Journal of International Information Management

1996

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Towards a specific architecture for international information systems: An exploratory study

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ABSTRACT

Despite their acknowledged importance, international information technology applications - defined as supporting a business activity across a number of diverse environments - are still largely unstudied and under-explored. Scholarly research has been relatively sparse, but there is anecdotal evidence of the serious difficulties facing the developer of international systems. In this exploratory paper it is investigated whether there is a specific architecture, generically common to international information systems which could provide a framework for the development of international systems.

The linkage between the global business strategy of international firms and the organization and structure of their information systems is discussed. Building on the body of research into the structure of global information systems and distilling from it some fundamental commonalities, an architecture consisting of a two-dimensional topology and five systems elements is proposed as a basic construct for the design of systems which operate across diverse environments.

The potential benefits of the architecture and the resulting implications for the design of international information systems are set out and the need for future research to validate and develop the architecture model further is emphasized.

INTRODUCTION

Purpose of the Paper

Information systems technology is often critical to the international operations of the globally oriented firm, either as the key to its expansion, or even as the main profit driver. Despite their obvious importance transnational information system's technology is still "largely unreported [and] unstudied" (Cash, McFarlan & McKenney, 1992) and ". . . generally ignored" (King & Sethi, 1993). While scholarly research into this field is sparse, there is an increasing amount of anecdotal evidence and technical reports indicating a strengthening interest by practitioners in this field.

This exploratory paper investigates (as one possible solution path to difficulties with international systems) whether there is an architecture common to international systems *sui generis* which would allow a more successful development approach.

Definition of "International Information Systems"

The literature does not clearly identify a generally accepted term for information systems technology applied across borders. Often "global" is used (Ives & Jarvenpaa, 1991), but "transnational" is also in general use (King & Sethi, 1993) for such systems. The first inevitably invites associations of vast enterprises covering the planet, whereas "transnational" is open to possible confusion with the precise use of the term coined by Bartlett and Goshal (1989) for describing one specific style of a firm's operation in more than one country. In this paper, therefore, the term "international"[1] is used.

Another definition is needed to distinguish international systems from other distributed systems. Information systems which support different business *activities*, e.g. in multi-divisional companies, are different by definition, whether these divisions are in a single or multiple locations, national or international. Similarly, systems supporting different business *functions* (such as Sales, Manufacturing, etc.) are different for each function, again independent of their location, be they all in one place or spread over several continents[2].

International Information Systems are defined as distributed information systems which support similar business activities in highly diverse environments commonly found across country boundaries.

A classification of firms' international operations along the dimensions of 'business focus' and 'environmental diversity' (of their operating locations) may help to sharpen the definition. *"Business Focus"* is high in operators who concentrate on a single business activity. Examples are car rental firms, international banks and international franchises. Low business focus is present in diversified conglomerates with many activities. Examples are the large Japanese and American multinationals. Low *Environmental Diversity*[3] would typically be encountered within one country and high diversity across different countries with divergent business cultures.

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[1] This too has been used by Bartlett and Goshal, but in a more general sense.

[2] However, where these disparate sites have a common information need, such as common management and financial information across divisions and/or functional sites, the (sub)systems serving this need are 'international' in the sense of our definition.

[3] This includes differences such as business practices, cultural influences, political establishments.

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Figure 1. Classification of Firms by Business Focus and Diversity of Their Operating Environment

Figure 1. Classification of Firms by Business Focus and Diversity of Their Operating Environment.

The figure shows a 2×2 matrix. The vertical axis is labeled "Business Focus" ranging from Low to High. The horizontal axis is labeled "Environmental Diversity" ranging from Low to High. The four quadrants are: top-left "Local Operator", top-right "International Operator" (shaded), bottom-left "Local Conglomerate", bottom-right "International Conglomerate".

This paper deals thus with the information systems for the "International Operator," i.e., a single business activity carried out in different countries. However, this is not a limiting restriction as each of the divisions or functional entities of an international conglomerate is often an "international" operator itself.

