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Toward a Theory of an IT Integration Infrastructure

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TOWARD A THEORY OF AN IT INTEGRATION INFRASTRUCTURE

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Abstract

Not long ago, the IT profession was concerned with integrating islands of information. Then the focus shifted to integration of applications to form enterprise systems. A major challenge of the new millennia is the integration of IT infrastructures that have emerged as technology rapidly advanced during the past couple of decades. This holistic view is similar to many ideas found in Stafford Beer's viable systems model. Information technology infrastructures have been the focus of much research during the past two decades. Unfortunately, infrastructure is a ubiquitous term applied to many systems and structures for both IT and non-IT areas. Infrastructure research has been conducted for information infrastructures, network infrastructures, enterprise system infrastructures, hardware infrastructures, and the like. IT infrastructures do not exist in a vacuum but rather depend upon and interact with other infrastructures found in organizations and society. A relatively new phrase is integration infrastructure, which is currently an ill-defined concept. This research proposes a model to represent the antecedents, components, and relationships of an integration infrastructure. The paper suggests that an integration infrastructure is the "glue" that holds the other IT infrastructures together and allows them to work together. Integration infrastructures are artificial mechanisms created by organizations to meet their specific needs. Since organizations depend on different stakeholder groups to create, integrate, and manage IT infrastructures, technological frames can be useful for operationalizing the model. A recent empirical study supports parts of the proposed model.

Keywords: Model, theory, integration, MIS, infrastructure

Introduction

IT infrastructures have gained much research attention during the past two decades (Richardson et al. 1990; Allen and Boynton 1991; Niederman et al. 1991; Brown and Magill 1994; Lee et al. 1995; Broadbent and Weill 1997; Cross et al. 1997; Brown 1999; El Sawy et al. 1999; Bharadwaj 2000; Dejnaronk and Tadisina 2000; Shaw 2000; Taudes 2000; Orlikowski and Barley 2001). An IT infrastructure is "A base of shared technological, human, and organizational capabilities that provide the foundation for computer-based business application systems in the form of services to users" (Dejnaronk and Tadisina 2000). Niederman et al. (1991) found that IT infrastructure first became a key issue for practitioners in 1987.

The contribution of this paper is a proposed model that represents the antecedents, components, and relationships of an integration infrastructure. Additionally, an expanded view of IT alignment is described based on past literature. The authors posit that (1) there are more IT infrastructures than has been previously discussed in the literature, (2) The need to integrate IT infrastructures is similar to past efforts to integrate islands of data, and (3) The scope of infrastructure integration (alignment) should be greater than previously called for. Our field research supports the views of other authors that integration is an ill-defined topic and is not well understood by practice.

Not long ago, the IT profession was concerned with integrating islands of information. Then the focus shifted to the integration of applications to form enterprise systems. A major challenge of the new millennia is the integration of several infrastructures that have emerged as technology rapidly advanced during the past couple of decades. During the last several years, the emphasis of senior IS professionals has shifted to architecting and infrastructure (Cross et al. 1997). Information technology infrastructures have been the focus of much research during the past two decades. Unfortunately, infrastructure is a ubiquitous term that probably has been used too liberally. The focus of this paper is information technology (IT) integration infrastructure. An IT integration infrastructure is defined as the integration of all the IT infrastructures within an organization, which is an artificial mechanism, created by the organization to meet their specific needs.

The term, "infrastructure" is a term commonly used to describe a variety of structures, and systems, although unfortunately, not very precisely. In general, an infrastructure is defined as:

1. An underlying base or foundation especially for an organization or system.[1]
2. The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons.

Source: *The American Heritage® Dictionary (2000)*

Common infrastructures include utilities (electrical, communications, water, etc), educational, governments, military, and agriculture. These can be classified as societal infrastructures which are different from organizational and industry infrastructures. Organizations depend on a number of external infrastructures like supply chains and distribution networks plus many of the previously mentioned societal ones. While IT infrastructures is the focus of this paper, it is important to remember that they do not exist in a vacuum and therefore typically depend upon and interact with many other infrastructures found in organizations, industry, and society. People, who represent various stakeholder groups, create IT infrastructures. Thus, it seems plausible that technological frames would be useful for understanding how groups view and interpret the numerous technological components of infrastructures as well the infrastructures themselves (Orlikowski and Gash 1994).

