

Understanding computer-mediated interorganizational collaboration: a model and framework

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Abstract

Purpose – To develop a process model of interorganizational systems (IOS) collaboration and systematic framework for understanding and classifying IOS technologies for interorganizational collaboration.

Design/methodology/approach – This paper synthesizes relevant concepts and findings in the IOS, economics, and management literature. It also presents empirical examples to illustrate key issues, practices, and solutions involved in IOS collaboration.

Findings – An integrative model of IOS collaboration is introduced and knowledge sharing, participative decision making, and conflict governance identified as three behavioral process elements underlying effective interorganizational collaboration. Extending Kumar and van Dissel's IOS framework to directly recognize these elements, a more complete collaboration-oriented framework for characterizing key elements of interorganizational collaboration and classifying IOS technologies is developed.

Research limitations/implications – This paper brings together diverse ideas into a systematic view of collaboration via interorganizational systems. It contributes to a deeper, fuller understanding of issues involved in achieving collaborative advantage with IOS technologies. The paper also identifies factors and relationships that researchers should consider in designing empirical studies, posing hypotheses about collaboration via IOS, and analyzing results.

Practical implications – The model and framework can serve as a check-list of considerations that need to be dealt with by leaders of collaboration-oriented IOS initiatives. The IOS framework and technology classification may also suggest ways in which IT vendors might provide better technological solutions, services, and software for interorganizational collaboration.

Originality/value – This new IOS collaboration model and framework provide more complete and useful guidance for researchers, educators, and practitioners.

Keywords Knowledge management, Organizations

Paper type Conceptual paper

1. Introduction

Interorganizational systems (IOS) have captured increasing interest of researchers and practitioners since Kaufman's (1966) visionary arguments about extra-corporate systems and computer time sharing. By providing the electronic infrastructure for sharing task performance between firms, these systems have opened avenues to collaborative knowledge work in several directions. They have fostered a new set of organizational design variables, such as shared repositories of knowledge, real-time integration of interrelated business processes, electronic communities that foster learning and allow multiple relationships to occur simultaneously, and virtual organizations that enable dynamic assembly of complimentary resources and skills among the collaborating firms (Strader *et al.*, 1998).

Early examples of successful IOS users provided strong evidence that aggressive pursuit of new possibilities for joint performance improvement through IOS can be an important source of sustainable competitiveness (Johnston and Vitale, 1988). IOS can reduce the cost of communication while expanding its reach (time and distance), increase the number and

quality of alternatives while decreasing the cost of transactions, enable tight integration between firms while reducing the cost of coordination (Malone *et al.*, 1987). They can also facilitate knowledge sharing and trust building (Holland, 1995; Li and Williams, 1999; Gallivan and Depledge, 2003), speed up expertise exploitation and knowledge application (Migliarese and Paolucci, 1995; Christiaanse and Venkatraman, 2002), and enhance innovation and knowledge generation (Thomke and von Hippel, 2002). Thus, by increasing competitive bases in achieving efficiency, flexibility, innovation, quality, and speed, IOS comprise an important class of knowledge management technology that offers significant opportunities for improving economic performance and competitiveness of many companies.

To more fully realize the potential of integrating this interorganizational knowledge management technology with business processes and competitive strategies, a systematic study is needed to help identify innovative inter-firm applications based on IOS and identify key factors in facilitating effective collaboration via IOS. Most existing studies on IOS are based on anecdotes, personal opinions, and experiences rather than on systematic research studies (Venkatraman and Zaheer, 1994). They are fragmented regarding the uses and impacts of IOS, and largely focus on the roles of IOS as competitive weapons for achieving power and efficiency.

Furthermore, underlying many studies is the assumption that humans produce errors while automation produces reliability. These studies view IOS as technologies designed and implemented to automate the relationships between firms. They largely fail to acknowledge the part human ingenuity plays in the work practice and the importance of learning (Sachs, 1995).

