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Towards a Taxonomy of information systems: or does anyone need a TAXI?

DAVID J. GRIMSHAW
University of Warwick, Coventry, CV4 7AL, UK

Many academic and practical traditions have been brought to bear upon the field of business information systems in an attempt to understand a rapidly changing subject. The insights provided by traditional disciplines to an essentially multi-disciplinary subject is essential and very healthy. However, there is a danger of proliferating many different, overlapping frameworks of information systems. There is a need to review the frameworks and suggest a way of integrating several approaches. The future research effort depends upon a consistent set of data being available and discussed. This paper reviews previous frameworks used to promote the understanding and discussion of information systems. The one-dimensional approach is rejected in favour of a three-dimensional approach built around three basic questions characterized as the three Ts. What *tasks* does the information system have to perform? What *technology* can best deliver the systems? In what *timeframe* are we operating? The paper concludes by suggesting an integrated taxonomy, based on the three Ts as the basis for future research and discussion.

Background

The study of information systems from a business perspective is a relatively new subject. Many academic and practical traditions have been brought to bear upon this field of endeavour in an attempt to understand a rapidly changing subject. Traditional disciplines from computer science to social science have made their contributions.

Such diversity is to be welcomed. The insight provided by traditional disciplines to an essentially multi-disciplinary subject is essential and very healthy. For those already initiated into the wonders of the subject, its challenges and rewards, it is all too easy to forget that for new entrants (students) we are building barriers to entry that are difficult to overcome.

Not only is the subject matter multi-disciplinary, it is also shrouded in jargon. Reading the professional press and the numerous magazines in this area the reader is likely to come across stories with eye-catching headlines like, 'mouse found plotting with robot'. All very amusing you might think. When the examples of jargon refer, as this one does, to physical entities, there is less of a problem in interpretation – the doubters can always see, touch and/or listen. Perhaps one could come to terms with jargon on its own, but when combined with a range of different definitions and a lack of basic theory the barrier to entry is indeed high. Lets take another example, this time more a question of definition than of jargon. The term 'artificial intelligence' has become counter productive in the public mind, 'expert systems' are woolly, so the term 'intelligent knowledge-based systems' is introduced. Meanwhile, all three terms continue to have currency in books, articles, and in the media generally.

The purpose of this paper is to review the literature for conceptual frameworks that have been used to promote the understanding and discussion of information systems from particular disciplinary perspectives. These approaches are then rejected on the grounds that they collectively produce a range of concepts that are not mutually consistent.

Why do we need a TAXI?

The simple answer to this question is because we want to move on – to go forward, to travel down the road of discovery. A taxonomy is normally associated with biological sciences although ways of classification are needed in every discipline. All taxi drivers (users) need an A to Z to find a route. In the field of information systems authors from Ackoff (1967) to Zorkoczy (1985) have pronounced – each contributing ideas and concepts, applications and cases, and inevitably new terminology with new definitions. A very practical reason for needing a taxonomy of information systems, in particular, is to promote more consistent, thorough research. Improving research will, in turn, improve understanding and hopefully practice.

Is there a TAXI already waiting?

The seasoned traveller knows well that finding a taxi is often a frustrating process, particularly if one happens to be in a foreign country. Most people studying and practising in the field of business information systems can be likened to the foreign traveller because they are coming to the subject from some other subject base, for example, the author happens to have an economics background. Just as the arbitrary boundaries around countries constrain the political, social and economic development, so the boundaries around subjects (or disciplines) can act to constrain thinking (Blume, 1990). The subject of business information systems is, in these terms, an interdisciplinary subject. The field of information systems has been defined by Lucas (1986) as 'concerned with the effective use of information technology in an organisation'.

Figure 1 illustrates how it is possible to think of information systems as drawing on a continuum of traditional subjects ranging from Psychology through to the 'hard' sciences represented by Computer Science (Lucas, 1986). An adaptation of the Lucas figure is made to reflect the importance of economics as a contributing discipline, particularly in the important area of measuring the value to the enterprise of investing in information technology.