Structure of the Paper

The paper is structured as follows:

- First, the business reasons for international systems are reviewed and their linkage with global business strategies iσ discussed;

- Second, the notion of a specific architecture as the basis for the development methodology for international systems is evolved.

- Finally, the potential benefits of the proposed architecture model for the development of international systems are set out and directions for further research are proposed.

GLOBAL BUSINESS STRATEGY AND
INTERNATIONAL INFORMATION SYSTEMS

Technology improvements, increase in market deregulation and the increased share of the knowledge sector of the economy are considered major reasons why business is feeling increasing pressure to operate outside its immediate surrounds (Applegate & Mason, 1991; Ehrlich, 1989). Linking this to information systems, Ives and Jarvenpaa (1991) developed a set of ten "business drivers for global information technology." Whereas most of the "drivers" are operations oriented, Butler Cox (1991) and Neo (1991) also found a significant marketing dimension as a driver towards the implementation of international systems.

Difficulties With International Information Systems

There seems to be widespread consensus that international systems are not only a major element of any global strategy but also a major, potential, stumbling block for global operators. The fact that only 8% of a large sample of European multinational companies have managed to implement international systems satisfactorily (KPMG, 1993) indicates the difficulties encountered. The issues are technology related problems and those of cultural diversity.

Technology Related Difficulties: In a comprehensive review Huff (1991) identified critical, constraining issues as extending practically across all functional areas of the traditional systems management and development framework:

- Failure to link information technology and business strategy (Popper, 1990; LaPlante, 1991)
- Unsuitable development methods (Passino, 1990; Popper, 1990; and Laplante, 1991)
- Technical complexities and adverse legal aspects of telecommunications (LaPlante 1991; Kobielus, 1992)
- Hardware incompatibility and failure to establish interconnectivity (LaPlante, 1991)
- Lack of and/or incompatible technology standards (Palframan, 1991)

Issues of Cultural Diversity: The assumption that international business is just a replication of domestic business has been refuted for general business a long time ago (e.g., Doz, 1980; Buss, 1982). Several researchers have more recently established that this assumption is also wrong for information systems.

Robey and Rodriguez-Diaz (1989) found that cultural differences such as the different ways in which information systems are interpreted and are given meaning proved a significant impediment to the implementation of an accounting system in one of two Latin American countries. Heitzman (1990), in a study on the acceptance and the influence of information technology in Southeast Asia sees the regionalization/localization of system development and implementation as a way to ameliorate the difficulties experienced across cultural and developmental divides.

These findings were confirmed in a wide-ranging analysis of multinational issues in information technology in less developed countries (Sarawat & Gorgone, 1991). They also found a

political element where lack of local involvement sometimes was interpreted as using information technology as an assertion of first-world dominance. Skills deficiency, lack of indigenous technology content and concern over employment issues were also cited as issues.

Whereas these studies concentrate mainly on the effect of different levels of development there is a second element of difference in culture in the way in which value systems, business philosophies (especially ethics) and general living habits diverge between different locations of an international system. Goodman and Green (1992) demonstrate this with an analysis of the information technology environment in the Middle East. A recent comparative study of management styles, perceptions and expectations across western Europe (Barsoux, 1992) revealed a variety of differences in the role of management, which can be of major significance for systems design and implementation.

It seems thus reasonable to consider at least two dimensions of cultural influence on the architecture of international information systems: the differential in developmental levels between users of the system on one side and the diversity of their cultures on the other.

Strategies and Management Structures of Global Business

A number of researchers have found that the architecture of international systems seems directly influenced by the strategy and structure of the international firms which use them (King & Sethi, 1993; Sankar, Apte & Palvia, 1993; Konsynski & Karimi, 1993; Butler Cox, 1991; Ives & Jarvenpaa, 1991). Therefore the strategic management of global firms is briefly discussed first, before systems architectures are investigated.