Therefore, these studies provide limited understanding of the relationship between IOS and the knowledge-intensive phenomenon of interorganizational collaboration. Many innovative opportunities of exploiting IOS potential for learning and mining the funds of knowledge across organizations for greater competitiveness are likely to be overlooked.

As such, this paper introduces a model and framework that more fully address the following questions faced by leaders of knowledge management initiatives and by researchers of knowledge management phenomena:

- What are the key elements underlying effective interorganizational collaboration among IOS participants?
- How can IOS be classified to facilitate an understanding of collaboration? What are characteristics and candidate implementation technologies for each type of IOS?
- What are key issues that a knowledge manager needs to address in IOS-based collaboration? How can these issues be addressed to enhance the processes and outcomes of this collaboration?

As a step toward answering these questions, this paper synthesizes relevant concepts and findings in the IOS, economics, and management literature to develop a process model of IOS collaboration and systematic framework for understanding and classifying IOS technologies for interorganizational collaboration.

The rest of this paper is organized as follows: section 2 defines IOS as a class of knowledge management technology for fostering interorganizational collaboration; section 3 introduces a model of IOS collaboration and identifies key elements underlying effective interorganizational collaboration processes; section 4 uses these elements to extend a framework by Kumar and van Dissel (1996) for classifying IOS, resulting in a more fully developed collaboration-oriented framework; and sections 5 briefly discusses contributions and implications of this research for researchers, practitioners, and educators.

2. Defining IOS

In 1966, Kaufman implored general managers to think beyond their own organizational boundaries and to explore the possibilities of extra-corporate systems for linking buyers and sellers or companies performing similar functions. Kaufman convincingly argued that these extra-corporate systems could greatly increase the efficiency of business operations and

“In the broadest sense, an IOS consists of computer and communications infrastructure for managing interdependencies between firms.”

enhance cooperation between firms through time sharing. In 1982, Barret and Konsynski (1982) used the term “interorganizational information sharing systems” to describe such systems. In 1985, Cash and Konsynski (1985) clearly defined the concept of “interorganizational systems” (IOS) as “automated information systems shared by two or more companies.” Some well-known examples of IOS are American Airlines’ SABRE reservation system, American Hospital Supply’s ASAP system, the CFAR system between Wal-Mart and Warner-Lambert, and Cisco’s eHub.

In the broadest sense, an IOS consists of computer and communications infrastructure for managing interdependencies between firms. From a knowledge management perspective, this infrastructure enables and facilitates knowledge flows among organizations (and their participating representatives) such that the needed knowledge gets to the relevant participants on a timely basis in a suitable presentation(s) in an affordable way for accomplishing their collaborative work. An IOS may involve one or more technologies, ranging from an electronic funds transfer system for data transmission to a collaborative CAD/CAM tool to a groupware system for joint product design. In recent years, rapid advancements in computer and communications technologies have made feasible many new applications of IOS that are greatly increasing the potential of effective inter-firm collaboration.

For instance, groupware encompasses previously considered independent technologies (e.g. messaging, conferencing, collaborative authoring, workflows and coordination, and group decision support) and has arisen to support dynamic business processes involving communication, coordination, and cooperative work (Freed, 1999).

The internet integrates technologies of the world wide web (hypertext transportation protocol (HTTP)), telnet, file transfer protocol (FTP), network news (network news transfer protocol (NTP)), internet relay chat (IRC), and e-mail (simple mail transport protocol (SMTP); internet message access protocol (IMAP)). It provides high flexibility for quick electronic access to external data and linkages to potential customers and partners around the world (Strader *et al.*, 1998).

An extranet combines the advantages of the internet (global access) with those of local area networks (security, easy management of resources, and client/server functionality). Based on internet technology and protocols, an extranet provides information in a way that is immediate, cost-effective, easy to use, rich in format, versatile, and secure over a private network (Strader *et al.*, 1998).