Each of the contributing disciplines has had an influence on the conceptual frameworks used in the information systems subject. This can best be illustrated by a further adaptation of Lucas (1986) to show the frameworks used and their source. This article focuses on the integration of these frameworks to provide one overall classification of information systems.

The focus of the subject is 'problem' centred. It is outward looking; observing the real world and attempting to make sense of it through research, development of theory and teaching. While on the one hand we should be aware of the dangers of trying to carve out a separate discipline, leading as Blume (1990) argues to greater abstract formalism, on the other hand we should pursue all avenues that reduce the barriers to entry or avoid 're-inventing the wheel'.

A search of the ABI/INFORM database (December 1990), using the terms 'information systems and taxonomy' revealed more than 40 000 citations of 'information systems'. When this term was searched for within 20 words of the term 'taxonomy' only nine articles were found. Of these, only two had any relevance to the general subject of defining a taxonomy of information systems. Some journals are not covered by this database, so a general scan of literature has been made. A further three sources have been uncovered in various conference proceedings. Nearly all of these references turned out to be concerned with decision support systems. These are regarded here as a sub-class of information systems. A further source of taxonomies within the general subject area of business information systems is in sub-classes such as geographical information systems (Harts *et al.*, 1990), end-user computing (Rockart and Flannery, 1983) and information systems research (Keen, 1987; Tan and Benbasat, 1990; Galliers, 1991).

The earliest attempts to classify information systems can be traced back to Gibson and Nolan (1974). Empirical research into the spending levels of organizations on information technology led them to postulate a four-stage model of the growth of data processing. Based on the notion that a new business requires a different managerial

←—— Traditional Discipline ——→							
Psychology	Organizational Behaviour	Economics	Business Management		Operational Research	Electrical Engineering	Computer Science
←—— Inter-disciplinary Information Systems ——→							
User Interfaces	Decision making & Org. change	Value of IT	Accounting Finance Marketing Production	Effective use of IT within the organization	Problem solving methods	Machine design	Hardware and software design
←—— Frameworks ——→							
Stages of growth	Organization	Info. as a resource	Applications		Systems		Technology
1	2	3	4		5		6

Amended from Lucas (1986) and (1990).

Figure 1 Contributing disciplines to business information systems style to 'middle-aged' or well-established businesses, the idea essentially envisaged organizations going through various stages in their use and application of information systems. Over time this model has been modified, most notably by Nolan (1981, 1984) to take into account the changes brought by the microcomputer. Information systems, according to the stages of growth model, evolve from data processing systems to decision support systems. Any organization will not develop, for example, decision support systems until their lower level information needs have been satisfied. This basic idea is founded on Maslow's (1954) theory of a hierarchy of personal needs.

Recent renewed interest in the stages of growth model by Sutherland and Galliers (1989) and Galliers and Sutherland (1991) is based on wider considerations of the human and organizational issues. The six stages of growth are categorized according to seven elements (seven 'S's after Pascale and Athos, 1981). One of these elements is that of 'systems'. However, the classification of systems at each stage has been done largely on the basis of organizational features. The focus of the model is one of investigating where any given organization is now. Having established the current position, the argument is that planning for where the organization is aiming should be easier. In other words the framework has been advanced specifically as part of the strategic planner's toolbox. Are there any generic lessons that can be applied to information systems more generally?

A further fruitful source of existing classifications of information systems might be expected from a search of current textbooks on the subject. How do textbooks present the subject to students? Here experience of teaching tells me that students are often confused by the seemingly contradictory statements in different books.

There are a number of approaches, used by these textbooks, to introduce the subject of business information systems. Generally we can explore these approaches with reference to Figure 2. Six approaches to introducing the subject of information systems appear to have been used. These approaches may be classed according to the following headings which also relate to those used in Figure 1.

