Modeling the Social & Technical Processes of Interorganizational Information Integration

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Abstract

Government leaders and IT executives increasingly recognize that interorganizational information integration (III) is a critical and complex process. Due to the need for integrated information at all levels of government, interorganizational information integration can no longer be pursued through ad hoc approaches that primarily rely on intuitive understandings of the way government operates [1]. *This paper presents an effort currently underway to model the social and technical processes of interorganizational information integration to improve our understanding of information system development and of interorganizational collaboration. This research seeks to enhance both the conceptual and practical models of III by building new understanding of the interaction among the social and technical processes in interorganizational information integration.*

1. Introduction

Government leaders and IT executives increasingly recognize that interorganizational information integration (III) is a critical and complex process. Due to the need for integrated information at all levels of government interorganizational information integration can no longer be pursued in an ad hoc approach that primarily relies on intuitive understandings of the way government operates [1].

This paper presents an effort currently underway[1] to model the social and technical processes of interorganizational information integration to improve our understanding of information system development and of interorganizational collaboration. This research seeks to enhance both the conceptual and practical models of III by building new understanding of the interaction among the social and technical processes in interorganizational information.

In *Building the Virtual State* (2001), Jane Fountain offers a concise statement of the core problem for government: "New information technologies are enacted -- made sense of, designed, and used -- . . . through the mediation of existing organizational and institutional arrangements with their own internal logics or tendencies. These multiple logics are embedded in operating routines, performance programs, bureaucratic politics, norms, cultural beliefs, and social networks (p.12)." It is the interaction of these "multiple logics" that we propose to investigate, drawing, as Fountain does, on the research lenses of political science/public management, organization theory, and information technology.

Models of the social and technical processes of integration will be generated through a multi-method, multidisciplinary effort. These models will be used to answer two basic questions:

1. What are the critical factors and processes involved in integrating information across levels and agencies in government?
2. How do IT and social factors interact to influence the effectiveness of interorganizational information integration?

A brief examination of existing efforts to develop frameworks for III by practitioners and a brief review of the current literature on social and technical process interactions in information systems development is presented as a warrant for this work. The current practical frameworks and theoretical models do not sufficiently account for the interactions among the social and technical processes that play out throughout integration initiatives. Models will be developed through a multi-context examination of selected integration initiatives.

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2. The Emergence of Architecture Frameworks in the Private and Public Sectors

The importance of establishing an architecture framework and its role in information integration emerged in the private sector during the 1990s. The combination of advancements in information technology in terms of computing capacity and speed and the evolving global business environment, which was characterized by mergers, downsizing, and the growth of e-commerce elevated the role of IT [2] [3] [4] [5]. Companies increasingly faced global market competition, which required "speed and flexibility" and, at the same time, "low cost and efficiency" to survive [6]. IT was viewed as a tool for radically changing the way companies did business; shifting it from a "back-room" business support service to a business driver. As the role of IT increased and information systems infrastructures began to grow in complexity, companies began seeing the need for both descriptive representations of companies IT architectures and the importance of aligning IT development with a companies business processes. By the mid-1990s, senior IT professionals' number one issue became building and maintaining a reliable and responsive infrastructure [3]. Continuing budget issues required IS executives to justify new investments and account for their resources [3]. As a result, less comprehensive and formal information systems architectures evolved into architecture frameworks. These frameworks included rigorous classification and organization of the architectural representations of the business processes, organizational structures, and information technology infrastructures used to guide the design and reengineering of core business processes.