The literature contains references to a variety of IT infrastructures including, information, network, database, organizational, hardware, software, and enterprise systems. Figure 1 contains five such infrastructure described in the early 1990s. In some cases, most, if not all of the infrastructures fall under the IT infrastructure umbrella. Broadbent et al. (1996) and others have described infrastructures for: (1) Application Development, (2) Communications Technology, (3) Database and Security, (4) Technical Support, and (5) Web Technologies. Included in these categories are hardware, software, and human-centered activities.

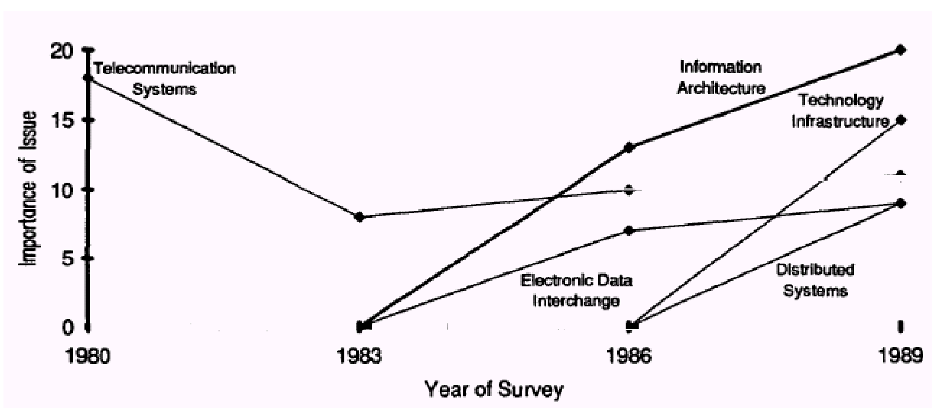

Figure 1. Five IT Related Infrastructures (Source: Niederman et al. 1991)

Regardless of the infrastructure categories or the number of categories, it appears reasonable that integration of infrastructures is required to maximize the full potential of individual infrastructures. In other words, a synergy of infrastructures will yield benefits greater than the sum of the individual infrastructures. This paper suggests that an integration infrastructure is the "glue" that holds all of the various IT infrastructures together to create the desired synergy thereby facilitating the coordination among the infrastructures which allows them to work together. This idea is similar to alignment of IT infrastructures with the organization as suggested and researched by Brown and Magill 1994; Lee et al. 1995, and others. Approaching IT as a holistic

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[1]Usage Note: The term infrastructure has been used since 1927 to refer collectively to the roads, bridges, rail lines, and similar public works that are required for an industrial economy, or a portion of it, to function. The term also has had specific application to the permanent military installations necessary for the defense of a country. Perhaps because of the word's technical sound, people now use infrastructure to refer to any substructure or underlying system. Big corporations are said to have their own financial infrastructure of smaller businesses, for example, and political organizations to have their infrastructure of groups, committees, and admirers.

infrastructure is consistent with the Viable Systems Model that suggests systems modules be considered as a whole and not just the components so that the total system can be aligned with the environment and the purpose for which the various infrastructures where created (Beer 1979, 1985).

The Literature

Integration is a widely applied concept in science, engineering, and economics as well as IT (Pelkmans 1980; Anderson 1991; Hill et al. 1993; Davenport 1998). To avoid continually expanding the scope of this research, the review of integration is limited to what can be discovered in IS/IT literature. References to integration as an act or a state can be found in discussions of applications (as a whole), computer programs and modules, business processes, data, and technology.

A closer look at the ubiquity of integration reveals not clarity but a tangled mess. Generally, the concept of integration is offered without definition; its value and the source of its value are generally unexamined. This situation becomes even more complex when placed in the context of enterprise systems due to their large scale and scope. Bhatt (1995) proposed that integration for ES is "the extent various information systems are formally linked for sharing of consistent information within an enterprise." Elaborating on integration, Kalakota and Whinston say, "The goals of integration are often the indicators by which the effectiveness of computing in organizations can be judged" (1993, p. vp[2]).