(1) *Stages of growth:* the stages of growth theory has its origins in psychology and carries with it a set of assumptions from that discipline which unfortunately are often not explicitly stated in the information systems literature (Gibson and Nolan, 1974);
(2) *Organization:* models of information systems originating in the organizational behaviour and decision science disciplines have had a major role to play in the development of frameworks for discussing information systems. Based on Anthony's (1965) model of an organization, this approach envisages an information system class serving each of the layers of the organization. Thus, we have operational control, managerial control and strategic planning;
(3) *Information:* with origins in economics and information science, this approach starts with a recognition that information has value and is essentially a corporate resource. It is also a physical resource which can be processed;
(4) *Application:* functional specialists delight in thinking that they are using systems which have some unique quality dependent on the use of the systems. However, in reality this is rarely the case. More commonly, there are a set of characteristics that cross traditional functional boundaries.
(5) *Systems:* the systems approach stems from the traditional domain of operational research. The emphasis here is on problem solving. The largest impact of systems thinking upon the field of information systems has been via methodologies for the development of information systems. Early work by Checkland and Griffin (1970) suggested

Approach	Stages	Organization	Information	Application	Systems	Technology
Author:						
Burn *et al.* (1990)	*	*	*		*	*
Knight and Silk (1990)		*	*		*	*
Burch and Grudnitski (1989)			*			*
Lucas (1986)		*	*	*	*	
Lucas 1990)	*	*	*	*	*	*

Figure 2 Approaches to information systems

that soft systems methodology could be used to produce information flow diagrams. Although recently Checkland (1988) has argued that systems thinking, with its orientation towards process, underpins the provision of information systems in organizations.

(6) *Technology:* Computer science has found it necessary to classify various 'technologies'. For strategic planning purposes also, it is often desirable to classify intelligence in consistent ways – hence the need for a taxonomy. Many authors have talked about a technology architecture (Earl, 1989) as comprising computers, communications, data and tools. Others, like Burn and Caldwell (1990) have emphasized a continuum from batch processing through to relational database management systems.

Hailing a TAXI

From our review of the literature, it is apparent that there is no one commonly-agreed framework for discussing information systems. Each contributory discipline has tended to use its own framework for a basis of a study, depending upon whether the study has, for example, an organizational, a technology or a systems perspective.

These frameworks all provide a one-dimensional (or at most a two-dimensional) viewpoint on a very complex subject. There are two main problems with such frameworks:

(1) They are an oversimplification based upon the relatively narrow view of one discipline. Therefore, the range of concepts are not and cannot be mutually exclusive. Further, work is thus required in order to develop a taxonomy which must, by definition, provide a comprehensive classification system with mutually exclusive categories.
(2) The assumptions, implicit in the earlier models is that familiar to the economist, namely *ceteris paribus* (all other things equal). But of course all other things are rarely held constant. It is the nature of the application of information technology that there is nothing so constant as change. How can this 'change' element be taken account of in the development of a taxonomy of information systems?

Taking as the starting point three basic questions that have to be answered by anyone concerned to understand information systems we shall then build on existing frameworks.

(1) What *tasks* do we have to perform?
(2) What *technology* can best deliver the systems?
(3) In what *timeframe* are we operating?

These basic questions, characterized as the 'three Ts', are used as a starting point.

(1) What *tasks* do we have to perform?
The kind of decisions that need to be made (tasks to be performed) are a useful starting point. Under this general question are the issues of what data is required, how this data might be assembled and who is going to use the system? There will usually be a trade-off between long-run and short-run requirements and the demand to summarize the data.
(2) What *technology* can best deliver the systems?
Present and future technologies may be considered. There will usually be a trade-off between flexibility and cost. Over time, the point at which it becomes economic to apply a particular technology will change.
(3) In what *timeframe* are we operating?
Building on the concept of the stages of growth, the people concerned with information systems will need to place them within the context of the organizational learning and the spending on information technology. This dimension recognizes that organizations learn as they move from one stage to another.

Figure 3 illustrates a three dimensional presentation of a proposed classification system for information systems using the three Ts outlined above. Each of the three Ts looked at in isolation would represent two dimensions. Before moving to discuss the concepts in abstract, some examples are introduced. Three examples of information systems are presented here to illustrate the use of the proposed taxonomy.

Firstly, the simplest case might be that of a payroll system. The three T classification would place a payroll system as a structured task, using tried and tested technology, developed at an *ad hoc* stage of time. Secondly, let us take the American Express Authorization Assistant as a case of a company using artificial intelligence to achieve higher profits (Feigenbaum *et al.*, 1988). The three Ts can be applied to place the Authorization Assistant as performing largely unstructured tasks, with use of advanced expert systems technology (and communications), and developed in an organization that had substantial maturity in terms of IT usage.

