome. '*State'* refers to the values of set properties that the system has at a moment in time.

A *goal-seeking system* is one that can *respond* differently to one or more different external or internal events, in one or more different internal or external states, and that can respond differently to a particular event in an unchanging environment until it produces a particular outcome.

An *ideal-seeking system* is a purposeful system which on accomplishment of any of its goals or objectives, then seeks another goal and objective which more closely approximates its ideal. A distinction should be made here between *purposeful* and *purposive* systems. A purposeful system is one that possesses the ability to change its goals under certain conditions. It can select ends as well as means thus differentiating it from a purposive system which does not select the goals to be pursued as these are dictated by initiating events. An *objective* refers to a preferred outcome that cannot be obtained within a specified period, but which can be obtained over a longer time period whereas an *ideal* is an objective which cannot be obtained in any time period but which can be approached without limit.

The concept of adaptation is central to systems theory as change is endemic to the world at large. Two aspects of adaptation are of particular interest and must be kept in mind. Firstly, any system which can interact with its environment in expected and pre-planned ways but cannot cope with unforeseen interactions is unlikely to survive. Secondly, continuous adaptation does not necessarily mean indefinite life, as any system faced with too great or too varied environmental changes may be unable to adapt its behaviour sufficiently and will as a result cease to exist.

According to [1], a system is *adaptive* if "when there is a change in its environment and/or internal state which reduces its efficiency in pursuing one or more of its goals which define its function(s), it reacts or responds by changing its own state and/or that of its environment so as to increase its efficiency with respect to that goal or goals". Thus adaptiveness is the ability of a system to modify itself or its environment when either has changed to the system's disadvantage, so as to regain at least some of its lost efficiency."

The definition of 'adaptive' implies four types of adaptation [1]. When a system reacts or responds to an *external change* by modifying the environment, we refer to *other-other adaptation*. When it modifies itself we refer to *other-self adaptation*. A system's response or reaction to an *internal change* by the modification of its environment is referred to as *self-other adaptation* whereas modifying itself is referred to as *self-adaptation*.

5. Living Information Systems

The need for information systems that can cope with both evolutionary and revolutionary changes had been addressed - although in most cases implicitly - by [4], [18], [6], [14] and [17]. However, how do we design (LIS) if we do not know what their nature and features are in relation to the organisational and external discourses? A consideration of the following questions may offer a glimpse of *what* is required.

• *are they concrete or abstract, open or closed, static or dynamic systems?*

There can be no argument that LIS are concrete systems. Similarly, no business information system can be so totally self-contained that it can be labelled 'closed'. There will always be some form of interaction with its environment which would place a demand on its output, and therefore determine in a way the input and accordingly the processing that takes place. However, it must always be remembered that 'closeness' and 'openness' are conceptualisations that are subject to individual interpretation depending upon where the boundary is drawn. A payroll system can hardly be conceptualised as dynamic for obvious reasons. In contrast, a IOS which is used strategically is dynamic - a change in corporate strategy or tactics could affect the systems' state with the imminent danger of becoming obsolete if it does not modify existing or acquire new properties that would enable it to continue and support the business strategy. When referring to an LIS, we assume it is of a dynamic nature.

• *are they purposive or purposeful systems?*

Our assumption is that the future cannot be foreseen. Information coupled with intelligence may offer a glimpse of the things to come and reduce uncertainty to some extent, but not totally. It follows that a business information system cannot possibly select the goals and then set out to achieve them as those will be dictated by initiating events over a future continuum. As such it is a purposive system which may or may not contain purposeful elements. To be 'living' however, it is mandatory that it has elements which possess the ability to change their own goals and to select ends as well as means. The *willingness* and *ability* for purposefulness will determine how fast and to what extent the overall system as a whole deals with unpredictable change. Ideally, most - if not possibly all - the elements of an LIS must be purposeful.