History of IT Integration

At ICIS 1998, the introduction to Panel 3 states:

> "Since the early days of computing, organizations have aspired to integrated, enterprise-wide information system architectures. Throughout the years, these aspirations have been reflected in the quest for integrated MIS, enterprise-wide data models, and integrated databases." (Veth 1998, p. 410)

Integration pursuits date back to the dawn of the computer age. The idea for enterprise-wide integration was considered as far back as the 1950s and 1960s (Alsene 1994). IT integration technologies have evolved from interfacing modules of a computer program to coupling of entire organizations with one another (known as B2B). As might be expected, successive generations of integration technologies have become increasingly complex as the scope continuously expands.

It appears that it has been (and continues to be) difficult to study massive and complex enterprise systems because these entities present some unique challenges not addressed in existing literature (Markus and Tanis 1999). Typically, most authors implicitly value integration. Several have discussed various aspects of integration such as data integration (e.g., Herr 1996; McGuire 1999; Goodhue et al., 1992) or inter-application connectivity (e.g., Shanley et al., 1999; Sor 1999). Virtually no academic research is available regarding the problems and benefits of integration for ES. Integration remains an ill-defined topic and the meaning seems to be highly contextual. The meaning also appears to be fluid and changes with the introduction of new technologies (Gulledge and Haszko 2000; Cadarette and Durward 2002).

Most people have implicitly assumed that integration is a success factor without any supporting evidence. It is often implied that integration strategies are an important ERP success factor because people make integration decisions. People base their perceptions of integration benefits on attributes and attitudes. "A major premise of social cognitive research is that people act on the basis of their interpretations of the world, and in doing so enact particular social realities and endow them with meaning…" (Orlikowski and Gash 1994). Fishbein and Ajzen's theory of reasoned behavior also supports this view.

Infrastructures

According to leading researchers, integration is the most distinguishing characteristic of current IT endeavors (ES) and often is a core objective for the organizations that acquire and implement large-scale systems (Markus 2001; Parr and Shanks 2000;

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[2]vp (virtual page) denotes that the article exists only on the web or the article was found on the web but the printed version was not available at press time.

Markus and Tanis 1999; Alsene 1994). Cadarette and Durward remind us that the goal of IT integration is not new and it has not been easy to achieve (2000, p. vp)):

> "…from the dawn of the computing age, integrated automation has been the Holy Grail of computing. And like the Holy Grail, achieving full integrated automation remains elusive, despite huge investments in a wide array of technologies that promise integration…"

One indicator of IT infrastructure importance is the magnitude of the investments that firms have been willing to make. For instance, the costs of an IT infrastructure can exceed 50% of the total IT budget in large companies (Broadbent and Weil 1997). This seems perfectly reasonable since "Increasingly, infrastructure is viewed as the enduring IT resource…" (Cross et al. 1997).

"IT infrastructure is defined as the shared IT capabilities that support information flow in an organization" (Shaw 2000). IT infrastructure consists of IT services, human IT infrastructure, and other IT infrastructure components (Broadbent et al. 1996). IT infrastructures must be well integrated into the overall infrastructure of the organization for the true benefits to be realized. "Aligning IS solutions with business goals and needs as well as building the infrastructure for technological integration are becoming the top priorities for IS activities" (Lee 1995 p. 332). This is similar to the notion of congruence of technological frames for stakeholder groups (Orlikowski and Gash 1994). However, we should extend this idea to include congruence of an IT integrated infrastructures with organizations in order to achieve alignment.

Different approaches to IT infrastructure implementation have been found. Investments in IS infrastructure often take the form of "corporate wide networks, central data collections, common business practices, common application systems, and standardized hardware, operating systems, and databases" (Allen and Boynton 1991, p. 440). The federal or hybrid form seems well suited for some large corporations so they can exercise central control over IT infrastructure decisions but allow business units to have responsibility for their systems development (Brown 1999).

In a 1994-1995 study, IT infrastructure was ranked as the most important key issue in MIS (Brancheau et al. 1996). Dejnaronk and Tadisina (2000) suggest that inadequate infrastructures are a major causes of IS failures for organizations that depend on computer systems. "An IT infrastructure is integral to the transformation of enterprise architecture to suit the needs of the electronic economy" (El Sawy et al. 1999). However, IT infrastructures are only one of several infrastructures that must be effectively integrated for companies to prosper or even survive in our increasingly global economy. This paper suggests one way to view and evaluate the integration of the requisite IT infrastructures needed by organizations.