Thirdly, where would a major IT project such as a Hospital Information Support System (HISS) be placed in the taxonomy? A system which has not as yet been fully developed is much more problematic in terms of where to place it within the taxonomy. Here is the utility of using

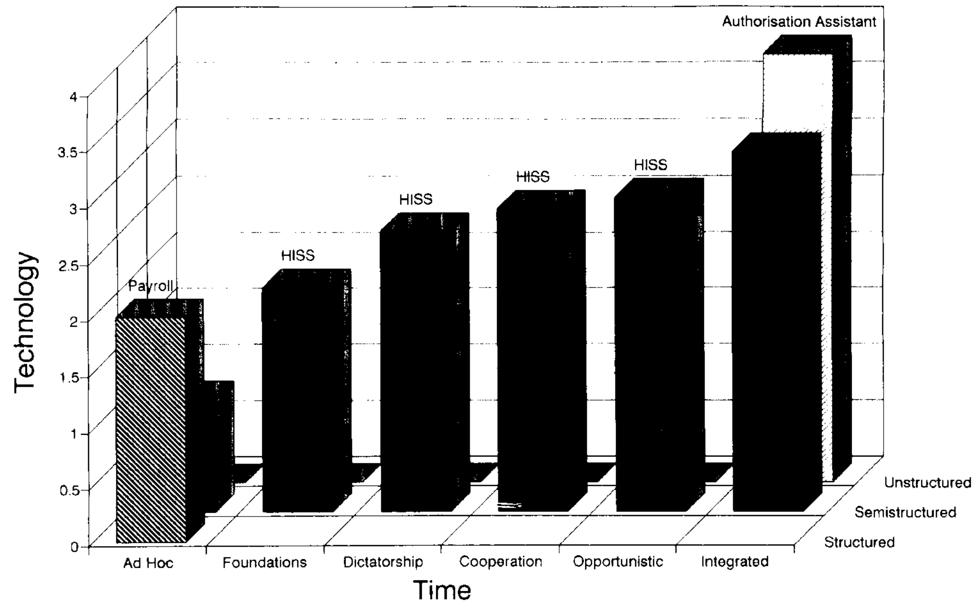

Figure 3 Taxonomy of information systems

the x axis of Figure 3 to denote time. The *ad hoc* and foundation stages of HISS will involve the development of feeder systems, for example small scale clinical audit systems. Basic patient admission systems will typically be developed in a dictatorship or cooperative stage. At a later stage in the development of information systems within the health service there will be a need to integrate towards the final goal of HISS. So, schematically, the development can be plotted as shown in Figure 3.

Each of the three Ts is now discussed in more detail and a full classification of each T is given in Figures 4, 5, and 6. When applying the taxonomy to a given information system the task, time, and technology would need to be classified with reference to these Figures.

The task dimension builds on frameworks based on the work of both Anthony (1965) and Gorry and Scott Morton (1971) which, as a result of a review of information systems frameworks by Lucas *et al.* (1974) were recommended. Sub-classes on this dimension cover the type of decision (task) being supported, for example, structured or unstructured and the level of the task, for example, strategic, managerial or operational. A detailed table of the classes in the task dimension is contained in Figure 4.

To determine the classification the following key questions need to be asked: (1) Who is to use the system? (operational, middle, or senior management); and (2) What decisions are being supported by the system? (structured, semi-structured or unstructured). The time dimension builds on frameworks based on the work by Gibson and Nolan (1974) and modified by Sutherland and Galliers (1989) and Galliers and Sutherland (1991). Sub-classes on this dimension cover the six stages of growth. A detailed table of the classes in the time dimension is contained in Figure 5.

