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Information flows and business process integration

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Abstract

Purpose – Many business process improvement efforts emphasize better integration, yet process integration can mean many things. The purpose of this paper is to emphasize the importance of information flows to modern business processes, and draw upon recent organizational and information systems literature to characterize process integration and to derive four principles of process integration: accessibility, timeliness, transparency, and granularity of information flows.

Design/methodology/approach – Using a field study, the four principles of process integration are applied to analyze ten different business processes across five organizations.

Findings – In total, 18 generalized activities are identified that describe non-integrated behavior, and "keying in known data" was found to be the most common. Among other findings, analysis highlights the importance of documentation to modern business processes, especially for coordination roles, and the paper describes three different purposes for documentation found in the data: content, process validation, and posterity.

Research limitations/implications – The articulation of "business process integration" offers a foundation for future research in this area. Findings are limited in generalizability to various levels of processes, as well as possible instrument-related biases.

Practical implications – The principles of process integration provide a lens through which practitioners can analyze processes. Empirical findings stress the role of documentation, forms of documentation, and types of non-integrated work.

Originality/value – The paper characterizes process integration in relation to other commonly-used constructs such as organizational integration, data integration, and application integration. Principles are derived from the literature that can guide future inquiry and practice associated with business process improvement.

Keywords Process management, Cross-functional integration, Information strategy

Paper type Research paper

Introduction

"Process integration" is fundamental to many business process improvement efforts. Process-oriented companies are continually integrating their processes (Hammer and Stanton, 1999), and process integration is a key focus for many types of business process reengineering or optimization activity (Wakayama *et al.*, 1998), as well as logistical planning efforts (Sabbath, 1995; Gustin *et al.*, 1995). Process integration is often cited as a key goal associated with the implementation of information technologies such as enterprise resource planning (ERP) (Markus *et al.*, 2000; Al-Mashari, 2003; Robey *et al.*, 2002), electronic data interchange (Mukhopadhyay and Kekre, 2002), or enterprise application integration (Kobayashi *et al.*, 2003; Hasselbring, 2000). However, the notion

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of process integration is not always used consistently, and it is frequently not differentiated from other forms of integration.

For example, in relation to business processes, the term "process integration" has been used to describe the act of process improvement in general (Wakayama *et al.*, 1998; Basu and Blanning, 2003; Mi and Scacchi, 1992; Benjamin and Scott-Morton, 1986), the connection or "synchronization" of two or more organizational processes (Browning, 2002; Hammer and Stanton, 1999; Malone and Crowston, 1994; Barnes *et al.*, 2002), or tightly linking activities or steps within particular organizational or interorganizational processes (Sikora and Shaw, 1998; Kobayashi *et al.*, 2003; Volkoff *et al.*, 2005; Malone *et al.*, 1987; Zaheer and Venkatraman, 1994; Gustin *et al.*, 1995). In manufacturing-engineering disciplines, process integration refers to the optimization of process manufacturing systems such as those associated with chemical processing (El Halwagi, 2006).

Process integration is often not explicitly defined or related to other forms of integration, such as data integration, application integration, systems integration, and organizational integration (Barki and Pinsonneault, 2005; Dougherty, 2001; Markus, 2001; Grant and Tu, 2005). Also, what is known as process integration to some often goes by another name, such as electronic integration (Malone *et al.*, 1987), business integration (Markus, 2000), and integration of information flows (Themistocleous, 2001).

We conceptualize an integrated business process as one in which the effort associated with information flows between activities is minimized, and business process integration describes the practices associated with the minimization of this effort, or the tighter coupling of organizational activities in a business process. Activities become more tightly coupled with each other by minimizing the human effort associated with communication and coordination of their inputs and outputs. As the majority of business processes deal primarily with information-based inputs and outputs (Kock *et al.*, 1997), improving the timeliness, accessibility, granularity, and transparency of information flows between activities in a process is key to business process integration.

In this paper, we will empirically investigate information flows across a ten business processes in five different organizations to better understand the challenges associated with information flows between activities, that is, those that inhibit business process integration. We begin by delineating the importance of information flows to business processes, and then reviewing organizational and information systems literature on integration to ground our conceptualization of process integration. We then develop four principles of process integration. We then contrast the notion of process integration with data quality, process efficiency, and process quality, and we describe an initial research study and present our findings. We conclude with implications for practice and future research.

Processes and information flows

A process is "a lateral or horizontal organizational form, that encapsulates the interdependence of tasks, roles, people, departments and functions required to provide a customer with a product or service" (Earl, 1994, p. 13). It consists of flows and activities (Hammer and Stanton, 1999). An activity "takes an input, adds value to it and provides output to an internal or external customer" (Harrington, 1991, p. 6). The "input" and the "output" represent the flows between activities, and are typically comprised of

information (Kock *et al.*, 1997; Child and McGrath, 2001). The output of one activity in a process is the input for the next one (Malone and Crowston, 1994).

In a study of 22 business processes that included those that generated products for external customers, those that generated products for internal customers, and those that improved other processes, Kock *et al.* (1997) found that approximately 90 percent of the flows were of information. It is difficult to conceive of any process with distinct tasks and activities that does not require information to move it forward. In fact, most of the literature on business process improvement focuses almost exclusively on the role of information and information systems (Broadbent and Weill, 1999; Bhatt, 2000).

That the bulk of process flows are comprised of information can be explained by the distributed nature of activities in a business process. Complex processes are split across individuals and across time in order to efficiently divide labor, leverage expertise, specialize and simplify. Distributed work requires coordination to manage the interdependencies of the process activities (Malone and Crowston, 1994), even though it has no direct impact on the process output. In addition, the attention of individuals is split across processes and projects. Distributed processes require information to flow between activities and personnel within the process and those managing and coordinating it overall. This information often takes an explicit, formal form, known as documentation (Osborn, 1998), or it can be informal, *ad hoc,* or tacit.

