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Interorganizational Ecology and Information Visibility

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Abstract

Increasingly, companies use interorganizational information systems to conduct joint business processes, such as automatic replenishment systems and other supply chain initiatives, invoicing and payments, insurance claims processing and numerous other interorganizational processes. Inter-firm networking in turn increases the visibility of information generated and used by business partners. These business partners may experience intended and unintended impacts from the changes in the partnering relationship, in effect altering the ecology of the organization. In this paper we briefly review principles of ecology from the natural and social sciences. Then, drawing on emerging principles of organizational ecology and information ecology, we propose a definition of interorganizational information ecology. An example from health care demonstrates the usefulness of the concept, and we conclude with suggestions for field-based research on the ecology of interorganizational information visibility.

Introduction

Firms of all sizes face increasing pressure from suppliers, customers, and others to connect information networks in order to streamline specific business processes. For example, retailers invest in automatic stock replenishment systems with their suppliers, and product design teams collaborate with suppliers to speed up the design life cycle and promote cost reductions. Such investments result in increased information visibility, which is expected to speed transaction processing and help managers in partner organizations make better decisions and engage in more effective planning. The primary focus of many interorganizational information visibility projects to date has been on perfecting the enabling technologies, as information technology (IT) managers have allocated most of their resources to identifying effective means for connecting enterprise application systems with other organizational systems (such as customer relationship systems) and identifying appropriate points of integration with their partners' systems.

Forrester Research predicts that corporate spending on interorganizational information integration will outpace spending on new stand-alone software applications over the next five years (Surmacz, 2003). Because the technologies that facilitate inter-organizational information visibility continue to evolve rapidly, managers run the risk of focusing on complex technical challenges at the expense of other factors that affect implementation.

It is our view that interorganizational information sharing systems (and the resulting information visibility between business partners) should be studied from a holistic perspective. This paper suggests that researchers build on previous studies of organizational and information ecology to examine the ecology of interorganizational information sharing. An ecologic view entails the study of processes of adaptation and the dynamic interplay of actors, technologies, information and processes. It is

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important that IT professionals and scholars begin to develop an understanding of the dynamic processes of interorganizational ecology that ultimately determine the effectiveness of these advances.

In what follows, we briefly review the literature of ecology leading to a definition of *interorganizational information ecology*. An example from health care demonstrates the usefulness of the concept, and we conclude with suggestions for research on the ecology of interorganizational information visibility.

The Evolution of Ecology

From Natural Science to Social Science

With roots in the natural sciences, ecology theory has been applied in numerous domains to explain specific relationships among humans and other life forms and their environments. The Institute for Ecosystems Studies describes ecology as the "…scientific study of the processes influencing the distribution and abundance of organisms and the transformation and flux of energy and matter." One branch of ecology theory, Population Ecology, examines the rise and decline of species, with an emphasis on the "vital" outcomes (birth of and extinction of species). Evolutionary Theory, another branch of ecology, examines the selective pressures imposed by the environment, and responses to these pressures over time, with an emphasis on evolutionary processes. Darwin (1859) proposed a unifying theory which explained both the transmutation of species (i.e., the vitals) and the adaptation of organisms to their environment (the processes) in his well-known theory of natural selection. Ecology theories in the social sciences and management have borrowed from all three approaches (population ecology, evolution, and natural selection). We discuss some of these social science ecology theories next.

Although rooted in natural science, ecology theory has been extended to social sciences such as sociology, anthropology, and archeology. Human Ecology is a branch of sociology dealing with the interaction of people with economic, social and political structures. A related branch, Cultural Ecology (Steward, 1955) is "the study of the processes by which a society adapts to its environment." Anthropologists, archaeologists and geographers have often borrowed from human and cultural ecology theories and methodologies. For example, anthropologists Nardi and O'Day (1999) examined technology use in schools, libraries, hospitals, and other work and recreation settings. They define an *information ecology* as "a system of people, practices, values, and technologies in a particular local environment, characterized as follows:

- a *system* of interrelated people and tools;
- contains a *diversity* of roles for the people and functions for the tools;
- there is a *coevolution* over time as new technologies arrive and are assimilated, and as people's roles develop and change;
- there is a *keystone species*—a particular role, such as a person who can translate across disciplines—that is essential to the success of the ecology; and
- has a defined *locality*."