• *are they reactive, responsive or autonomous or do they display some combination of these changes?*

The answer to this question is based on a consideration of

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what brings about changes in an information system, and as such information systems cannot be categorised as autonomous as this would imply a neutrality towards changes in the environment or in other systems with which a relationship is in place. LIS, in particular, are responsive as they are co-producers - together with their environment (the organisation) - of responses (events) which are being necessitated by external events. However, such systems although they don't have to respond to a stimulus, have to react to its cause. This can be illustrated by a person turning on a light when it gets dark - a response to darkness. The light going on when the switch is turned is a reaction [1].

• *are both antecedents and consequences of their behaviour of importance?*

A system's *behaviour* is one of a series of events which are either necessary or sufficient for the initiation of another event in the system itself or its environment. A system's response should naturally prompt the researcher to question and identify the reasons that caused this and therefore focus on the antecedents of this event. A system's behaviour would on the other hand initiate an interest on the consequences - to what extend for example, or with what means the information system dealt with change would be two obvious research themes.

For LIS *both* the antecedents and consequences are of importance. The former should be studied so that in turn offers a knowledge of the nature of the system's environment, its characteristics and dynamics. How can we attempt to built something if we don't know what it should be built for? The latter would be invaluable in evaluating the information system. Throughout the implementation, and even after, when the system has gone through its useful life, guidelines would emerge that could guide the process of developing the next system hopefully more successfully. A cumulative knowledge for the development of LIS is only possible through researching both the antecedents and consequences of their behaviour. Only by this we would be able to develop information systems that will have the capacity to monitor the effects of the environment and control their behaviour in response.

• *are they state-maintaining, goal-seeking or ideal-seeking systems?*

One has to consider the state of ISD today if one wishes to come up with an answer to this question, i.e. where are we now and where do we want to go? It would be difficult considering the Fixed - Point Theorem and the ways information systems have been developed, to place any existing information system under one of the above categories. Examples may point out that if systems were able to *at least* react in some way, we would have avoided in many cases the stigma that proclaims "no matter what you do, your information system will disappoint."

We have perfected the art of building systems to meet static objectives, but in the process we have robbed ourselves - consciously or not - of the opportunity to learn and make them react, let alone respond or be ideal - seeking. What do we then mean when we say a 'living information system'? The answer is simple. It is anything that falls outside the Fixed - Point Theorem mentality and the 'orthodoxy trap' that has been created by the transfer of the prevailing - but obviously false - assumptions of information systems researchers and practitioners to the next generation. It refers to information systems which will be built so as to be able to certainly react and adapt successfully in at least one way as a first step, and to respond differently to one or more different external events as a second. When such a system reaches the stage when it constantly evolves, i.e. when it is fully engaged in the never - ending process of satisfying one and then looking for another objective which more closely approximates an ideal, then it would be a true LIS.

• *what type of adaptation do they exhibit?*

We have mentioned above what we mean by 'adaptation'. The type of adaptation that an LIS exhibits depends (a) upon our definition of its environment and (b) the particular situation and type of business information system. These should not be considered as mutually exclusive as they are interrelated. If we perceive the information system as an organisational subsystem then it is possible that at a particular moment in time the system may exhibit *any* of the four types of adaptation. It can respond by modifying itself but also some of the environment's properties as well. For example, an existing organisational structure may be altered as a result of a change in the information system which is being perceived as fundamental and unavoidable for the continuing survival of the organisation. The type of information system is also important as it can define the environment on its own. Consider for example an IOS and the domain within it operates. The distant organisation which the IOS connects can be conceptualised depending on the situation as being outside or inside the system's boundary.

Summarising the above, we would refer to a Living Information System as one which should be

open and dynamic, of a purposive nature, but containing elements that display some willingness and ability for purposefulness. It must be reactive, and ideally responsive to externally or internally imposed changes, and exhibit some form of control over its behaviour as a response to monitoring the effects of its environment. This form of adaptation can be of any type.