The key criteria associated with flows between activities in a business process are transfer and usability (Malone and Crowston, 1994). Transfer involves the timely transportation and communication of information, and usability relates to the understandability of the information and ease with which the information can be appropriated. These are not unproblematic criteria. The literature on integration indicates that different groups responsible for adjacent activities in business processes may not always communicate easily, as their goals, values, dispositions, and practices can be quite inconsistent (Lawrence and Lorsch, 1967; Boland and Tenkasi, 1995) and integration of technical systems can entail a number of tradeoffs (Markus, 2001). Next we will look to organizational and information systems literature to develop the principles by which these information flows can be assessed in order to gain insight into the level of integration of a given business process.

Integration

While a number of different academic disciplines have addressed the notion of integration, research into organizational structures and information systems literature is most salient to discussions of business process integration. From organizational research we draw principles associated with the integration of differentiated, interdependent functional groups (Barki and Pinsonneault, 2005; Lawrence and Lorsch, 1967). From information systems literature we address forms of integration associated with information technology, including data, system, and application integration (Volkoff *et al.*, 2005; Sikora and Shaw, 1998; Goodhue *et al.*, 1992; Markus, 2001). These two streams of literature highlight the importance of information flows to business processes and ground the four principles of business process integration that we propose.

Organizational integration

Integration has long been one of the fundamental problems of researchers studying organizations and their structures. Lawrence and Lorsch (1967) looked at organizations

as a collection of differentiated, interdependent functional units. The level of integration between units was measured by the quality of the collaborative relationship linking them. Essentially, functional units are differentiated across a variety of dimensions, and integration often takes the form of interdepartmental conflict resolution. The level of differentiation and integration between business units varies depending on an organization's environment. Mintzberg (1979), when discussing the key elements of structure, separated the choice of structure into two key decisions: the division of the organizational mission into a number of tasks and the coordination of them. Particular coordination styles – or integrative mechanisms – can vary between functional groups, but also within functional groups as they coordinate the activities associated with specific processes and subprocesses (Mintzberg, 1979).

Despite decades of research associated with the idea of integration, Barki and Pinsonneault (2005, p. 166) found that the concept of organizational integration was still ill-defined and under-theorized. They define the notion of organizational integration as "the extent to which distinct and interdependent organizational components constitute a unified whole," where the components represent functional units along an organization's process-chain. Integration implies a high degree of responsiveness between interconnected functional units, implying rapid access to and interpretation of messages for units that are considered to be highly integrated (Barki and Pinsonneault, 2005). This responsiveness has the effect of tightly coupling organizational units (Orton and Weick, 1990). Integration between organizational units can occur across combinations of sequential, parallel and pooled processes directly associated with a firm's operations, in support of these operations, or interorganizationally. Barki and Pinsonneault (2005) indicate that integration between functional organizational components can require different levels of implementation effort, and lead to different results depending on the type of organizational processes that that integration supports. For example, internal operational organizational integration is generally thought to enable the standardization and streamlining of business processes, leading to greater organizational efficiencies (Barki and Pinsonneault, 2005). In this view, organizational integration is a firm-level construct that supports the streamlining of processes by more closely linking functional units. Thus, the emphasis remains on the integration of functional structures, rather than lateral activities and the flows between these activities. As Child and McGrath (2001) suggested, the shift from material-intensity to information-intensity in the economy puts more emphasis on interdependence and coordination in lateral process streams. While integration of functional organizational units is important for cross-functional processes, this level of integration does not address the integration of activities within a process, and the information flows associated with these activities. For this, we look to complement the literature on organizational integration with that of information integration.

Information integration

Information systems literature shows how information technology can support integration across functional groups, business units, or entire organizations through data integration, application integration, and systems integration (Davenport *et al.*, 2004; Gattiker and Goodhue, 2005; Volkoff *et al.*, 2005; Grant and Tu, 2005; Zaheer and Venkatraman, 1994; Benjamin and Scott-Morton, 1986). For the purposes of this paper, we describe these three forms of integration as "information integration" to capture the

linkage of syntactic aspects of communication associated with business processes (Carlile, 2004).

Data integration involves common definitions of electronic data across functional groups, which can sometimes be problematic due to differentiation between these groups (Goodhue *et al.*, 1992). Application integration involves the electronic linking of autonomous applications (Grant and Tu, 2005; Themistocleous, 2001), and systems integration involves the connection of disparate systems (Davenport *et al.*, 2004; Markus, 2001). Infrastructural linking of systems (i.e. systems integration) is a precondition for the integration of data. Similarly, data integration is a necessary prerequisite for application integration, which involves real-time messaging between applications, computer platforms, and any associated data transformations – both of which is considered necessary for process integration (Kobayashi *et al.*, 2003). Sikora and Shaw (1998) label the combination of data, application, and system integration as "information integration." For information to be truly integrated, however, technical connectivity and instantaneous delivery of data is necessary but not sufficient for process integration, as this data must be structured coherently so that humans can readily interpret it properly (Wakayama *et al.*, 1998).

Information integration is the foundation for integrated processes (Sikora and Shaw, 1998; Wakayama *et al.*, 1998; Davenport *et al.*, 2004; Browning, 2002). However, information integration is not a sufficient precondition for a fully integrated business processes because different individuals and groups responsible for process activities have different information needs, interpretations, and practices.