Peer-to-peer (P2P) communication, by allowing users to bypass central exchanges and exchange information directly with one other, provides a promising alternative to the conventional client/server model. Compared to the client/server model, P2P may significantly reduce the complexity and expense of networking (McAfee, 2000). In addition, P2P networks have no bounds, while membership in the client/server model is limited. Thus, P2P may provide solutions to the potential communication overflows that restrict the communication capabilities of most current network communities (Yoshida *et al.*, 2003).

Wireless communication uses wireless devices, sensors, positioning locators, and networks to allow real-time communication with anyone at any time, anywhere. Radio frequency identification (RFID), global positioning systems (GPS), voice e-mail, enhanced specialized mobile radio (ESMR), and MicroBurst wireless are some of the available wireless technologies that may have important implications for the collaborative area of supply chain management (Shankar and O’Driscoll, 2002).

Extensible markup language (XML) has quickly arisen as a standard data representation format. Being fully Unicode compliant, XML will greatly enhance EDI's ability with its extensibility, platform-independence, and support for a universal data access. Simple object access protocol (SOAP) uses XML technologies to define an extensible message framework that allows structured information to be exchanged over a variety of underlying protocols and programming models in a decentralized, distributed environment. Web services description language (WSDL) defines an XML-based grammar for describing network services as a set of endpoints that accept messages containing either document-oriented or procedure-oriented knowledge. WSDL is extensible to allow the description of endpoints and their messages regardless of what message formats or network protocols are being used to communicate. Universal description, discovery, and integration (UDDI) defines a SOAP-based web service for locating WSDL-formatted protocol descriptions of web services (MSDN Library – msdn.microsoft.com/library). XML, SOAP, WSDL, and UDDI will provide a foundation for companies to have real-time access to structured and semi-structured knowledge resources around the globe.

3. A model of IOS collaboration

Through an examination of the IOS literature, we identify eight distinct and critical motives[1] underlying an organization's use of IOS: necessity, asymmetry, reciprocity, efficiency, agility, innovation, stability, and legitimacy. We contend that the leader of an knowledge management initiative contemplating or implementing IOS technology needs to carefully consider which of these motives are applicable to his/her situation, how they relate to relational bonding and behavioral processes, and what are their impacts on collaborative advantage:

- *The necessity motive:* an organization adopts the use of an IOS in order to meet necessary legal, regulatory, or deregulatory requirements from higher authorities (e.g. government agencies, legislation, industry, or professional regulatory bodies) that otherwise might not have been used voluntarily (as in the case of US Department of Transportation regulation in 1987 exemplified by Christiaanse and Venkatraman, 2002, and the case of London Stock Exchange's Big Bang in 1986 studied by Clemons and Weber, 1990).
- *The asymmetry motive:* an organization is prompted to use an IOS for purposes of exerting power or control over other organizations (Kling, 1980; Webster, 1995; Iacovou *et al.*, 1995; Reekers and Smithson, 1995; Hart and Saunders, 1997).
- *The reciprocity motive:* an organization uses an IOS in order to pursue common or mutually beneficial goals or interests and to facilitate collaboration, trust building, and coordination (Holland, 1995; Ferrat *et al.*, 1996; Kumar *et al.*, 1998; Pouloudi, 1999).
- *The efficiency motive:* an organization is motivated to use an IOS in an attempt to improve both its internal efficiency and its interorganizational efficiency (Malone *et al.*, 1987; Johnston and Vitale, 1988; Konsynski and McFarlan, 1990; Clemons and Row, 1991).
- *The agility motive:* an organization is prompted to use an IOS to increase agility and responsiveness to environmental changes (Rockart and Short, 1991; Zaheer and Zaheer, 1997).
- *The innovation motive:* an organization is induced to use an IOS for purposes of innovation and value creation (Strader *et al.*, 1998; Bowker and Star, 2001; May and Carter, 2001; Thomke and von Hippel, 2002).
- *The stability motive:* an organization is prompted to use an IOS in order to reduce environmental uncertainty and to achieve stability, predictability, and dependability in its relations with others (Li and Williams, 1999).
- *The legitimacy motive:* an organization is motivated to use an IOS to increase its legitimacy and reputation in order to appear in agreement with prevailing norms, beliefs, expectations of external constituents, or prevalence of a practice in the industry (Teo *et al.*, 2003).