The work by Nardi and O'Day offers a glimpse at the benefits that can be gained when theories developed in one discipline are applied to another. In this example, ecology theory was borrowed from the natural sciences and applied to the social sciences, with useful findings.

From Social Science to Management Studies

Nardi and O'Day's information ecology theory drew on the cultural perspective of anthropology. To provide a glimpse at extension of their theory from the realm of anthropology to strategic IT management, we can ask: how might Nardi and O'Day's definitional criteria (listed above) apply to interorganizational information sharing? Clearly, the first two criteria fit well: an interorganizational system is comprised of people playing a variety of roles in multiple organizations and using various tools, including hardware or software technologies and methodologies. The next two criteria offer intriguing possibilities: research might fruitfully examine processes of co-evolution among people, organizations, and tools over time. And, research can examine whether a so-called "keystone species" is essential and if so, who plays that role and why. The final criterion, "locality," could be a problematic construct for describing interorganizational information sharing arrangements, unless a *virtual* "locality" can be defined and observed (similar to Rayport and Sviokla's mapping of "marketplace" to "marketspace" in 1994).

To further consider the application of ecology theory to interorganizational information sharing, it is helpful first to examine work that has already been done to apply ecology theory to economic and management disciplines, including the sub-disciplines of industrial organization, competitive strategy and organizational behavior. A useful review is provided by Lewin and Volberda (1999), which we briefly summarize here (see also Amburgey and Rao, 1996 and Lewin, et al., 1999). According to Lewin and Volberda, sociologists Michael Hannan and John Freeman (1976) pioneered the application of population ecology to organization studies, triggering several decades of research in this stream. Researchers have drawn on population ecology theory to explain why some organizations adapt to changes in the environment and survive, while others fail to adapt and (sometimes) fail entirely. Rao (2001) extended the population-based concepts of organizational ecology to an interorganizational ecology to predict which organizations in a strategic alliance would survive or fail.

While Rao took the population ecology perspective, other research in strategy and organizational studies borrowed from the evolutionary branch of ecology theory. In this paper, we also focus primarily on this evolutionary stream of management-related ecology literature, since the population ecology perspective is not likely to shed much light on interorganizational information sharing *processes*. Evolutionary theory, with its emphasis on organizational choices and structural and process changes that occur over time, seems on its face to offer a stronger fit with our topic. For example, Polos, et al. (2002) focused on the development of new organizational forms, which is highly relevant to the issue of interorganizational systems and authority structures. Polos et al. (along with many organization theorists) noted that organizational structures (for defining authority and accountability within the organization, and boundaries with the external environment) can impact how organizations adapt to internal and external challenges. And, they proposed, in turn the processes of adaptation can change organizational culture which ultimately leads to changes in organizational structure. In an influential paper that built on this and other work (such as the seminal work on dynamic organizational processes of exploration and exploitation by March, 1991), Lewin et al. (op cit.) proposed a general theory of organization-environment *coevolution*, which "attempts to integrate the interplay between the adaptation of individual organizations, their competitive dynamics, and the dynamics of the institutional systems within which firms and industries are embedded." Lewin et al. explain: "The theory assumes that organizations, industries (populations) and environments (institutional and extra-institutional) coevolve, that their rate, pace and patterns of change are distinct and interdependent, and that the directions of these changes is not unidirectional." They present an ambitious research agenda that includes the following aspects (Lewin et al. op cit., p. 536):

- "Studying organizations over time
- Multidirectional causalities between micro-and macro-coevolution
- Mutual, simultaneous, lagged, and nested effects
- Restricting and enabling constraints of organization path dependence
- Contingent effects such as nation-state institutional arrangements
- Extra-institutional influences … as well as social movements that affect the deep structure enveloping the enterprise and market competition."