Figure 2. Global Business Strategies

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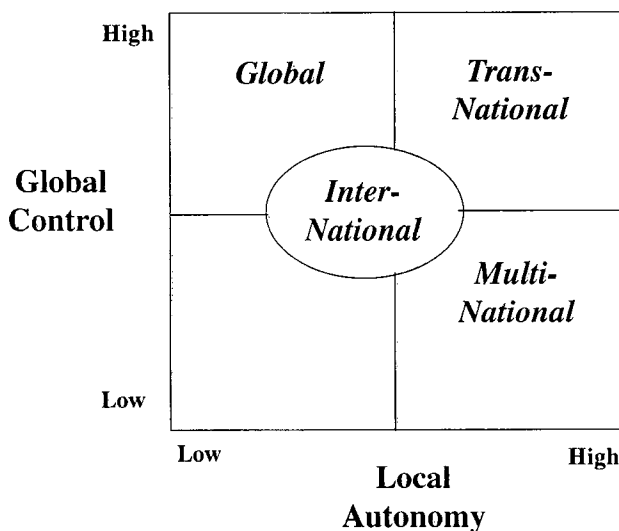
The major factors shaping an international firm's operations and management structure seem to be the level and intensity of global control versus local autonomy. The model developed by Bartlett and Goshal (1989), illustrated in Figure 2, seems best to integrate business strategy with the organizational forces acting upon the international firm:

- The "global" business strategy shows a high degree of global control at the expense of local autonomy;

- Juxtaposed to this is the "multinational" strategy with loose global and high local control.

- "Transnational" organizations balance tight global control in certain aspects with a policy of vigorously fostering local autonomy, particularly for the diffusion of innovation. These firms "think global and act local" (Bartlett & Goshal, 1989). This strategy is considered optimal for many multinational corporations.

- Defined as in interim stage, the "international" firm strikes a balance between global and local control, often with neither control modus dominant.

Corresponding to these global business strategies are organization structures of firms operating in more than one environment/country. Konsynski and Karimi (1993) summarize:

- Global organizations tend to be structured in a "centralized" fashion, with strong, prescriptive operational direction flowing from the center and highly formalized performance measurement information returning from the subsidiaries.

- Multinational companies tend towards a "decentralized" federation, with little direction from the center, most of the decision power devolved and minimal performance information flowing from the local companies.

- International enterprises operate in a constellation referred to by Konsynski and Karimi as a "coordinated federation," while the operational direction is much less stringent (than in the centralized structure) the subsidiary companies rely on the parent for new ideas and processes. There is little cross-talk among subsidiaries. Most information flows through and is cleared by the center.

- "Transnational" companies are characterized by a network of relationships among the companies in the group. Hedlund and Rolander (1990) described this "heterarchical" organization as fundamentally different from the other, hierarchical ones. The difference is in the way in which strategy is defined as "heuristic action," focused on "exploiting current potential" and the "creative utilization of the symbiotic potential of the [local] environment."

While most of these strategic and structural models are static, Butler Cox (1991) also put a developmental perspective on the Bartlett-Goshal framework (Figure 3). While they use a different terminology, companies seem to become active internationally first as "Exporter" of their goods or services - usually applying a *"Global"*[4] business strategy. Increased activity in any

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[4] Italics denote the Bartlett and Goshal classification.

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one location encourages autonomy for local operations, taking on the role of "National Adaptor," similar to the *Multinational* classification. In the next phase this degree of autonomy is counter-balanced by some global control as "Central Coordinator," i.e., an *International* firm. Finally, as global operations mature, firms move towards a status of "Global Coordinator" (equivalent to the *Transnational*).