Process integration

Business process integration involves the minimization of communication and coordination effort between activities of a process. The time associated with the flow of information between distributed activities is a key indicator of the level of integration of a process. The fewer steps and handoffs of information in a process, and the less effort is involved with each handoff, the greater the integration of the process. We have derived four principles of process integration from the literature on organizational integration and information integration:

(1) accessibility;

(2) timeliness;

(3) transparency; and

(4) granularity (Table I).

Next we will address each of these principles in detail.

Principle	Definition	Source
Accessibility	Information is readily available to activities	Malone and Crowston (1994), Culnan (1984), Strong *et al.* (1997)
Timeliness	Information is available when needed	Malone and Crowston (1994), Wakayama *et al.* (1998), Browning (2002)
Transparency	Information is understandable	Barki and Pinsonneault (2005), Lee *et al.* (2002)
Granularity	Information is at the right level of detail	Volkoff *et al.* (2005)

Table I.
Principles of process integration

Process integration necessarily requires information integration as a foundation, and therefore requires the timely transfer of appropriately usable information (Malone and Crowston, 1994). The notion of transfer highlights the first principle of process integration – that information flows in a process be instantaneous (Wakayama *et al.*, 1998). Information timeliness refers to the currency of the information passed from one task to another, along with the instantaneity of the information for the task to be completed. Instantaneity does not mean that information is necessarily processed and transferred instantly. It means that it is provided at the instant required for processing, i.e. there is no delay. Information acquisition is therefore not on the critical path of a series of activities. When assessing timeliness, one has to investigate if each activity could be initiated sooner if information was provided sooner. Information must be provided at the earliest possible start of an activity for timeliness to be achieved.

In addition to being timely, the information must also be accessible. Accessibility refers to the ability to access information from each required point within the process. Beyond the currency associated with the principle of timeliness, accessibility implies the straightforward elicitation of information at the *right* time (Browning, 2002). Accessibility has many consequences. It enables information sharing, treatment of resources as if they were centralized, and the single capture of data. Culnan (1984) defined accessibility as having three dimensions:

(1) reliability;

(2) convenience; and

(3) ease of use.

The user of the information has to be sure that the access method to use the information is dependable and that the information is available when it is supposed to be available. In addition, the access method must be convenient in comparison to other access methods for the data, and finally, the data must be easy to manipulate (Strong *et al.*, 1997).

Simply because information is timely and accessible, does not necessarily indicate that it is the correct information. Different groups interpret information differently, and therefore problem-free communication cannot be taken for granted (Lawrence and Lorsch, 1967; Barki and Pinsonneault, 2005; Boland and Tenkasi, 1995), and different groups often require information at different levels of detail (Volkoff *et al.*, 2005). These two caveats to timely information transfer highlight the criticality of information usability, and also describe two additional principles associated with process integration: information transparency and granularity.

Transparency refers to the ease with which information passed from one task in a process to another can be understood. Where the principle of accessibility addresses the syntactic aspects of process flows, transparency addresses the meaning of these flows, or semantics (Carlile, 2004). Lee *et al.*'s (2002) use of the terms understandability and consistency refer to our notion of transparency. Transparency can be achieved through translation among several "languages" (a more flexible approach) or through standardization (Malone and Crowston, 1994; Davenport *et al.*, 1994). That is, establishing one common language. For example, UPC codes are perfectly transparent. Everyone who uses them knows what they mean and how to interpret them.

The other principle of process integration involves the granularity of the information. All information exchanged in the process has to be provided at the right level of detail.

The level of detail that is required varies between groups and activities (Volkoff *et al.*, 2005). Therefore, either earlier activities in the process are charged with capturing data beyond their own data requirements, or subsequent activities in a process do not have adequate detail for their processes. The common solution of capturing all of the data necessary at the earliest point of the process for all downstream activities can often lead to conflicts among groups in the process (Volkoff *et al.*, 2005). Information passed from one task in a process to another must balance conciseness and completeness. Appropriate granularity enables the elimination of extraneous activities that would be required to decompose or summarize the information.

Based on our review of the literature, we conceptualize an integrated process to be one in which the effort associated with information flows between activities is minimized. This effort can be minimized in accordance with the four principles:

(1) timeliness;

(2) accessibility;

(3) transparency; and

(4) granularity.

The main goal of our empirical research is to assess and explore these principles and better understand how they apply to real-world business processes.

A common strategy for implementation of these principles involves information standardization (Davenport *et al.*, 2004; Volkoff *et al.*, 2005; Browning, 2002; Benjamin and Scott-Morton, 1986). However, standardization is not without risks, as it leads to tightly coupled organizational processes that are rigid in the face of exceptions, leading to occasions of significantly reduced efficiency (Volkoff *et al.*, 2005). Also, tightly integrated processes based on internal standards can have difficulty being extended beyond organizational boundaries (Markus, 2001). The principles we identified, as well as the implications of highly integrated, standardized processes, evoke similar concepts such as process quality, process efficiency, and data quality. Before addressing our empirical evaluation of the principles associated with process integration, we will contrast the notion of process integration with these other concepts.

What integration is not

It may be important to distinguish integration from information quality as well as from the business process improvement objectives of process efficiency and process quality.

Process integration and information quality

Information systems researchers have a long history of assessing information quality and have developed many measures and conceptual schemes to describe it. In one of the earliest studies, Zmud (1978) derived several dimensions of information quality. He found that high quality information was relevant, accurate, factual, complete, reliable, timely, orderly, precise, readable and reasonable. Because he was working with paper reports, accessibility was not part of his scheme. O'Reilly (1982) operationalized Zmud's definition and found that accuracy, specificity, relevance, reliability and timeliness were indicative of information quality as well as accessibility.