Lewin's broad and ambitious research agenda offers potential for the study of interorganizational information sharing. It is also important to note that, just as biologists have debated aspects of evolutionary theory, so have management theorists. Haveman (2001) explains the current debate surrounding different perspectives within the evolutionary branch: "Adaptation theories predict that change occurs as fluid organizations adjust to meet shifting environmental demands, while selection theories predict that change occurs through the differential selection and replacement of inert organizations as environmental demands vary over time." Haveman further proposed that management theory can be strengthened by borrowing from recent advances in biology, such as Stephen J. Gould's theory of punctuated equilibrium (Gould, 1989). According to Gould, evolutionary change more often occurs as a result of rapid adaptation to sudden abrupt events, not as a long, slow steady progression over time. Like Gould, Haveman proposed that industries sometimes change dramatically in response to sudden and abrupt events, including radical technologies (such as the integrated circuit), economic events (such as the Great Depression) and new laws or regulations (such as the Glass-Steagall Act, which dramatically affected financial services, and its subsequent repeal, which caused a new round of changes in the financial services industry). Haveman argues that exogenous system "shocks" stimulate organizations to overcome inertia and make dramatic changes in strategy, structure and other elements under managerial control.

Van de Bosch et al. (1999) examined coevolutionary processes in a longitudinal comparison of two firms in the Dutch publishing industry. Having found that a firm's ability to assimilate new knowledge (absorptive capacity) was a key element in its organizational adaptation, Van de Bosch et al called for further research that would focus on interorganizational co-evolution processes.

In this brief review of the adaptation of ecology theories from the social sciences to management studies, we have shown that ecology theory can fruitfully be used to examine organizations and their broader environment, particularly when (per Lewin et al.), longitudinal studies are conducted to assess the complex interplay of these relationships. Research is still needed to shed further light on processes of interorganizational coevolution and adaptation. We next turn to the final piece of our evolutionary puzzle: the application of ecology theories from the natural science, social science and management disciplines to the field of management information systems (MIS).

From Multiple Reference Disciplines to MIS

MIS consultants and researchers have also applied ecology concepts. Davenport and Prusak (1997) define Information Ecology as "holistic management of information." Consistent with evolutionary theories from both management and anthropology, they argue that for a given organization, a separate information environment/ecology exists and includes a balance of organizational staff, culture/behavior, politics, architecture, process and strategy. The information environment is embedded within the organizational environment, which is in turn embedded in a larger external environment (See Figure 1).

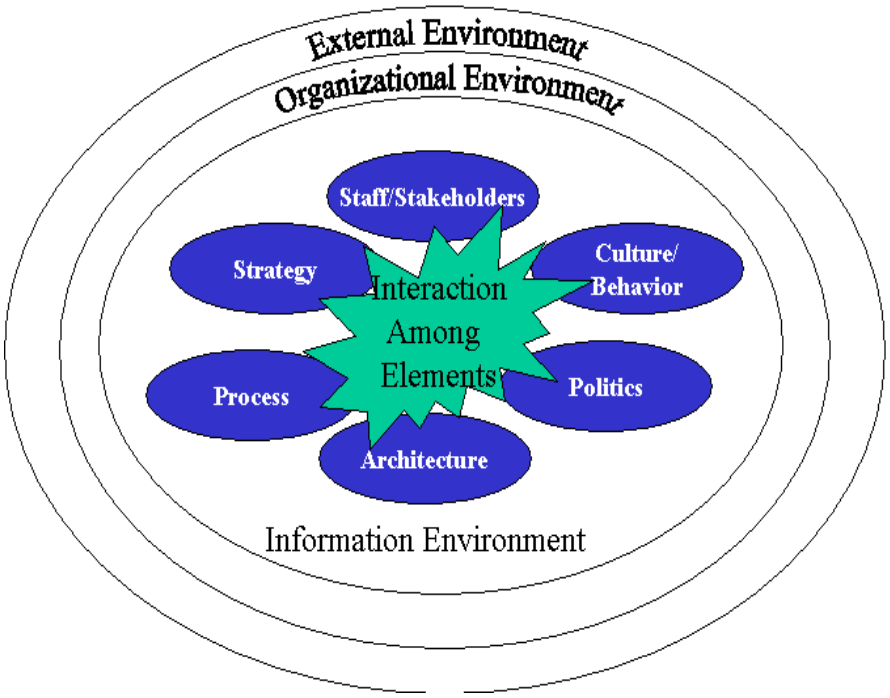

Figure 1. Adaptation of Davenport et al. Information Ecology

Davenport and Prusak observed that effective management of an information ecology entails four key elements:

1. integration of diverse types of information
2. recognition of evolutionary change
3. emphasis on observation and description
4. focus on people and information behavior