Figure 3. Migration Through Global Business Strategies
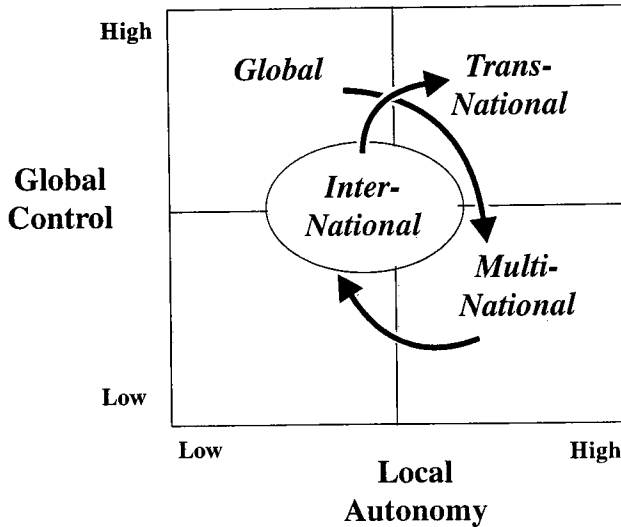
This migration does not necessarily follow a set pattern of clear stages, nor does it move synchronously in all locations, or with all products, at the same pace[5]. Such a developmental perspective on global business strategies puts a strong requirement of flexibility to any systems architecture for international systems.

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[5] The McDonald's hamburger chain is a demonstration of this development notion. Having progressed from domestic operations straight to a multinational stance with their policy of global expansion through (mainly) franchising, they are now reviewing the need to exercise more global control or coordination. ("Big Mac's Counter Attack." *The Economist*, November 13, 1993.)

A SPECIFIC ARCHITECTURE FOR INTERNATIONAL SYSTEMS?

The literature is not conclusive on the link between the "goodness" of systems architecture and the effectiveness of systems development approaches. However, the value of an infrastructure (Weill, 1992; Weill, et al., 1994) of sufficient "reach and range" (Keen, 1991) is accepted as essential for providing the flexibility to deal with future systems demands. Earl (1989) suggests that a typical information technology architecture (which he also defines as the prerequisite for such an infrastructure in Weill's sense) contains "blueprints" for the development of application systems. It is thus safe to assume that establishing an appropriately specific architecture for international systems would have a beneficial impact on their development.

Systems architecture is defined in many ways. For the purpose of this exploration a working definition of architecture is borrowed from Earl (1989): "[Information technology architecture is] the technology framework which guides the organization in satisfying business and management information systems needs." This also encompasses functional applications in the sense of Weill's (1992) "enabling foundation [for the application of the technology]."

The Structure of International Systems in the Literature

In the context of international systems, there is very little literature on the subject of a specific systems architecture model. There is evidence of the importance of having an "architecture strategy" for global systems (*IS Analyzer*, 1991). The architecture of the "global village" (Targowski, 1990), with its backbone of electronic highways connected to information utilities could provide a starting point for an architecture model. The need for infrastructure to allow connection between individual parts in the form of a central network (*IS Analyzer*, 1991) points in the same direction. Bingham and Pezzini (1990), researching logistics systems, set out the requirement for a "common carrier information system" into which generic, packaged application systems can interface.

Butler Cox (1991) classify information systems structures according to systems management style. In their model (in which "systems" is defined as technology *and* applications) there is a direct, one-to-one relationship between the global business strategies (given in both 'Butler Cox/*Bartlett & Goshall*' nomenclature below) and these systems architectures. They distinguish between:

- "Centralized" systems, with local terminals connected to a centrally developed and operated system ('Exporter/*Global*');
- "Replicated," i.e., copies of one (centrally developed and maintained) system are operated in all local sites ('Central Coordinator/*International*');
- "Autonomous," i.e., locally developed and operated systems which have little in common with each other ('National Adaptor/*Multinational*'); and finally
- "Integrated" systems, locally operated and assembled from compatible components developed at different local and/or central sites ('Global Coordinator/*Transnational*').

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Konsynski & Karimi (1993) develop a very similar relationship between information systems structure and business structure, which (in the same sequence as above) they name "centralization," "inter-organizational" (to emphasize the link-up between local databases and processes), "decentralization" and "integrated architecture." The key elements in their architecture model are network and data management strategy.

Sankar, Apte and Palvia (1993) take a different perspective. They define global information architecture mainly in terms of the configurations of two architectural elements, one mainly hardware and the other mainly operating software of the "middleware" type. Their architecture model thus explicitly excludes application systems. These elements can then be structured in three configurations:

- Integrated (elements are physically separate, but logically connected);
- Centralized (together and connected); and
- Decentralized (separate and disconnected).