The need for similar architecture frameworks in the public sector was realized at the federal level in the mid to late 1990s. Beginning with the Clinger-Cohen Act of 1996, federal agencies were required to develop "information technology architectures" in an effort to streamline IT investment throughout the government. Moreover, there was a perception among some federal agencies that IT offered a promising solution for doing more with less in times when downsizing and budget reductions were quite popular [7]. Unfortunately, the lack of both executive sponsorship of information systems architectures as a funding priority at the agency level and expertise in architecture frameworks resulted in minimal progress in this endeavor [8] [9]. Since then, the perceived need for public sector architecture frameworks has intensified as a result of the continuing economic downturn and the impact of the terrorist attacks of September 11, 2001. The combination of severe federal and state budget crises and intensified homeland security efforts now demands a higher level of "speed and flexibility" and "low cost and efficiency". The high priority the U.S. federal government has placed on architecture frameworks was evident in the President's 2002 guidance for developing the fiscal year 2004 budget. The instructions on budget execution required, for the first time, that government agencies align their budget justifications with the government's architecture framework initiative, the Federal Enterprise Architecture [10].

2.1 Architecture Framework Tools for the Public Sector

Comprehensive and detailed models of architecture frameworks are emerging from developments at the federal and state levels including Connecticut, Kentucky, Missouri and North Dakota. Chief information officers at both the federal and state level recognize that developing and implementing architecture frameworks can be expensive, challenging, and time consuming for agency IT professionals. To assist agencies in this difficult but essential task, both the federal government (under the direction of the Office of Management and Budget) and state chief information officers (with the National Association of State Chief Information Officers) are developing guides and tool-kits to assist agencies and to standardize the process. While the federal and state efforts differ in approach and tools they are grounded in two fundamental principles.

Holistic – The framework should include multiple architectural representations encompassing the business processes, organizational structures, and information technology infrastructures within and across agencies.

In the Federal Enterprise Architecture organizational and business process architectures are developed using the Business Reference Model , and information technology architectures are developed using the Data and Information Reference, the Application-Capability, and the Technical Reference Models [10]. In the NASCIO tool-kit organizational architectures are developed using the Governance Architecture Framework, business process architectures are developed using the Business Architecture Framework, and technology architectures are developed using the Technology Architecture Framework [11].

Cross-agency architecture standardization – The framework should include a jointly agreed upon logical structure for classifying and organizing the individual architectures (i.e., business processes, organizational structures, and information technology

infrastructures). With the NASCIO tool-kit these are developed using the Governance, Technology, and Business Architecture Frameworks [11]. At the federal level, standardization is achieved using each of the Federal Enterprise Architecture models [10].

The federal and state architecture framework development tools and guides are relatively new and incomplete (initial models and frameworks published in 2002) with subsequent tools and sections forthcoming. They provide government leaders and IT practitioners with templates and instructions for the construction of holistic and rigorous frameworks to help bound the complexities of integration. Current federal and state efforts recognize that integration requires a comprehensive and disciplined approach to looking at and analyzing business processes, organizational structures, and information technology infrastructures within and across government agencies. However, integration is a process that involves the interaction of social as well as technical factors.

While an essential component of any intergovernmental integration effort, architecture frameworks have one major limitation: they are static. They depict technical and social factors as related but existing within separate environments. What is currently missing is knowledge about how technical and social factors will interact to influence the effectiveness of interorganizational information integration. Identification of these factors and processes in an integration strategy is a first step in helping government agencies establish and maintain collaborative relationships in which knowledge sharing is critical to resolving issues such as data definitions and meaning.

3. Perspectives on Information Integration

Social processes such as decision-making, collaboration, and conflict resolution are critical components of integration. Social processes interact with resources (e.g., *architecture frameworks*, political will, and interorganizational policies) to produce integration artifacts (e.g., integrated system architecture; standards and data definitions; interoperable hardware, and revised *architecture frameworks*). These social and technical interactions, if studied, can offer very valuable theoretical and practitioner insight into how social processes influence and are influenced by interorganizational information integration.

A sociotechnical framework will be used to understand the complex web of mutual causality among factors that influence the ability of organizations to integrate information [12]. Sociotechnical theory emerged from the work of Trist in the 1950s and 60s to provide a framework for joining the social and technical perspectives of organizational study. This foundational work relies on two essential premises: “in a purposive organization in which people are required to perform functions, there is a joint system operating: a social and a technical system. The performance of an organization is a function of the fit between these two systems. Second, every sociotechnical system is embedded in an environment that is influenced by a culture and its values and sets of generally accepted practices, and the environment permits certain roles for organizations, groups, and people” [13].