How might these principles inform a study of interorganizational information sharing? Clearly the first element (information integration) is a primary goal of the interorganizational collaborations that we are studying. Davenport and Prusak's three additional elements suggest an avenue for research that would address such questions as: Do the principles proposed by Davenport and Prusak for organizational information ecologies apply to interorganizational information ecologies? That is, must these systems be designed with an emphasis on flexibility and adaptability so that they may change in response to events in the broader environment? Is there just as great a need for observation and description of the processes and tasks that are to be supported by interorganizational systems as is true for those processes that take place solely within organizational boundaries? Are new

techniques required to depict interorganizational processes? And, will the same techniques that are recommended for helping to ensure acceptance and effective use of within-organization systems prove useful for ensuring effective use of systems that cross organizational boundaries?

Davenport and Prusak cautioned their readers to avoid taking a mechanistic "engineering" view of information systems. Porra (1999) took this advice a step further, by arguing that the traditional dichotomy in organizational theory (first proposed by Burns and Stalker, 1961), which pits "mechanistic" versus "organic" policies and structures on opposite sides, fails to capture the full range of choices available to managers. Porra (op cit., p. 39) explains that, like the mechanistic model: "The organic model also includes an implicit assumption of progressive evolution, which is incorrect." Drawing on Gould's theory of punctuated equilibrium, Porra proposes a "colonial system" explanation. A "colony " is defined by Porra (op cit., p. 56) as "a collection of individuals who share a history and an environment and who cooperate directly or indirectly for the maintenance of the colony." Porra asserts: "The colonial viewpoint attempts to explain how history, local refinement, and radical change are all required to operate in periods of both calm and turbulence." In applying this theory to information systems, Porra proposed that successful systems use a process of "punctuated prototyping," in which each system is designed with built-in adaptability in mind, by incorporating alternative, just-in-case designs. In this way, Porra contends (p. 66) that "successful (i.e., persistent) systems operate like a colony, whereas unsuccessful (i.e., rigid) systems fail because they are predicated on machine or cellular processes." Similar to Haveman's (op cit.) findings about organizational processes of adaptation to exogenous shocks, the colonial systems theory claims that inter-organizational systems need to be designed with built-in flexibility so as to withstand the shocks of occasional punctuations (exogenous shocks). In our view, while not all evolutionary change may be attributed to the occurrence of historically significant punctuating events, ecological change typically can be attributed to a development that shifts an organization's internal environment or its surroundings. These developments might occur within any of the elements depicted in figure 1.

In this review, we have established that previous ecology research in organization studies and information systems provides a useful foundation for our proposal to extend these findings to interorganizational information sharing relationships. Building on this previous work, we propose to define an interorganizational information ecology as *a system of people, processes, technologies, and information sharing behaviors, in a local environment, and characterized by colonial processes of adaptation.* In the following sections, we illustrate how this concept can be applied to defining, measuring and observing change in interorganizational settings.

Viewing Interorganizational Information Visibility through an Ecological Lens

Davenport and Prusak (op cit.) suggested that systems investments are more likely to succeed when the ecology of the firm is considered, and Porra (op cit.) proposed colonial-systems theory to explain why adaptability needs to be built into systems. Because the boundaries of interorganizational systems are often unclear, and because relationships in interorganizational information sharing are dynamic and complex, it seems clear that research aimed at understanding these systems is quite important. Each organization's computing environment is unique and complex, so integration efforts bring technical challenges. Each participating organization has a different motivation for investing in information-sharing technologies, and as they change their business processes to capitalize on these investments (or to respond to external challenges), their motivations and concerns will also evolve. Furthermore, punctuating events (such as a disruptive technology or a new governmental regulation) can occasionally stimulate abrupt changes in participants and processes.

We propose a theory of interorganizational information ecology based on close examination of the interplay of technical, strategic and operational choices of participants (separately and collectively as a virtual organization) and information sharing behavior (including choices regarding when and how to disclose different types of information), under both stable and turbulent conditions.

The theory can accommodate both ongoing interactions and responses to occasional punctuating events, including the impact of newly-visible information on people, business processes, and institutions. Building on the work of Davenport and Prusak; Haveman; Nardi and O'Day; Lewin et al.; and Porra, the theory proposes that successful interorganizational information sharing systems a) successfully engage in processes of co-evolution among participants and system elements (including abrupt responses to punctuating events), b) rely on a "keystone species" that bridges organizational and phenomenological boundaries; c) incorporate adaptable/alternative (just-in-case) processes and technologies, and d) maintain an equilibrium among people, processes and behaviors.