Subsequently, researchers have used many additional words to describe the dimensions of information quality. We find that, for the most part, these dimensions are

not mutually exclusive. For example, Delone and McLean (1992) added understandability, and clarity. While these words do indeed have different meanings from those Zmud used, we find it hard to imagine that someone evaluating a system would think that it was understandable but not readable or clear but not orderly. In developing the dimensions of information that result in process integration, it is critical to ensure their orthogonality. They must be mutually exclusive and collectively exhaustive.

To test whether these four principles are both complete and parsimonious for the information aspect of processes, we compared them to the 15 dimensions of information quality developed by Lee *et al.* (2002). Their list is the amalgamation of academic and practitioner views of information quality. Table II provides our categorization.

It appears that integration addresses a subset of overall information quality characteristics. The five dimensions that our properties do not cover refer to the correctness of the data and to its security. It seems to us that correctness is such a basic attribute of information that it need not form part of a measure of integration. Security concerns may hamper the integration of a process, but are not a measure of its integration. For example, if privacy concerns preclude the transfer of data from one task to another, the receiving task may find that the information it is provided is not sufficiently granular. This supports the complete and parsimonious character of the four principles of integration.

Process integration vs efficiency

Integration should not be confused with efficiency, as integration is concerned only with information flows that result from distributed work among individuals or groups. Integration is not concerned with the activities that take place in between these information flows. Efficiency, on the other hand, is concerned with the overall process – both information flows and work in between these flows (Harrington, 1991).

Also, efficiency is concerned with the resources required for a given output, whereas integration refers to the information within a given process. Therefore, although increased integration can often lead to greater efficiency, this is not always the case.

Table II.
Information quality and process integration

Information quality dimension	Process integration principle
Accessibility	Accessibility
Appropriate amount	Granularity
Believability	n/a
Completeness	Accessibility
Concise representation	Granularity
Consistent representation	Transparency
Ease of operation	Accessibility
Free-of-error	n/a
Interpretability	Transparency
Objectivity	n/a
Relevancy	Granularity
Reputation	n/a
Security	n/a
Timeliness	Timeliness
Understandability	Transparency

A highly integrated process could be inflexible, thereby reducing the efficiency of exception handling (Volkoff *et al.*, 2005). Also, there are cases where efficiency and integration are not related. For example, a highly integrated multi-divisional electronic approval process may be well-integrated, but an entirely inefficient means of handling approvals.

Process integration vs quality

The two components of process quality are:

(1) efficacy; and

(2) effectiveness.

Efficacy is concerned with the nature of the output, whereas effectiveness is concerned with the nature of the process itself. Davenport and Beers (1995) refer to this as the performance loop and the relevance loop (based on Argyris and Schon's double-loop learning). The performance loop refers to the ongoing activity, whereas the relevance loop is concerned with the overall process output and its fit with the organization. Our notion of integration falls solidly within the performance loop and overlaps with effectiveness only insofar as the level of integration enables participants to perform their tasks. If too much or too little integration prohibits participants from performing their activities effectively, then the integration can influence effectiveness. However, a highly integrated process may have no impact on process effectiveness if, for example, the individuals are too inexperienced to adequately perform their tasks.

We characterize business process integration as the minimum of effort associated with information flows between activities in a process, and we propose four principles of process integration. Next we describe our empirical research undertaken to explore business processes using these principles.

Methodology

We undertook empirical research to determine whether the principles we associate with process integration: accessibility, transparency, timeliness and granularity, can be differentiated empirically, and how they might offer insight into business process improvement. In order to accomplish this, we investigated whether these properties are mutually exclusive and collectively exhaustive. We also investigated the differences between activities that directly produce or contribute to the output of the process (professional/technical work) with those that indirectly contribute, or coordinate (managerial/administrative). Malone and Crowston (1994) refer to these as production and coordination activities.

Ten processes from five different organizations were analyzed using a *field study* approach (Stone, 1978). Although similar to a case study, the field study allows for a more systematic means of obtaining information, albeit a less thorough one. Given the early state of understanding and the preliminary nature of the principles associated with process integration, a highly detailed study would have been premature. Instead we chose interviews and limited observation to inform our research.

We worked with a convenience sample, choosing business processes from four industries. In some cases comparable processes within an organization were also measured. Forty-two process participants in ten different processes from five different organizations were interviewed (Table III).

Organization	Process	No. of interviews
Bank	Problem management process	7
Home Builder	Scheduling process	5
Manufacturer	Engineering change process 1	8
Manufacturer	Engineering change process 2	4
Bank	Waterfall project management process	4
Bank	RUP project management process	4
Hospital	Patient admission process 1	8
Hospital	Patient discharge process 1	7
Hospital	Patient admission process 2	4
Hospital	Patient discharge process 2	4

Table III.
Sample

The objective of the interviews was to accurately create a process map with a particular concern for information flows between activities, to document instances of process integration issues associated with each task in the process, and to obtain supporting qualitative data. The resulting list of instances was then interpreted to determine whether our definition of integration was comprehensive and appropriate, and to gain insight into issues associated with its application. Interviewees were asked to describe their role in the process being investigated. Probes loosely followed an interview guide, searching for instances in which non-integrated activity was taking place (according to the accessibility, transparency, granularity, and timeliness principles). For example, a probe for granularity asked "Is there enough detail in the information you receive to handle all situations?" A probe for timeliness asked "Is there ever any delay in this information?"

Activities were observed in real time, and interviewees were asked to demonstrate how they would interact with a given input or output. Several people were interviewed for each role in each process, when applicable, to ensure completeness.