Integration processes often involve new work processes and significant organizational change. Moreover, designing and implementing cross-agency information integration is a lengthy process, involving learning and evolving interorganizational relationships. The social and technical processes of interorganizational information integration can be modeled in ways that improve our understanding of information system development and of interorganizational collaboration and therefore capture some of the “learning,” which is generated from the integration effort itself. Moreover, such models would contribute to new theoretical insights for developing and implementing advanced applications of IT.

To better understand these interactions, information integration must be viewed holistically, as embedded in four different but related contexts. Each has related theoretical perspectives useful for studying information integration processes. The contexts are nested as shown in Figure 1 below.

The figure illustrates how a specific technology solution for integration, which relies on the concepts and techniques of computer and information science, depends also on connections and interactions with the relevant business practices of the involved organizations. These, in turn, involve work flows, information flows, and decision processes in each organization. The interaction and adaptation of business processes across organizations is shaped in large part on other elements of the larger multi-organizational setting (such as resource sharing and trust), which can be studied from the perspective of interorganizational relationships and collaborative structures. These relationships and structures are influenced, in turn, by factors in their shared environment. At this macro level, influences can be examined from the perspectives of such fields as political science. Highlights of the research literature pertaining to each of these four contexts are summarized in the next section.

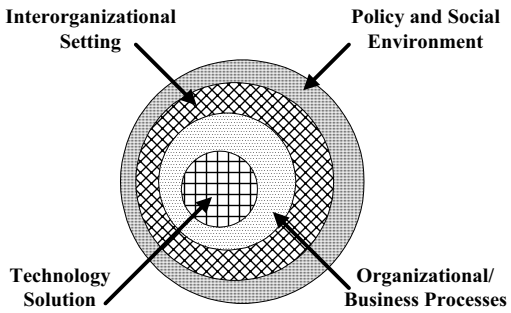

Figure 1. Contexts of Information Integration

4. Interorganizational Information Integration as a Process

The foregoing research traditions lead us to conceptualize integration across distributed information sources and organizational boundaries as a complex social process in which technological and organizational artifacts are developed and assembled for the purpose of information use. Integration components are organized into the groups shown in Table 1 below.

Table 1. Components of Information Integration

Social Processes	Resources	Organizational Artifacts	Technology Artifacts
• information and knowledge sharing • collaboration in work processes • trust building • negotiating • decision making	• leadership and authority • skills, materials, and facilities • interorganizational policies • resource allocation mechanisms • political will	• goal alignment • policies • management structures and decisions • interpersonal relationships • contracts and other agreements • trust • incentives • norms • social translation techniques • shared understandings • life-cycle/ budget-cycle alignment • integrated work rules and procedures	• physical networks • integrated system architecture • interoperable hardware • protocols • standards and data definitions • integrated applications • process maps and models • integrated databases and data warehouses • analytical and decision support tools • technical reports and analyses

The social processes identified in the first column are generic ones we expect to be involved in typical interorganizational relationships [14] [15]. The processes require resources, both tangible and intangible, to proceed (second column). The results of the social processes of developing integrated information systems and resources result in a potentially wide range of organizational and technological artifacts (columns three and four).

These components of information integration can be thought of as having influences on access to and use of integrated information in several ways. Analysis of the interaction of social and technical processes develop and explore alternative models of these influence relationships. A preliminary model based on the material in Table 1 is shown in Figure 2 below. The achievement of integration requires the development and use of IT artifacts, which are embedded in a social process. The artifacts are developed jointly, through emerging social and technical processes. Thus the full significance and effects of any technological artifact cannot be separated from the related processes and organizational artifacts. Artifacts thus embody both technical and socially constructed attributes, resulting from the interaction of social and technical actions and decisions along the development path.