A brief review of an old and familiar interorganizational system story – that of American Airlines' and United Airlines' travel-agency reservation system -- will illustrate some key features of an interorganizational information sharing ecology. Back in the 1960's and 1970's, the airline industry was regulated, and shifts in competitive power occurred slowly. The key participants were airlines, airports, travel agencies and customers. Some airlines – including American and United, but others as well – invested during this period in computers and proprietary software that improved their internal operational efficiency. A grass-roots initiative at American Airlines in 1967 involved a marketing manager who equipped several large travel agencies with computer terminals and a direct connection to American's reservation system. This was found to improve efficiency, but the airline-travel agency connection was not aggressively exploited in the seventies, since during that period travel agencies were not an important intermediary for the sale of air tickets (most customers booked directly with the airline; they used their travel agent for other purposes). Although changes in competitive position, technology use, relationships between airlines and travel agencies and other elements occurred over time, this ecology remained in a state of equilibrium during the sixties and seventies.

In 1978 a punctuating event occurred: deregulation of the airline industry. Suddenly, airlines had great latitude in terms of pricing seats, setting schedules, and changing routes, resulting in large changes in their internal operations. Very quickly, individual travelers found that the process of booking a reasonably-priced ticket had become quite complicated – unless a travel agency was used. The travel agents suddenly found themselves playing a pivotal role in the sale of air tickets, especially through computerized reservation systems. Both American Airlines (with its SABRE system) and United Airlines (with its Apollo system) introduced new reservation systems to the travel agencies. By 1981 (just three years after deregulation), 68% of airline tickets were sold through travel agencies using the automated systems provided by American or United.

This example offers a glimpse at the dynamic co-evolutionary processes that quickly unfolded in response to a punctuating event (deregulation). American and United would undoubtedly have evolved into even more-dominant "species" had they not been stopped by the Department of Justice's anti-trust actions. Note also that in 1994, two other important punctuating events occurred: the National Science Foundation's decision to open the Internet to commercial activity, and the introduction of the first web browser (Mosaic), which together enabled a new communication medium for electronic commerce. These events led to another period of significant instability for the airline industry. Viewing the evolution of the travel reservation process in this light gives an expanded understanding of the intended and unintended impacts of the deregulation event.

There are many examples to draw from that illustrate the power of the ecological lens for viewing information visibility consequences. The next section discusses an example of interorganizational information ecology within the health care industry. What is particularly interesting about this example is that it depicts an ecological environment that is currently reacting to a known punctuating event. In this light, the ecology perspective can be used to identify or predict key impacts of the event on interorganizational and intraorganizational processes and relationships.

An Interorganizational Information Ecology for Health Care Providers

All US health care organizations must soon comply with a legislative act entitled the Health Insurance Portability and Accountability Act (HIPAA) (Hulme, 2003; Brewin, 2003). The original intent of HIPAA was to simplify administrative tasks such as filing health claims, while simultaneously ensuring security and privacy of shared patient information. A secondary purpose of HIPAA was to encourage more electronic filing of health claims. At the time, the number of claims filed was increasing dramatically but the percentage of claims that were filed electronically remained very low. The rationale was that increasing electronic claims filing should improve transaction efficiency and effectiveness, ultimately leading to faster payment to physicians, faster turnaround of patient information and reduced errors in health care records. HIPAA takes effect in stages, with substantial parts of the standards for administrative simplification required by October 15, 2002, compliance with standards for privacy of patient data required by April 14, 2003 (April 14, 2004 for small health plans) and compliance with security standards required by April 21, 2005 for large organizations, April 21, 2006 for small health plans. Organizations that must comply with HIPAA include doctor's offices, insurance companies and HMOs, hospitals, health care clinics, pharmaceutical and medical equipment suppliers, pharmacy benefits managers and health care research organizations. All of these organizations share information with each other and altogether form a complex interorganizational information ecology.