After the interviews were completed, process maps were developed for each process. The bank's project management processes were highly defined, so we used their formal process as a guide to determine how activities in practice strayed from the formal process, and then addressed the information flows for the actual activities.

Using the process maps as a guide we listed each activity in a spreadsheet. Then we reviewed interview and observation notes for each activity and briefly described any work that focused on information flows between activities, using the interviewee's own terms. Next, these instances were grouped together based on similarities, and 18 categories emerged. For example, in the hospital admission process secretaries "take off" orders, this involves the transfer of data from handwritten doctor's orders to the computer. In the construction company, faxing orders involves creating fax documents using data from an accounting system. In both cases existing information is manually transferred from one document to another. The category "transferring data from one document to another" emerged to cover these and similar activities. For a complete list of the 18 categories (Table IV).

This categorization was an iterative exercise in which the researchers attempted to maintain a consistent level of abstraction while assigning activities to mutually exclusive categories. Each category had at least two occurrences, across at least two processes, with the exception of two categories. In the case of the bank problem management process, an activity involved circumventing the system to effectively

Principle	Non-integrated behaviors
Timeliness	Waiting for person (input)
	Waiting for technology (input)
Granularity	Reformatting for appearances (output)
	Getting more information (input)
	Summarizing for management (output)
Accessibility	Keying in known data (output)
	Keying in search criteria (output)
	Navigating computer interface (input/output)
	Documenting work the first time (output)
	Documenting work redundantly (output)
	Finding/obtaining information (input)
	Circumventing the system (input/output)
	Transferring data from one document to another (output)
	Checking for correctness (input)
	Manually performing automatable process (input/output)
Transparency	Requiring clarification (input)
	Clarifying for others (output)

Table IV.
Details of process integration properties

input information. This occurrence was unique and could not be included faithfully in another category. Another single occurrence was a nurse who was expected to document the same information twice. This would involve not merely documenting known information, but doing so redundantly. The 18 categories were then mapped to the properties of process integration in our definition.

In certain instances, we found it difficult to objectively make a categorization. For example, when addressing the work request form in the Waterfall project management process, one project manager indicated that "level of detail determines the understandability." In this case the participant did not understand an input (transparency), because there was not enough information provided (granularity). Since the information was not provided, the participant may have to search for it (accessibility). During this search, the participant may be required to wait for some information (timeliness). Similarly, when a hospital secretary cannot decipher the doctor's handwriting (transparency) she may have to track down the doctor to obtain the required information (accessibility). If the doctor is in surgery, the secretary must wait on hold while a nurse walks in and out of surgery to request the information (timeliness).

Because of these overlaps, we developed priorities for categorization. An examination of the four properties reveals that they can be split into two groups: activities that transform information and those that transfer it. Granularity and transparency imply a transformation of the information. They can involve translation, summarization, itemization, etc. All of these activities involve some changes in the information for use within the process. Accessibility and timeliness do not imply any modification of the information content. They involve pulling, sharing, re-keying, or passing information among different participants involved in a process.

Since granularity and transparency involve transformation, they could (but do not necessarily) add content value to the business process. Because of the potential for added value, we first determined whether a specific process integration issue could apply to the transformational properties before categorizing them into accessibility

and timeliness. In those situations such as the one described above, we categorized based on level of understanding. If the participant understands the information clearly, but requires more information, this involves granularity. If, however, there is some problem in understanding the information that is in front of the participant, then we categorized it under transparency. The situation above in which our project manager said that she could not understand a document because there was not enough information was categorized as a granularity issue.

In addition to mapping the 18 categories to the four properties, we grouped them based on whether they stemmed from an input to an activity, contributed to an output, either, or both (Malone and Crowston, 1994). There were a total of nine categories that apply solely to outputs, five to inputs, and four that can apply to either. The outputs were usually formal process requirements, or documentation. Even though the documentation that was created was often not required by the process we were analyzing, the act of documentation was still considered to be part of that process.

The 18 categories were also grouped according to the people performing activities. We did this to get a sense of whether the roles of individuals impacted the way in which they treated information flows. As mentioned above, distributed work requires individuals to perform the activity, and individuals to manage or facilitate it. The first can be categorized as production work, the second is coordination (Malone and Crowston, 1994).

Findings

Table V summarizes the number of instances of each category across all processes.

Keying in known data is by far the most common accessibility instance – making up over 25 percent of total instances (Table IV). "Known data" is data or information

	Total	Percent
Tranparency	*10*	*8*
Clarifying for others	3	2
Requiring clarification	7	6
Granularity	*27*	*22*
Get more information	7	6
Organizing information	8	7
Reformatting for appearances	4	3
Summarizing for management	8	7
Accessibility	*75*	*61*
Checking for correctness	3	2
Circumventing the system	1	1
Documenting work redundantly	1	1
Documenting work the first time	4	3
Finding/obtaining information	14	11
Keying in known data	29	24
Keying in search data	2	2
Manually performing automatable activity	4	3
Navigating computer interface	3	2
Transferring data from one document to another	14	11
Timeliness	*10*	*8*
Waiting for person	7	6
Waiting for technology	3	2
Total instances	122	

Table V.
Instances of non-integrated behaviors

that has been previously documented or entered into a computer system by someone else, and therefore exists in some form. The act of "keying in" known data implies input into a computer (its most common manifestation), but also included verbal communication, written documentation, etc. Examples of "keying in known data" include:

- In the engineering change process, the "affects jobs" field in the engineering change notice form of the product data management (PDM) system is the same exact data in the "where used" field of the ERP system. Engineers are expected to look up this data in the ERP system, and then manually key it into the PDM system.
- In the construction scheduling process of the home builder, superintendents each keep their own schedules with accurate dates for their projects. In Wednesday meetings, schedule dates are communicated as administrators update their own schedules accordingly.
- On the admission form for both nursing units, the nurse must interview the patient to obtain emergency contact, allergy, and other historical information that was already captured by the main hospital admission department and again in the surgical unit.