An example of a living information system that displays the above properties is provided in [10]. The

author undertaking action research in a large organisation operating in the UK and overseas electricity markets was confronted with an interesting phenomenon. Although there was a negative overall perception regarding the fit of the information systems in place, with a large percentage of those not being used as they were supposed to, user activities and tasks did not seem to be disrupted in any way. Indeed, the paradox was that although the organisation was heavily dependent on these systems, it was still able to flex and adapt successfully to continuous environmental contingencies, without being tied down by them. It was found that users had developed small applications of their own, and along with application packages have cannibalised the over-arching systems to give themselves a system that is working by adapting it to their particular needs - a living information system, but certainly not a planned or intended one. [10] provides a detailed insight with respect to the reasons and conditions which resulted in its genesis, and kept sustaining its existence.

6. Future Research

In a paper on four paradigms on information systems development, [9] emphasised that developing computer-based information systems involves making a number of implicit and explicit assumptions which guide the innovation process, affecting the system which is designed and implemented. Typically, those are assumptions about knowledge and how to acquire it (Epistemological assumptions), and about the physical and social world (Ontological assumptions).

It is the contention of the authors that *by focusing on the epistemological assumptions* about ISD, and *by exploring the concept of 'fit'* [19], [13], [16] and *finding ways to measure it*, is one way towards the development of flexible information systems that are less prone to disappointment. The degree of fit between a given organisation, its external environment, and a given information system can be judged subjectively, but currently there exists no measure which is general, useful and objective. There is also no research that identifies what criteria people use when they make these subjective judgements. Research currently undertaken by the authors looks to explore the concept of fit and its measurement, and uses it as a central theme for the development of an epistemological framework which in a given context, induces awareness to the effects of change upon an information system, enables the practitioner to make connected statements that are epistemologically valid, and might stimulate self-correcting action. In particular we are investigating the following issues:

• how can we deduce things about the future from present snapshots?

• how are people (including ourselves) currently trying to think about future fit? What is wrong with the way people are currently trying to think about future fit?

• what theoretical leverage is available to improve our ability to think about future fit?

• how do we confirm a method (or epistemological framework) that purports to make statements about the future?

• what actions do people take or think are appropriate in order to attain a level of flexibility in designing information systems? What are the obstacles in doing so and how far/close is the actual result to the intended one? What is the frequency of the occurrence of such gaps if any?

• how and what criteria do people actually use in assigning values to various aspects of information systems flexibility? Are there any cultural or political factors that influence this process?

Other research attempts that seek to enhance our understanding with respect to LIS are currently being undertaken at the *Centre for Living Information Systems Thinking* at Brunel University. A description of those can be found at the following WWW address:

http://www.brunel.ac.uk/research/clist/

7. Conclusions

With the rise of inter-organisational information systems iminent, comes the great challenge in developing them successfully. The size and complexity that will characterise such systems, will be proportionately higher when compared to the information systems of the past. It is inevitable that so will be the challenge. As part of this evolution, system developers will look back to see what 'tradition' has to offer in terms of advice and aid in developing these new systems. We hope that with this paper, we showed that care should be taken when making our own or adopting any prevailing assumptions about ISD.

We all want to build successful information systems and prevent failure, and the literature is abound with examples and guidelines of how to do just that. The fact however that these information systems should be 'living' is largely and explicitly ignored. We have tried to illustrate the importance of this factor and to set a vision by raising a number of questions based on the adaptation concept of systems theory and then discussing them. Our aim was to conceptualise certain properties that the inter-organisational information systems of the future must exhibit, if they are to survive the effects of the unpredictable change that will be demanded from them by the turbulence of the contemporary socio-economic environments.

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It should be clear that we are not trying to offer a 'solution'. This paper has attempted to propose a way of exploring the issue of adaptability with the aim of illustrating its importance in relation to the IOS of the future. The purpose has been simply to raise awareness and to provide a focus for debate. If it does that, then it will have served its purpose.

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