To illustrate the complexity of the health care information ecology, we have developed a series of diagrams that depict the interplay among a hypothetical hospital and its business partners. We adopt the viewpoint of a non-teaching, general service hospital in this illustration of interorganizational ecology theory. The hospital activities included in this illustration are: accepting patients for care, administering medical services, discharging patients after services have been rendered, and follow-on services and care. Bills are sent to patients and/or insurers reflecting the services provided. These processes are depicted in Figure 2.

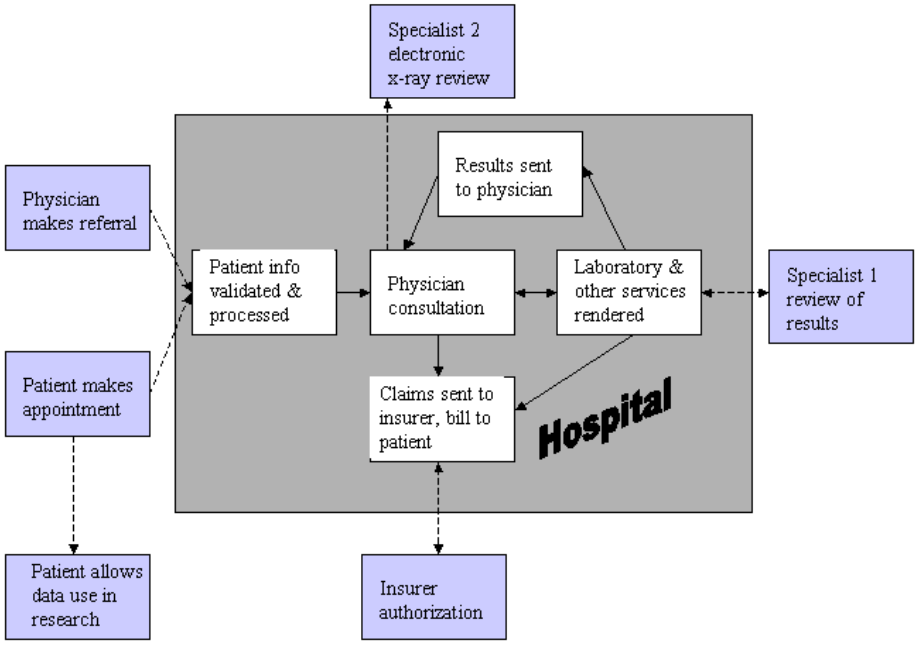

Figure 2. Simple Patient Care Process, Hospital View

Even in the elementary health care case illustrated in Figure 2 there are a number of interorganizational information sharing points, shown by dashed lines. HIPAA, when fully implemented, will dictate the data format for the type of information exchanges shown in Figure 2 and will also legislate requirements for protecting private patient information when it is shared as well as the methods for providing security of information as it is shared internally and externally. Most organizations will have to completely reengineer their information systems and security practices in order to be compliant with HIPAA. HIPAA can be viewed as an example of a punctuating event because most health care organizations have made and continue to make substantial investments in IT and business process changes in order to meet the compliance deadlines or 'events'. While actual financial costs are not yet known, estimates of total costs to comply with HIPAA range from $5.8 billion from the Department of Health and Human Services to $43 billion from the Blue Cross-Blue Shield Association (Bogen, 2002). As health care organizations reengineer their information systems, consideration of the interorganizational ecologies should facilitate generation of alternative means for leveraging HIPAA investments.

Continuing on with the health care example of interorganizational ecologies, after mapping interfirm processes, the hospital may try to apply a variation of Davenport et al.'s model shown in Figure 1 in order to identify the population for each element in an *interorganizational* information environment. For example, the staff/stakeholders in an interorganizational information environment would include insurance company personnel, conferring physicians from other hospitals, health care research organization personnel, etc., in addition to internal staff/stakeholders, as shown in Figure 3. Note that in an illustration for a different stakeholder, for example an insurance company, the interorganizational stakeholders should be quite similar although not exactly the same, but the internal/external relationships will be very different. Ultimately, the organization's view of an interorganizational ecology will dictate what is considered an internal or external stakeholder, or other element of the information ecology. Firms pursuing this strategy should also complete interorganizational diagrams for each of the other information environment elements (strategy, process, etc.).

All entities within the health care industry need to reexamine their interorganizational relationships in order to leverage required HIPAA-related investments. Hospitals should not limit their analysis to internal information sharing needs. Most health care processes require outside access to medical and financial information. A schematic diagram of interorganizational relationships among stakeholders, processes and strategies may be a useful first step to help to identify the scope of possible alternatives and may also be useful for determining metrics for ongoing assessment of the consequences of interorganizational information sharing.