The three configurations of the two elements result in nine possible architectures of which four, however, are either not feasible or inappropriate. Three are the "pure" versions (with both elements in the same configuration) and two are mixed.

Figure 4 summarizes the architectures and systems configuration structures discussed above. If the replicated/decentralized structure is disregarded as a physically distributed incarnation of the centralized architecture, there are thus three generic architectures outlined, namely centralized, autonomous/decentralized and integrated.

Figure 4. Architectures and Configurations of International Information Systems

Centralised

Decentral/Replicated

Decentral/Autonomous

Integrated

● = Access Terminals   ▦ ⬭ = (Different) Systems
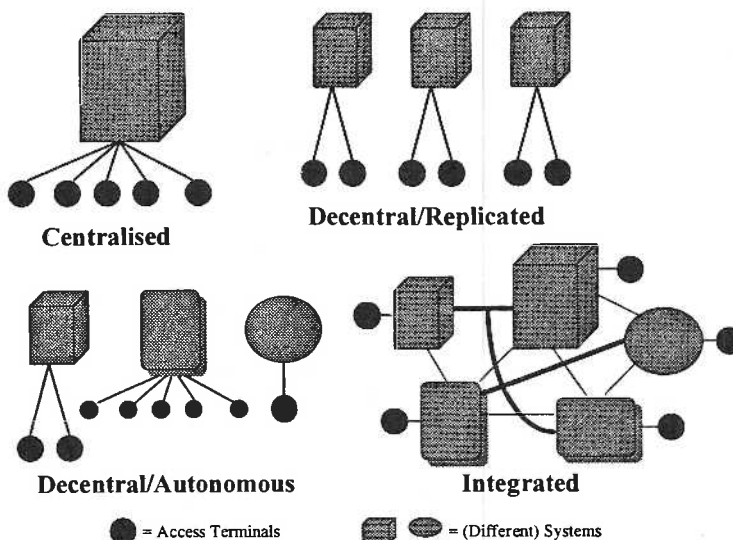
The centralized architecture ignores environmental diversity. The fact that its terminals may be spread across international boundaries is incidental and of no relevance to the architecture of the system[6]. Airline systems, as an example, impose their "culture" on the user, wherever they may be. At the other end of the spectrum, environmental diversity is the paramount imperative for the autonomous architecture: Each system is closely tailored to local cultural parameters with a resultant high degree of independence and isolation[7] between systems. The integrated structure is the one where environmental diversity counts: The level of integration reflects the extent to which diversity is addressed in the design of the system. An architecture which provides a catalytic medium for this integration would thus become the information systems equivalent of the heterarchical organization of the transnational firm.

A main issue for an integrated architecture is its flexibility. The three generic architectures are all discrete in the sense that a revolutionary step such as re-writing systems or re-establishing the technical infrastructure is needed to move from one to the other. That firms do indeed migrate between business strategies is commonly acknowledged (Butler Cox, 1991; Konsynski & Karimi, 1993; Sankar et al., 1993). In consequence, a flexible architecture which allows gradual variations and smooth transitions between different types of models of global business strategy is required.

Moreover, flexibility is not only required to migrate, but also for companies who have arrived at the most mature (transnational) level, as Hedlund and Rolander (1990) point out. Hagström (1990) sees the structure for information systems as allowing for the "un- and re-bundling of information based activities." In the same vein Galliers (1993) has pointed out that the information technology component of business strategy needs to be proactively flexible to enable 'serendipitous' exploitation of opportunities.

An Architecture Model for International Information System

That there needs to be variation in international systems to accommodate differing local needs has been established early on by Buss (1982), when he found that using "common" systems across different countries can be fraught with difficulty. In the same year Keen, Bronsema and Auboff (1982) first articulate a paradigm of a "common core" of information systems applications with local alterations. There has been little further development of this model as far as the functionality of application systems is concerned, and Ives and Jarvenpaa (1991) conclude that "the literature offers little guidance for . . . local versus common applications." The notion of a common structure, linking together divergent (local) elements of a global system, however, has been further developed by Keen (1991) who states that a "transnational platform" is required to carry the "transnational information technology capability" required for global operations.