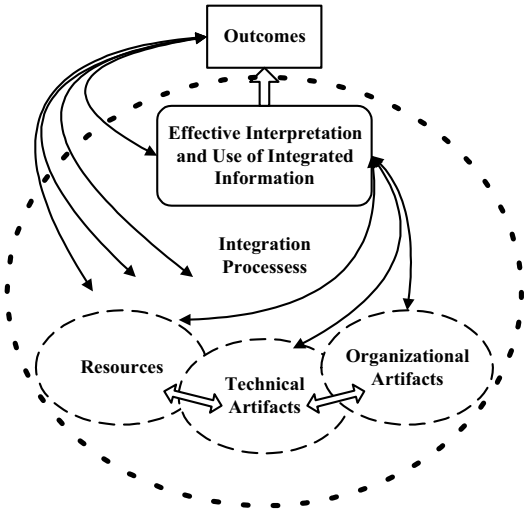

Figure 2. Relationship of Integration Components

These social and technical processes are embedded in four different but related contexts: technology, business process, interorganizational, and political. Therefore advancing understanding of information integration must be viewed as a multi-disciplinary undertaking. Such a multi-disciplinary perspective can enhance government leaders and IT professionals' ability to look beyond traditional organizational and information systems technology boundaries. This ability is critical to the success of their information integration initiatives.

4.1 The Technology Context

Issues of meaning and semantic translation are central to integrating and sharing information from diverse, distributed sources such as data bases, text files, images, or web sites. Solving the technical

problems of access and use of information from these diverse sources typically involves development of standards, platform and application interoperability, metadata, and use of algorithms and other software devices. These address the problems resulting from unstructured textual information and natural language names for objects and data by developing automated matching methods [16] [17]. Other techniques involve constructing systems of ontologies that provide the underlying structure for alignment of meanings across heterogeneous data bases [18] [19] [20]. These methods have the potential to greatly reduce the cost of manual searching and translation processes and make automated searching and matching of heterogeneous data feasible in large data base environments. However, these methods will not in themselves resolve issues of agreement about the significance or use of integrated data or problems of policy in the public sector [21].

The changing and expanding use of data in governmental and private organizations demands increased attention to all the components of data quality – accuracy, timeliness, consistency and completeness [22]. Until recently this attention was confined to improving the quality of data generated and used within single organizations. Today, the effectiveness of both public and private organizations often depends data exchanges with others. As more organizations deploy and use communication networks in their day-to-day processes, sharing and integrating data across institutions becomes more attractive and more feasible [23]. However, integrating large amounts of data that often differ in form, as well as organizational and geographical origin, poses a myriad of challenges in ensuring the quality of the integrated data. These problems arise because the integrated data reveals broad inconsistencies in definition, content and overall quality, even when the individual data sources appear to be valid [24]. Moreover, data quality cannot be evaluated, and hence improved, independently of the context in which data are produced, stored, and used. Whether data are of high quality depends on the characteristics of the resulting integrated information infrastructure and on the demands of the tasks that use these data [25].

4.2 The Business Process Context

The tasks and production processes of complex organizations have been the subject of research since the early 20th century when Taylor offered his principles of scientific management that so strongly influenced the structure and functional specialization of business and government organizations [26]. Work processes, including decision processes, have interested contemporary scholars especially as they relate to productivity and information technology. Hammer & Champy (1993) contend that over time processes lose their connection to productive purposes and become rigid and self-perpetuating. Productivity breakthroughs demand radical re-engineering of entire organizations. Taking a less dramatic view, Davenport (1993) recognizes the intractability of complex organizations and advocates more selective process innovation, coupled with applications of advanced IT to achieve performance improvements. Zuboff (1984) studied the infusion of information technology into work processes and the effects that the technology has on the discretion of workers, the means of process control, and the meaning of work. Information systems are commonly understood to embed processes and information flows in complex software, which become difficult to change and have strong influences on the work of the organization and its employees, managers, and leaders. Information integration demands that the work processes of multiple organizations be both understood and mutually adjusted. However, the development of separate operating procedures, control mechanisms, information flows, and work flows make such integration exceedingly difficult, leading to serious problems, quick disintegration, or outright failures of information system initiatives that depend on not only information integration but process integration [27] [28].