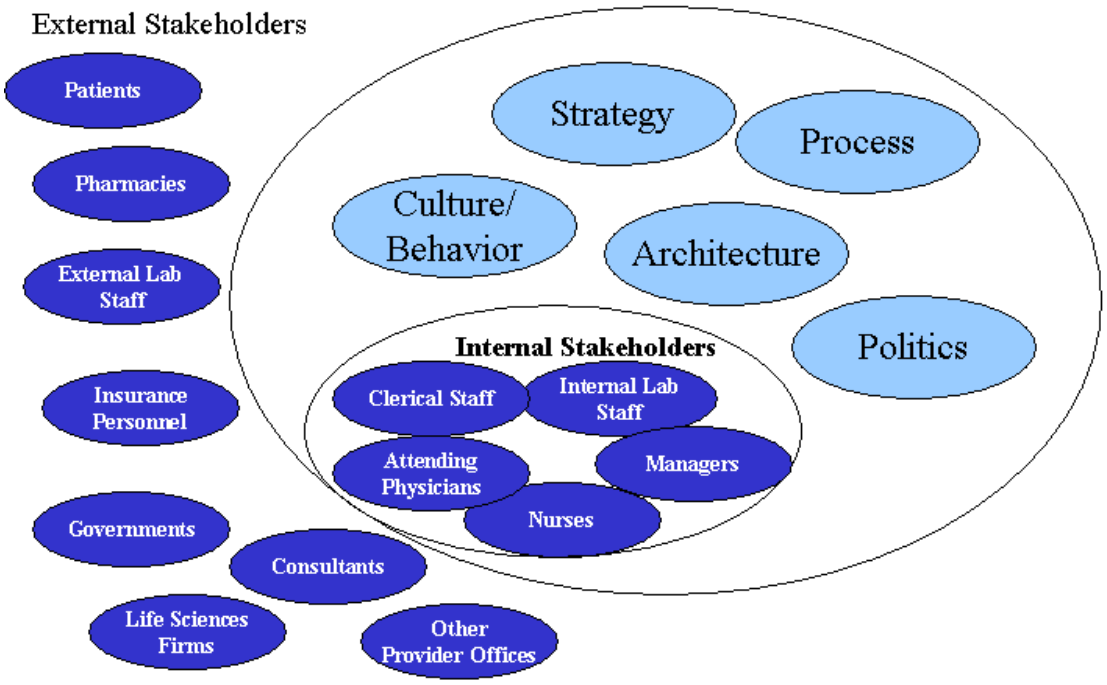

Figure 3. Interorganizational Stakeholder Example for Hospital

Future Research

The holistic view enabled by an interorganizational information ecology gives a more complete picture of the issues, benefits, costs and consequences surrounding the introduction of new technologies for creating or enhancing information visibility. An interorganizational ecology depicts a dynamic system. It is not sufficient to take a snapshot of one. To be useful, the ecology must be considered over time to truly understand the interplay of its elements. We call on the IS community to consider the larger information ecology when pursuing research on interorganizational information sharing. This will entail examining punctuating events, processes of co-evolution, and other dynamics that are not often captured in research studies.

The identification of parties affected by information sharing is a good first step, followed by close examination of the interplay among these parties, the affected business processes, and other aspects of the ecology. Case studies can examine the subtleties of interorganizational information sharing processes, and perceptions of actors in different roles. Development of a set of metrics that measure information-sharing behaviors and impacts through the lens of each of the affected parties can also be a useful next step that will facilitate ongoing research on the dynamics of a particular interorganizational ecology.

Although the figures in this paper depict a fictitious hospital, the example does represent an ongoing research effort to identify the ecological elements within the healthcare area that are impacted by HIPAA. Our multi-year project to study the players, roles, information requirements, IT, processes and policies that will be affected by HIPAA will yield insights into the adaptive processes in the interorganizational ecology of healthcare as the key stakeholders respond to (and further shape) the range of the legislation's impacts. In addition, similar studies of the information ecology within other interorganizational settings will enable us to generalize the types of consequences experienced by organizations faced with choices brought about by punctuating events.

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