[6] Except perhaps for legal issues with cross-border data flows.

[7] Ignoring mere message connections such as e-mail and file transfer.

Both Konsynski et al. (1993) and Sankar et al. (1993) mainly include hardware and "middleware" elements in their interpretation of information technology architecture. However, Butler Cox (1991) include application systems in their definition of systems architecture. Also, information technology infrastructure, in the sense Weill (1992) defines and interprets it, does include (common parts of) application systems. This is in line with Earl (1989) who argues that if the architecture in question should have relevance to the development of business systems, then _all_ the elements which make up such business systems need to be included in it.

An architecture for international systems is therefore postulated, which has two dimensions to it, namely the system's "topology" and the characteristics of its "elements." The topology of the system is what designates the parts and defines their relation to each other.[8] Using Kroenke's (1992) practical definition of the components of an information system, these parts consist of five elements, namely people, procedures, data, software, and hardware. The sum of the characteristics of each element (such as the typical technology platform, typical application programs, etc.) together shape the characteristics of the overall system.

Figure 5. The Generic 'Core/Local' Topology

Generic Systems Topology
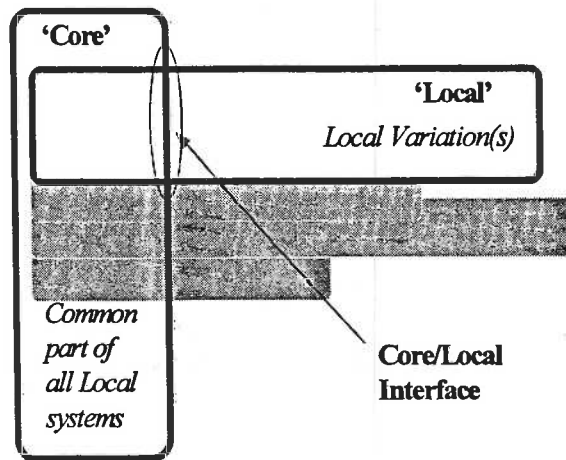
[8] The term "topology" is chosen (rather than "structure") because what is being described is likely to appear in many disguises. A structure always needs to be recognizable as such, whereas a topology, by definition, is "the [set] of properties . . . which remain unchanged even if [the shape] is bent, stretched, etc." (_Chambers Twentieth Century Dictionary_, 1972 Ed.)

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The 'common-local' paradigm can thus be expressed in a two-dimensional topology with a common 'core' and 'local' parts. Conceptually, the 'core' is similar to Weill's (1992) notion of an information technology infrastructure. The core's main purpose too is "to provide a stable base of reliable services" and furthermore to ensure that local applications can be implemented in the right balance of functionality to adapt optimally to local culture and provide at the same time the required level of global control. The degree to which applications are included in the core corresponds to Keen's (1991) notion of 'infrastructure range' whereas the extent of integration and the number of local sites correlate with his concept of 'reach.' The common 'core' of systems elements (people, procedures, data, programs, equipment) is the same throughout all locations in which the international system is used; it need not contain all elements nor need it be used in all its functionality at every site all of the time.

The 'local' part of systems elements are the ones unique to the local site. In Weill's (1992) model, this would encompass the parts of the business-unit infrastructure together with business processes technology unique to the respective local business unit. In both dimensions each element in use, however, would be defined twofold:

- Once in terms of its own functionality
- Secondly in terms of its interface with its correspondent part in the core/local dimension

The two-dimensional topology is flexible, as a variety of systems architectures can be accommodated. Variety can occur not only in terms of 'core' versus 'local' across the board, but each 'core'/'local' mix and interface can be defined, maintained and changed in precise response to individual local site requirements.

The two-dimensional topology therefore implement all the architectures cited above:

- *Centralized* architectures have a 'local' content of zero;

- *Decentralized* architectures have a 'core' of (near) zero;

- *Integrated* architectures have a varying 'core' to 'local' ratio for each element and/or for each location.