Proposed Integration Theory

"Nothing is quite so practical as a good theory" (Van de Ven 1989, p. 486 quoting Lewin 1945). Van de Ven goes on to say that, "Good theory is practical…because it advances knowledge…[and] guides research…" There appears to be a general lack of theory about IT infrastructures, especially IT integration infrastructures. This paper reports the authors' progress in formulating a theory of IT integration infrastructures. Admittedly, the proposed theory is in the theorizing stage. However, it appears that the proposal meets many of the tests of theorizing as suggested by Karl Weick (1995, p. 398) who says, "The process of theorizing consists of activities like abstracting, generalizing, relating, selecting, explaining, synthesizing, and idealizing." The paper describes a model that explains the elements and relationship among these elements that are important for organizations that create an IT integration infrastructure to meet their specific needs.

"A theory is the attempt by man to model some aspect of the empirical world" (Dubin 1976, p. 26). The proposed theory attempts to model integration infrastructures so that we can better understand these artificially created mechanisms. IT integration is defined in terms of specific constructs and is the basis of perceptions about integration which directly lead to integration decisions. Integration decisions are responsible for the integration infrastructures that are created. Key motivators also determine decisions. The decisions determine costs and success. A number of environmental issues moderate benefits, decisions, cost, and outcomes. Several stimuli moderate decisions and directly affect motivation. Although not shown in our model, it appears reasonable that certain environmental factors may affect motivation. Finally, there is both a direct and indirect effect between integration attributes and the integration infrastructure.

Figure 2 provides a visual model of an <u>ideal</u> unified integration infrastructure. The graphic depicts nine infrastructures that are coordinated and held together by a tenth super infrastructure – the integration infrastructure. All the infrastructures exist within a specific domain and are subject to numerous external and internal environmental influences and pressures. This paper describes only the IT related infrastructures of the ideal model. The proposed model attempts to represent the various IT infrastructures depicted in figure 2 along with the relationships among them. Due to space limitations, only a parsimonious description of the model's constructs and relationships are given. This is followed by a brief description of recent research that sought to validate a portion of the theory.

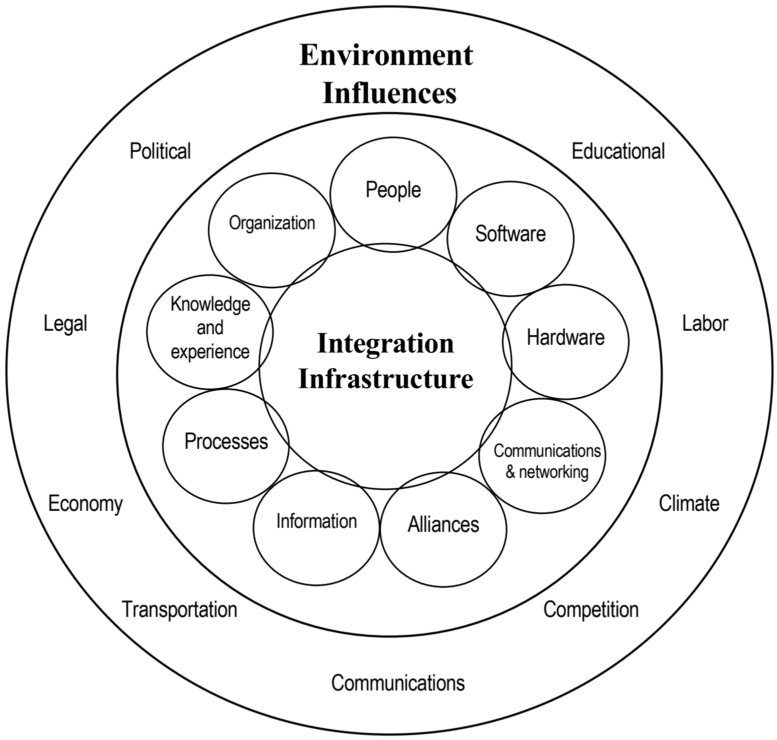

Figure 2. Visualizing a Unified Integration Structure

The theory is described in terms of a graphical model (figure 3) in order to convey the constructs' antecedents and relationships. At this point, the ideas are more precisely reflected in the proposed model than in a theoretical statement. There is some debate regarding the relationship between models and theory although most seem to agree that there is a fine line or no line at all between theory and models (Sutton and Staw 1995; Weick 1995; Whetten 1989; Dubin 1976). Even though we have limited data to validate the proposed theory, this concern is eased by Whetten who says, "During the theory development process, logic replaces data as the basis for evaluation" (1989, p. 491).