Beyond "keying in known data," no single issue appeared to have greater significance than any other.

Timeliness was rarely ever considered to contribute to process integration shortcomings. This could be explained by the observation that all of the people interviewed were busy with multiple tasks. Therefore, they rarely experienced idle time waiting for an input. Instead, they performed other work. This does not imply that timeliness is not problematic, just that our methods were unable to capture it:

> Lab results must often be reviewed before a patient can be discharged. A nurse, who will occasionally check for lab results throughout the morning, also has many other activities to remain occupied. Therefore, the delay in lab results actually does delay the process, but has no effect on the process integration, because the nurse is not idle waiting for the information.

Also, many priority situations simply circumvent the process so the process never actually holds up production activity:

> The bulk of critical urgency I&II problems are resolved by system monitoring, and are therefore handled without invoking the problem management process. Many other customers with critical issues skip the help desk and call a situation manager directly. Still others call the appropriate support engineer directly, circumventing the entire problem management process. Only small portion of urgency I&II issues find their way through the entirety of the problem management process.

Work practices have also accommodated the expected times, and many inputs are addressed in batch mode:

- The production engineer receives a print-out every morning of the approved engineering changes from the day before. She then routes the information to the proper place in the manufacturing process and updates the ERP system with all new information every morning. New engineering changes throughout the day

will be inputted in ERP the following morning, and other corporate processes have incorporated this work practice into their own practices.

- The role of a problem analyst is to document, close, and communicate resolved problems (or activity in certain chronic or longer-term issues) in reports and meetings throughout the week. If a resolution reaches the problem analyst five minutes after a meeting, there is a lag of days or even a week, until the appropriate report or meeting is scheduled. Due to this lag, information is not communicated real-time to management.

Timeliness is important only when the delay of information causes extra work for the individual. For example, every half hour, beyond the first half hour that transport is late in picking up a patient for discharge, is estimated to cost a nurse ten minutes in dealing with family and patient issues. Similarly, when an individual is truly idle while waiting for an input, such as when the problem manager spends up to 20 min waiting for his computer to generate "WIR" reports after a meeting, timeliness is relevant.

Transparency was not a major concern, because most process communication is routine, and individuals have experience in understanding the inputs required to do their respective jobs. The one instance in which transparency problems were fairly high, was the challenge hospital secretaries and nurses faced when reading doctors' handwriting, which could result in hours of work per day (across multiple discharge processes).

The bulk of process integration shortcomings occurred in the preparation of information for subsequent steps, or documentation. Documentation is important to a process when it provides the information necessary for downstream activities. For example:

> While approving the ECN form in an engineering change process, an engineer will often read only the "description of change," and if this is adequate, he may not view the drawing before approving the ECN. Without an adequate description, he will often call the initiating engineer to clarify the change, or further inspect the drawings to determine if he will approve.

Such "content" documentation should not be confused with documentation that is required by a rule or the organization's structure to be completed before an activity can occur. Such documentation is not in place for its content, but rather for its procedural validation. Another type of procedural validation is documentation that occurs to inform an auditing or management process, but adds no value to the process itself. The RUP project management process offers an example:

> A group outside of the project management process, known as "Process Compliance" is one of the only groups that gain information from the "Project Development Plan." Although the project manager is told to consider process compliance to be his lowest of many priorities, the findings of Process Compliance affect his performance-based compensation and therefore a project manager does regard the document as important.

Some documentation is simply stored "just in case" – or for posterity. This documentation may never be reviewed by another participant in any process, but is still stored to record the content in some sort of archive. This archive can be searched and information can be retrieved if it is ever needed. Often the information stored in such documents is critical for insurance, legal, or liability issues. The hospital general surgery unit illustrates:

> Before a patient is discharged, the doctor fills out discharge orders and completes the green chart. The nurse documents discharge training, final labs, and then completes the blue chart. The secretary takes all of the patient information from the green and blue charts and condenses them into the patient's archive folder. This folder will be picked up by the hospital archival staff and will be stored in the hospital archives until the patient is readmitted or information is required by an outside hospital.

Many activities center on documentation that adds no value to the process being evaluated, but may contribute to other intersecting processes. Yet these activities are usually considered part of the document generating process, rather than the document consuming process (where they probably should be attributed).

The role of documentation seems to vary significantly depending on the nature of work. In our interviews, we labeled engineers, nurses, and construction superintendents as producers, and managers and administrative support people as coordinators[1]. Examples abound in which producers skip documentation that is not critical to their jobs:

- Engineers make changes for parts in production and immediately provide prints to manufacturing, then follow up with an official change process. By the time the official paperwork reaches the production personnel, the change has already been in place for a day or two.
- Engineers often skip filling out the "affects jobs" field of the ECN form without penalty.
- All but two nurses in the general surgery unit skip filling out the redundant discharge training form on the computer. They have already filled out the paper form in a file, and the electronic copy is only used for quality control. Management has attempted both penalties and incentives, yet busy nurses do not fill out the form.
- Project superintendents at a construction site keep a certain amount of construction scheduling knowledge in their heads and do not document it in their schedules.