There is also no structural hurdle in the 'core/local' topology for the migration between global business strategies:

- The large 'core' of an Exporter/*Global*[9] firm would
- shrink as the autonomy of the parts of a National Adaptor/*Multinational* increases;
- reestablishing global control for the Central Coordinator/*International* would increase the size of the 'core' again and decrease 'local' parts until they reach
- equilibrium in the Global Coordinator/*Transnational* with specific 'core/local' ratios for each business unit.

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[9] Butler Cox and *Bartlett and Goshal* nomenclature.

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POTENTIAL BENEFITS OF THE 'CORE/LOCAL' ARCHITECTURE

Two main areas of benefit arising from the adoption of the two-dimensional topology are discussed below:

- It would provide a coherent and separate framework aimed specifically at the use and exploitation of information technology in applications of high environmental diversity (i.e., international systems);

- It would point to a different way of building international systems.

A Framework for Using Information Technology Globally

King and Sethi (1993) point out that "Past literature has generally ignored the international aspect of IS . . ." and they therefore expected that international systems developments "would fail to show any coherent strategy . . ."

A framework such as the two-dimensional topology, which can cater for all constellations of business strategy and the resulting systems and technology architectures could be useful:

- In the first instance as a formal, structured depository for case experience in order to build up a body of knowledge;

- Subsequently as a vehicle for developing codes of good practice for the creation and implementation of international systems. Eventually this could lead to the development of a specific systems development life cycle for international systems.

Implications for Systems Development

Designing and developing an international system, following the two-dimensional architecture, would involve the three generic design domains (one for each generic element, as shown in Figure 6) of the international systems architecture:

- The 'core' of common systems (infrastructure and applications);

- The 'local' systems;

- The 'core'/'local' interfaces.

These systems parts would lso be developed in three distinct steps. First, the global business strategy would guide the definition of the 'core' parts. Deciding the nature of the infrastructure elements and delineating which functional applications are to be rigid across local sites would be the major design parameters.

The definition of the core parts would then allow a detailed specification of the core/local interfaces, in terms of technical standards for the infrastructure elements and in terms of data and information standards and formats for the functional and application systems parts. The

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technical specifications, taking into account any processing requirements and constraints as implied by the data/information interfaces, would then define a common technology platform.

Figure 6. The Three Design Domains of an International Information System
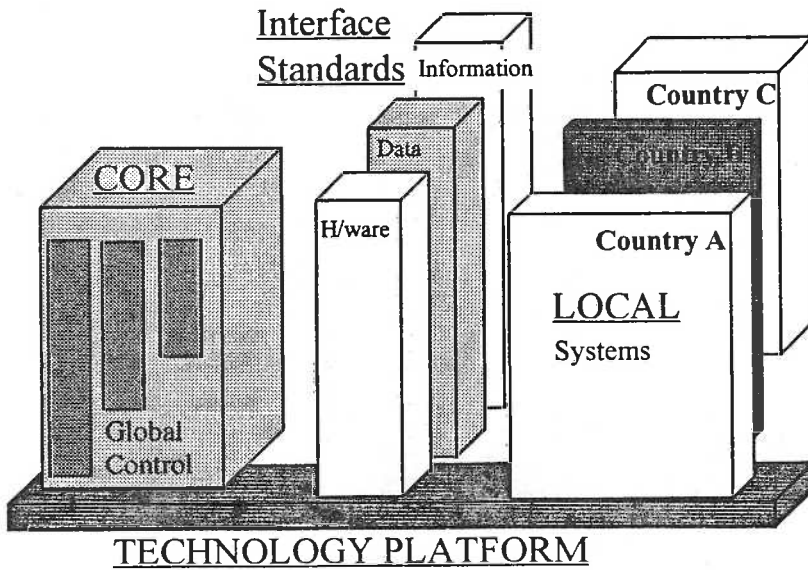
'Local' systems would be defined to complement 'core' applications requirements where these exist, or follow, within the framework of the technology platform, entirely their own specifications.

Table 2 provides an overview of some of the major design considerations for each of the element components within the three generic design domains.