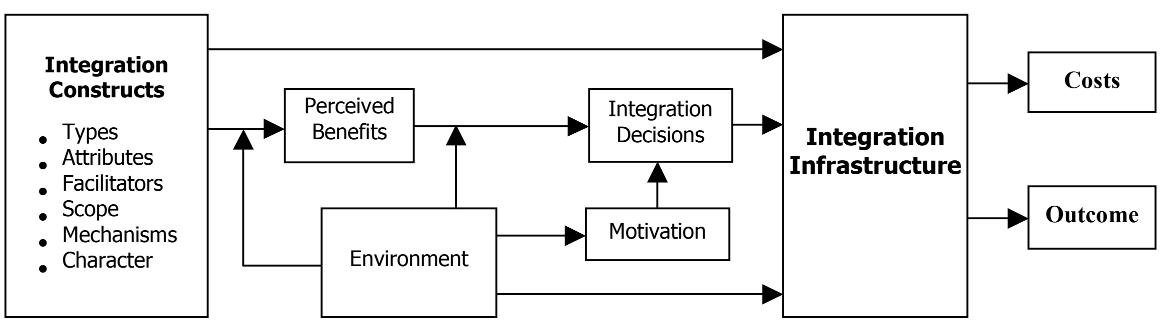

Figure 3. Information Technology Integration Infrastructure Model

Constructs

Each construct is briefly described below along with examples for the construct.

Types – refers to a specific IT domain and is typically called an IT infrastructure or infrastructure component. When a discussion of integration is undertaken without specifying the domain, invariably someone asks the question, "What type of integration are you talking about?" Examples of integration types are data, process, application, platform (hardware and software), and communications. The small circles in figure 2 depict the infrastructure types.

Attributes – are the properties that characterize the relationships among the components to be integrated. They are closely related to "the nature of technology," which is one of the three domains for technological frames (Orlikowski and Gash 1994). Attributes define integration at a very basic level. Example attributes of applications integration include: data sharing, real-time, seamless, connections, and coordination. A combination of attributes is generally required to define integration. For instance, data sharing can occur a number of ways during a variety of time periods. We could *share* data using paper printouts once a month but this would not satisfy the integration requirements envisioned by most people.

Facilitators – are those things that make integration possible or easier. Examples are software (OS and utilities), communication networks, common database, and standards (industry and firm-specific).

Scope – specifies how much integration is desired as well as what is to be integrated. Scope can also be thought of as the amount of integration and the form that it takes. Examples include internal (organizational, divisional, departmental), external (customers, suppliers, government, competitors, alliances, industry organizations, the public), and geographic area.

Mechanisms – refers to the strategy and technology employed to achieve integration. These can be thought of as alternatives. Examples are: coupling intensity (e.g. continuum from loosely to tightly), component ware, packaged enterprise systems, and middleware including XML type technology and semantic database tools.

Character – describes the overall operational characteristics of integration. Examples: functionality, flexibility, configurability, performance (efficiency), ease-of-use, human-computer interface, scalability, and maintability.

Perceived Benefits – are the outcomes associated with integration and valued by individuals and organizations. Benefits are different from reasons although sometimes they are the same. Examples: customer service, competitive advantage, lower costs, functionality, multi-country needs (e.g. accounting standards), scalability, expanded capacity, and to facilitate operational change.

Integration Decision – is the decision to create a specific integration infrastructure and is similar to the "technology strategy" domain (Orlikowski and Gash 1994).

Environmental – is the setting and associated influences that directly affect perceptions, decisions, operations, and outcomes. Examples: political and legal (government), cultural and language (includes religion), knowledge (organization, stakeholders, community), geographic (implies a variety of societal infrastructures like transportation, education, and communications), and economic. Environmental influences and pressures are shown in the other ring of figure 2. Environment is an important component of other models especially the Viable Systems Model (Beer 1985, Leonard 1999).