To determine the classification the key question to be asked is: where is the organization now in terms of the seven 'Ss'? (Pascale and Athos, 1981). The technology dimension builds on frameworks based on the work of

1.	Structured decisions:
1.1	– operational control
1.2	– management control
1.3	– strategic planning
2.	Semistructured decisions:
2.1	– operational control
2.2	– management control
2.3	– strategic planning
3.	Unstructured decisions:
3.1	– operational control
3.2	– management control
3.3	– strategic planning

Note: Adapted from Gorry and Scott Morton (1971)

Figure 4 The *Task* dimension – classification

1.	Ad Hocracy
1.1	– Strategy
1.2	– Structure
1.3	– Systems
1.4	– Staff
1.5	– Style
1.6	– Skills
1.7	– Superordinate goals
2.	Starting the Foundations
2.1	– Strategy
2.2	– Structure
2.3	– Systems
2.4	– Staff
2.5	– Style
2.6	– Skills
2.7	– Superordinate goals
3.	Centralized Dictatorship
3.1	– Strategy
3.2	– Structure
3.3	– Systems
3.4	– Staff
3.5	– Style
3.6	– Skills
3.7	– Superordinate goals
4.	Democratic Dialectic and Cooperation
4.1	– Strategy
4.2	– Structure
4.3	– Systems
4.4	– Staff
4.5	– Style
4.6	– Skills
4.7	– Superordinate goals
5.	Entrepreneurial Opportunity
5.1	– Strategy
5.2	– Structure
5.3	– Systems
5.4	– Staff
5.5	– Style
5.6	– Skills
5.7	– Superordinate goals
6.	Integrated Harmonious Relationships
6.1	– Strategy
6.2	– Structure
6.3	– Systems
6.4	– Staff
6.5	– Style
6.6	– Skills
6.7	– Superordinate goals

Figure 5 The *time* dimension – classification

Istel (1988), Earl (1989), and Burn and Caldwell (1990). Sub-classes to this dimension cover computers, communications, data and tools. Some organizations who need to collect and analyse information about new technology as it becomes available and the opportunities that might be available tomorrow from exploiting that technology have developed their own in-house taxonomies (Istel, 1988). A detailed table of the classes in the technology dimension is contained in Figure 6.

When to hail a TAXI

A 'TAXI' is often not appropriate transport for our needs. It may be too expensive, impractical etc. The taxonomy of information systems suggested in this paper will not always be appropriate – it may be unnecessarily complex. However, the availability of the TAXI may be reassuring. Before it is used extensively it will need road testing in a variety of conditions.

The strength of the design is that it is based on tried and tested components. Each dimension has already been applied in practice and found to be useful. The thrust of this paper has been to advance arguments in favour of using a multidimensional framework to provide a classification system (or taxonomy) that reflects a dynamic environment.

The three dimensional 'TAXI' fits the philosophy and nature of the field of information systems as an

1.	Computers
1.1	– Digital
1.1.1	– General purpose
1.1.1.1	– mainframes
1.1.1.2	– minicomputers
1.1.1.3	– microcomputers
1.1.2	– Experimental
1.1.2.1	– optical computers
1.1.2.2	– data flow computers
1.1.2.3	– parallel computers
1.1.3	– Special purpose
1.2	– Analogue
1.2.1	– General purpose
1.2.2	– Experimental
1.2.3	– Special purpose
1.3	– Hybrid
1.3.1	– General purpose
1.3.2	– Experimental
1.3.3	– Special purpose
2.	Communications
2.1	– Computer intraconnect
2.2	– Computer system interconnect
2.2.1	– DEC DECNET
2.2.2	– IBM 3270
2.2.3	– IBM SNA
2.2.4	– OSI
2.3	– LANS
2.4	– MANS (Metropolitan Area Networks)
2.5	– WANS
2.6	– GANS (Global Area Networks)
3.	Data
3.1	– Data schema
3.2	– Data dictionary
4.	Tools
4.1	– Operating Systems Software
4.2	– CASE tools
4.3	– Database management systems

Figure 6 The *technology* dimension – classification

interdisciplinary subject. It should serve to remind us that there is often another way of approaching the problem. The utility of the vehicle must be measured in terms of how useful it is to assist in the discussion and development of research and practice of information systems and the extent to which it may help in reducing the barriers to entry into this challenging subject arena.

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Address for correspondence: Warwick Business School, University of Warwick, Coventry CV4 7AL, UK.