4.3 The Interorganizational Context

Sharing and integrating information among organizations depends on the creation and maintenance of interorganizational relationships. The formation of these relationships, involving differing goals and interests, requires negotiation and the development of commitment [29] [30] [14] [31]. The strength and richness of resource commitments and their distribution can be influential [32] [15]. The development and maintenance of the relationships may also be critically dependent on trust [33] [34] [35] [36] [37] [38]. Knowledge and information sharing among organizations is also characterized by substantial risk, resource constraints, and conflict [39] [40]. Some risk and conflict come from differences in expectations and goals the various parties bring to the sharing process [41] [42] [43]. These differing expectations may reflect each party's individual and organizational history [44] [45], or simply variations in the characteristics of the individuals or organizations [46]. Interorganizational relationships are also influenced by the characteristics of the problem or goal motivating the activity.

Interorganizational relationships may result from mandates, or common interests [30] or interdependence [47] [48] or from the need to resolve a variety of different problem situations [41]. In addition, there may be substantial disagreement among potential participants about the level or exact nature of the problem to be addressed [46].

Interorganizational networks in the public sector have traditionally been studied as political structures [49] [50] [51] [52] and more recently as dynamic operational partnerships (for example, [53] [54]. The bureaucratic and institutional issues surrounding interorganizational networks in the public sector have also been the subject of recent studies [55] [27].

4.4 The Political Context

The political environment of government agencies exerts strong institutional and situational influences on information integration. Our focus on government organizations requires attention to bureaucratic and political theories. Most government activity is defined and funded through legislation that creates specific programs and assigns responsibility for those programs to specific agencies. This web of vertical relationships leads agencies to focus on their own programs rather than on cross-boundary issues or linkages with outside organizations. These program boundaries are powerful barriers to collaboration [55] [56]. Agency staffs develop deep knowledge and expertise in their respective programs and protect their ability to act with discretion and autonomy [57]. Since information integration may subject agencies to external evaluation and criticism, agencies seldom regard program information as an asset of the whole agency, the entire government, or the public [41]. Since cooperation across organizations implies joint responsibility and shared control, it often involves coordination, monitoring, and feedback that can potentially damage legitimacy and integrity if cooperation fails [58]. Dawes (1995) contends that some of these barriers can be lessened by policies that encourage information use and stewardship (rather than ownership) and by the creation of practical tools, such as metadata inventories and standardized data sharing agreements. Landsbergen & Wolken (1998) propose similar tools including an economic model to help agencies identify costs and benefits of information integration. Citing the experiences of information technology initiatives sponsored by the National Partnership for Reinventing Government, Fountain (2001) maintains that strong institutional pressures and existing incentives and resource allocation patterns mitigate against even the most highly visible and politically popular integration efforts.

5. Multidisciplinary Models of Interorganizational Information Integration

Modeling the dynamics of interorganizational information integration over time contributes to a neglected aspect of information technology research, namely understanding the way IT systems and artifacts emerge from social and technical interactions. Upon reviewing ten years of information systems development research, Orlikowski and Iacono (2001) note,

"We need to generate new theories to help us make sense of these processes, particularly if we are to understand the dynamic and unprecedented technologies and uses comprising contemporary initiatives . . . Even the ensemble views of technology, which do engage with the social and embedded aspects of technology development and use, tend not to take into account the multigenerational and emergent aspects of technological artifacts that arise as designers, developers, users, regulators, and other stakeholders engage with evolving artifacts over time and across a variety of contexts" (p. 132). It will provide a basis for better understanding the place of the IT artifact in the context of practice as well as information and knowledge sharing [59] [60].

This eighteen month effort will seek to generate new theories necessary to help us make sense of the social and embedded aspects of technology development and use. It will provide insight into the complexity of III and the nature of the interactions among embedded social and technical processes.

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