Just as those involved with production activity appear to devalue documentation for subsequent steps, those involved with coordination often faithfully produce documentation when they do not necessarily see value in it:

- The "Project Development Plan" is considered to be a critical document for the project management process. The document typically has over 40 pages. According to one project manager, 80 percent of the document is "unneeded overhead . . . lots of canned stuff no one reads. Relevant information is buried in the document and you have to cross the Great Wall of China to find the relevant information." Yet they are monitored by this document and fill it out dutifully.
- One problem manager creates reports for a weekly meeting which are made available to all parties through the company intranet. Since his experience is that managers do not download nor read the reports, he sends the reports to each meeting participant in an email before the meeting, thus increasing the likelihood that they will bring the reports to the meeting and follow along.

To explore these observations, we broke down the frequency of non-integrated instances by type of work (Table VI).

In coordination activities such as project management or problem management, it is difficult to tell the activities in the process from the information flows between them. This is because this type of work is essentially dealing strictly with information flows of between other processes – so the activities in the process involve information flows, as do the practices between these activities. In these cases the entire process exists largely to document production activity being carried on elsewhere. The roles of managers, secretaries, and administrative personnel are created by the need to coordinate activities in a distributed process and the resulting information flow required to monitor the process.

Discussion

We have shown that the four principles of information flows that we associate with business process integration (accessibility, transparency, timeliness, and granularity) occasionally overlap, and therefore are not mutually exclusive. In order to allow for consistent categorization, we assess whether an activity requires that information flows be transformed before they can transfer information.

The transfer of information between activities in a distributed process can typically be automated without detracting from the output. Transformational activity, however, can potentially add value to a process. Although it can be automated, in many cases the

	Production	Percent	Coordination	Percent	Total	Percent
Transparency	*2*	*5*	*8*	*10*	*10*	*8*
Clarifying for others	0	0	3	4	3	2
Requiring clarification	2	5	5	6	7	6
Granularity	*5*	*12*	*22*	*27*	*27*	*22*
Get more information	4	10	3	4	7	6
Organizing information	0	0	8	10	8	7
Reformatting for appearances	1	2	3	4	4	3
Summarizing for management	0	0	8	10	8	7
Accessibility	*31*	*76*	*44*	*54*	*75*	*61*
Checking for correctness	2	5	1	1	3	2
Circumventing the system	1	2	0	0	1	1
Documenting work redundantly	1	2	0		1	1
Documenting work the first time	2	5	2	2	4	3
Finding/obtaining information	7	17	7	9	14	11
Keying in known data	13	32	16	20	29	24
Keying in search data	2	5	0		2	2
Manually performing automatable activity	0	0	4	5	4	3
Navigating computer interface	1	2	2	2	3	2
Transferring data from one document to another	2	5	12	15	14	11
Timeliness	*3*	*7*	*7*	*9*	*10*	*8*
Waiting for person	3	7	4	5	7	6
Waiting for technology	0	0	3	4	3	2
Total instances	41		81		122	

Table VI.
Frequency of non-integrated behavior instances by type of work

transformational activity requires human judgment and may not be conducive to automation. For example, automatically generating faxes from invoices for the home builder is easy, but the tasks in which a project manager summarizes for management may require human judgment.

We contend that a lens for viewing a process integration by categorizing information flows as either "transfer" or "transform" would not arm the process analyst with enough detail to understand the nature of an information flow for purposes of process improvement. For example, an indication of transfer issues may indicate problems with information access, which could involve training or it could involve information timeliness, which could require IT performance enhancement. A richer lens is required for stronger process analysis.

The entire list of 18 coded categories, on the other hand, would be thorough but unwieldy. We believe accessibility, transparency, timeliness and granularity lens are a parsimonious group of principles for viewing an information flow in order to determine the level of integration of a business process.

Processes suffer the various process integration shortcomings in vastly different configurations, and often do not suffer the same shortcomings. The only exception to this is the finding that "keying in known data" is prevalent in all processes. Timeliness and transparency of information flows have little negative effect. This conclusion with regard to transparency is understandable, as process participants understand the information associated with their daily work[2]. The timeliness conclusion, however, is problematic.

Organizations are under pressure to shorten process times in general, but for process participants timeliness of information flows is not a problem because they are busy with multiple tasks and rarely wait idle for a process input. They adapt their work to the times that the information arrives. Our findings do not indicate that timeliness of information flows is not a problem with processes, but that a lack of timeliness does not often adversely affect the process participants and their perceptions of process integration.

The processes we studied are all comprised of production activity and coordination activity. The closer to production, the less important non-integrated documentation becomes. According to Table VI, for production activity accessibility of information flows is the key issue, primarily taking the form of *keying in known data*. Clearly, implementing technology to remove the need to key in known data has a dramatic impact. Since the producers themselves often circumvent non-integrated information activities, coordinating roles such as secretaries, problem managers and project managers support them. The work of the coordinators is driven primarily by the need to document.

Accessibility of information flows was still a significant factor for coordination activities, but in addition to keying in known data, processes also included many instances of transferring data from one document to another and finding and obtaining information. Granularity of information flows in the form of summarizing the data for management and organizing information was also a frequent category.

Our data indicate that only by gaining an understanding of documentation is it possible to improve the integration of processes. Keying in data, documenting work (the first time and redundantly), transferring data, summarizing, and organizing all involve preparing information for downstream activities in the process being evaluated or in some other process or processes. That is, they all involve documentation.

By applying the principles of business process integration, we better understand the nature of process information flows as they apply to different work practices. In what we designate as a production activities, information flows are fairly efficient, since professional/technical workers do not prioritize information work unless it supports the production activity in which they are engaged. Coordination work, on the other hand, tends to be largely focused on information about the production activity. Managers and administrators often consider documentation to be the output of their activities, because the work directly resulting in the process output is being done by others. Therefore, categories associated with documentation, such as formatting, summarizing, and transferring data tend to apply more to coordinators.