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Table 2. Design Issues Across the Generic
Domains for Each Element Component

	CORE	CORE/LOCAL INTERFACE	LOCAL
People	Level of Technical/Applications Support and Training	Responsibility for Maintenance?	Level of Technical/Application Support and Training
Procedures	Reporting/Operation Cycles	Performance Management and Contingency Planning	Compliance with 'Core' Reporting/Operation Cycles
Data	Common Data Models; Data & Information Interchange Standards	Technical & Legal Data Communications Considerations	Fit 'Core' Data Models Into Local Applications (e.g., Schema Mapping, etc.)
Software	Delimiting Functionality	Attached to Core/Local?	Availability of Adequate Local Software Under 'Core' Constraints
Hardware	Common Denominators of Local Availability	Common Denominator of Local Compliance Ability	Availability of Adequate Local Hardware under 'Core' Constraints

These system parts could be developed in three distinct steps and by independent teams within overlapping, or, in the case of 'local' systems acquisition projects, parallel time frames. This would:

- Break down and simplify the design task, defusing the complexity;
- Spread, and thereby reduce, the development risk;
- Increase the predictability ⏍f project outcomes.

An illustration of such a development framework is given in Figure 7.

While this working in parallel would undoubtedly bring tangible time savings, the reduction of complexity and the related increase in project success is probably the more significant benefit. However, the concerted and synchronized team effort will also result in significantly increased management complexity in the supervision and progressing of a number of interlocking systems projects.

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Figure 7. Parallel Development of an International Information System
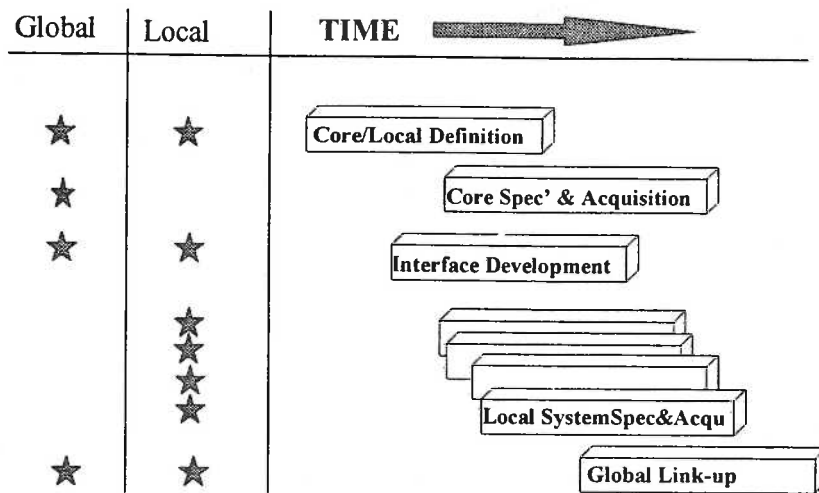
CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

Although they are very important, there is only a small and diffuse body of literature on the nature of international systems.

The literature suggests a correlation between the architecture of international information systems and global business strategy. Three generic architectures are distilled from the literature. The centralized structure is not specifically relevant to international systems. The autonomous structure by definition is not a coherent information system. It is only the integrated systems structure which is of relevance to international information systems. It thus forms the base for the suggested architecture model, a two-dimensional topology, consisting of a core of common technology and different parts for local environments.

The architecture has significant implications for the modus of development of international systems. Using this architecture as a framework for the building and implementation of global application systems allows in the first instance a systematic accumulation of a body of knowledge about this process and in the second instance enables a modular and parallel systems building approach. This makes the development process more predictable, shortens it and spreads the risk. The two-dimensional structure also provides in-built flexibility for gradual future enhancement.

To be of practical use, however, more research into developing a structure and architecture of international information systems is needed. As this is a theory building exercise, a multi-stepped research process is appropriate. Beginning with a grounded theory approach to 'anchor' the basic concepts in empirical fact and then subsequently using a 'triangulation' design with multiple-case studies to develop more specific hypotheses and quantitative measures to verify them.

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