Motivation – represents the incentives that trigger and provide the impetus for integration infrastructure projects. These include: perceived need, competition, opportunity, available technology, and pressures (vendors, stakeholders, trends, etc.). Motivation is affected by competition, the economy, budgets, stakeholders, current IT infrastructures, security, and management (style, experience, orientation, knowledge).

Integration Infrastructure – is the set of enabling mechanisms chosen to facilitate coordination among IT components and between IT and all areas of the organization as well as the external interfaces to customers, governments, and other organizations. These include standards, policies, procedures, platforms, and guidelines.

Costs – are the actual direct and indirect expenditures of money, time, and other resources to create or modify integration infrastructure.

Outcome – is the IT services that are enabled, created, or acquired as a direct result of integration infrastructure decisions. The results can range from a total failure to 100% success.

Relationships

There is an intimate and necessary relationship between the environment and infrastructure components, operations, and management of infrastructures (Beer 1985). The six integration constructs (type, attributes, facilitators, scope, mechanisms, and character) define integration. While these six constructs are undoubtedly related, these relations are not considered in the proposed model because the relationships do not appear to bear directly on the primary purpose of the theory.

Perceptions are based on attributes and attitudes (Fishbein and Ajzen 1975; Ajzen 1991). Stimuli and environmental factors are phenomenon that, in large part, account for a person's attitude toward integration. Decisions result from motivation pressures (e.g. perceived need) and are based on perceived benefits and anticipated outcomes. However, decisions are greatly influenced by a variety of things that include stimuli (e.g. budget, IT infrastructure) and environmental realities (e.g. knowledge, cultural implications). Actual costs and success are directly linked to specific decisions and are influenced by a variety of environmental factors including knowledge and economic realities of the region and the organization.

Recent Integration Research

This section briefly describes integration research recently completed (Singletary 2003). The research investigated the very essence of information technology integration. Integration is thought to be the most important and distinguishing characteristic of information systems. The research focused only on the integration among applications and was concerned with the attributes (characteristics) and perceived benefits of integration. The study was conducted in two phases.

The first phase consisted of in-depth semi-structured interviews with 51 people representing three stakeholder groups (managers, IT professionals, and end-users) from four different organizations. Phase I participating organizations included two universities and two large petro-chemical companies. The second phase consisted of sending a questionnaire to 941 people in three organizations.

Phase I results revealed that applications integration characteristics consisted of at least three dimensions and perceived benefits represented at least five dimensions. Twenty unique integration characteristics were identified along with 38 unique perceived benefit items. The top five for each category are listed in tables 1A and 1B.

Organizations, collectively, spend billions of dollars to achieve integration. Yet, as this study showed, there was no generally accepted definition of what integration is or what it ought to be. The value of integration is never completely defined either in abstract or practical terms. It is generally assumed that the value of integration is obvious although supporting evidence is lacking. Moreover, an agreed upon standard for how integration should or could be measured is lacking. If you can't measure it, you can't manage it!

Discussion and Summary

In the past, the major concern was integrating islands of information and disparate systems and applications. It appears the trend is shifting to include integration of the various IT infrastructures that have rapidly emerged during the past three decades. This paper proposed a theory of an IT integration infrastructure. The theory was presented as a model to depict the components and relationships. Although in the theorizing stage, the theory appears promising. A segment of the theory was investigated and the results appear to support the proposed model. The theory is a step toward understanding, measuring, and valuation of IT integration. We know that multiple strategies are available to achieve integration but have no evidence that one strategy is superior to another for a given set of circumstances. Yet, integration is the cornerstone of virtually all MIS endeavors.

The primary contribution of this paper is the proposed IT integration infrastructure model. This paper reviewed much of the prior research on IT infrastructures and in doing so has revealed at least two important themes. First, many more IT infrastructures exists than have previously been described. Second, there is a need to integrate these infrastructures to create a holistic infrastructure, which should be integrated with other organizational, industry, and societal infrastructures. Doing so is consistent with the need to align and integrate the IT function (infrastructures) with the business function of the organization as previously called for by other authors. Third, the proposed model is consistent with the primary ideas found in the Viable Systems Model. Finally, utilization of technological frames is appealing to operationalize the model because in reality different stakeholder groups ultimately make and enact integration and infrastructure decisions.

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