The nature of documentation is important to any serious integration effort. Documentation can be categorized into content documentation when the content is used in downstream real work; procedural validation documentation when a document is used for the subsequent steps in the process or intersecting processes to determine the level of completion or compliance of an activity; and documentation for posterity, when a document is archived with the likely possibility of never being accessed in the future.

Limitations

As Table II indicates, all categories associated with unnecessary time spent working with information in a process appear to fit neatly into our proposed definition of process integration. One concern may be that use of the principles as a lens may have affected the framing of the interviews, and therefore the interviewees' responses and our findings. We do not feel that this is cause for serious concern as the terms used to describe instances accurately reflect the integration shortcoming described by the participant.

Using Earl's (1994) definition of a process, an entire firm or supply chain is essentially a single process. This process is made of sub-processes, which are in turn made up of more sub-processes, until these processes become small enough to be considered activities. The arbitrary nature of the process designation has resulted in further non-descriptive terminology, such as "enterprise process" and "business process" (as opposed to the non-business process). When measuring processes, it may be necessary to define the level of abstraction of the process being analyzed, as different levels of abstraction may have different integration issues. As the exercise of defining the boundaries of any given business problem can be quite problematic (Nickols, 1998), in this research, we have specifically and narrowly defined our processes at an activity level, such as a hospital admission or an engineering change, and thus began and ended the process in question with reasonable "anchoring points" within the larger stream of organizational activity (Nickols, 1998).

Future research

In this research, we have focused on the information flows inherent in distributed information processes. We have found that the complexion of process integration categories vary among organizations, types of processes, and types of work. We have a better understanding of the definition we used to do this research, and we have both increased and decreased the level of abstraction of this definition to aid in its application. With this insight, we can now embark on more specific research.

With further process integration research, two main objectives will be pursued. First, we have to ensure that we have an exhaustive list of instances. Even with the current limited sample, many instances recurred in different organizations and in different processes. It is reasonable to assume that, for business processes, there is a finite number of these categories. However, this is not the most important objective. Application of the definition to a greater number and wider range of processes, with an eye toward quantitative rigor and understanding antecedents and consequences of different activities, would enable us to determine correlations between types of work practices and associated integration properties. For example, a rigorous investigation of the relationship between production activity and documentation might be fruitful.

Rather than focusing exclusively on the process integration aspect of process improvement, it will be necessary to empirically test the relationship between process integration and the key objectives of process improvement (quality and efficiency). It is imperative that we work toward building a strong theoretical foundation on which to further build the process improvement literature.

Another possible development of process integration research is by linking it with the efforts in ontology. Formalisms (like UML) are developed to represent data and processes. The ontological quality of these formalisms depends on their ability to represent reality (Dussart *et al.*, 2004). Many formalisms were developed to represent static properties (like data) and were later adapted and enhanced to represent dynamic properties of processes. Developing constructs and a grammar to represent the four principles of integration would be another improvement that would increase the richness of the formalisms and their ability to represent reality. This could enable analysts to design better processes and systems.

Implications for practice

As practitioners look to implement business process improvements, our research suggests that they focus on accessibility issues associated with information flows, as they represent the bulk of non-integrated work. These instances of accessibility often involve information transfer, which indicates fairly straightforward automation potential using information technology.

That timeliness of information flows was not considered important to process participants indicates that there may be some misalignment with individual and organizational objectives. Given the popularity of user participation in requirements determination and change management, it is important for process improvement efforts to temper the perspectives of the participants with respect to time by focusing on organizational objectives regarding the timeliness property when implementing a system. Strictly participant-informed processes may allow for longer process timeframes than might be optimal for the organization.

Finally, it is important to understand the role of documentation in a process, as the activities associated with documentation comprise the bulk of non-integrated work. Before specifying an instance of documentation in a process, it is important for practitioners to understand the actual use of the information, its relevance, and its destination.

The better understanding of business process integration is becoming crucial in many different sectors of the economy. For example, the Sarbanes-Oxley Act and the Basel II Accord are imposing severe constraints on companies with respect to

operational risk. Responding adequately to these regulations requires more reliable business processes and a minimization of the risks of errors. Therefore, better integration is intuitively related to the efficient management of these processes. These regulations impose robust business process management capabilities. Companies have to manage complex business processes and the corresponding data and information that drive these processes. Only this improved management can enable effective process controls and trigger organizational response to risk (McLaughlin, 2003).

Conclusion

In this research, we have determined that the combination of the principles we identified with respect to information flows in a business process – accessibility, timeliness, transparency, and granularity – comprise a collectively exhaustive lens for viewing process integration. It is important to note that these properties are not mutually exclusive. The notions of information transfer and transformation offer further insight into the nature of integration in a given information flow. Information transfer issues tend to indicate potential for IT insertion in a process improvement effort. Information transformation activities would require a closer look at the content of that information when engaging in process improvement.

As organizations look to improve business processes or to assess their previous improvement efforts, an important first step is to understand the information flows associated with the processes. Researchers and process analysts working from our proposed definition of process integration base their analysis on a rich foundation which should offer insight into specific process integration issues.

These efforts are at the core of organizational research, in particular the information systems discipline. Understanding information, its flow in the organization, the technology that supports it, and its utilization and impact in the organization is critical to improving organizational performance.

Notes

1. This choice of label is not intended to imply superiority of either type of process participant, but was chosen to reflect Malone and Crowston's (1994) distinction between production activity that contributes directly to the output of the process, and coordination activity that manages the interdependencies.
2. We did not study any processes that cross organizational boundaries where transparency may be a much greater concern.

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