Although each of the eight motives may be a separate and sufficient cause for an organization's IOS adoption, the decision to use IOS is commonly based on multiple motives.

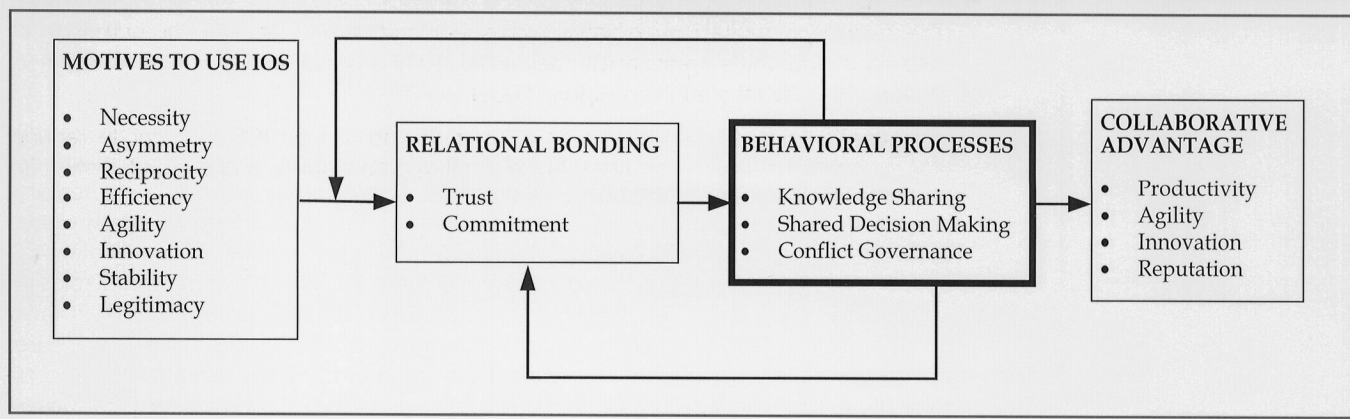
“Effective knowledge sharing can promote understanding, suppress opportunistic behaviors, and induce commitment and trust among partners, thus leading to greater collaboration.”

Furthermore, these eight motives are likely to interact with each other. Certain motives will become dominant under favorable conditions and be suppressed under unfavorable conditions. For example, the underlying process of IOS use prompted by the asymmetry motive can be characterized by inequality, knowledge asymmetry, manipulation, coercion, or conflict. Under transparent knowledge sharing, participative decision making and effective governance for conflict resolution, the asymmetry motive is likely to be suppressed, while the reciprocity motive tends to become dominant. Concurrently, the reciprocity motive may interact with certain other motives. For example, when cooperative use of an IOS is also expected to lead to the fulfillment of other organizational requirements and expectations (e.g. higher levels of efficiency or productivity, greater agility, greater innovation, greater stability, or greater legitimacy or reputation), cooperative behaviors and collaboration will be more likely.

Based on the interaction among the eight motives, we introduce the model of IOS collaboration depicted in Figure 1. An organization may be prompted to use an IOS under certain motives (e.g. stability). When such behavioral processes as transparent knowledge sharing, shared decision making, and effective governance for conflict resolution are promoted among IOS participants, cooperative behaviors are likely to be induced and prevail. These cooperative behaviors tend to interact with an organization's effort to develop stable and reliable relations. Power plays are likely to be suppressed in the hopes that equity, reciprocity, and harmony will facilitate stability. As a result, trust and commitment will increase among the partners. Increased trust and commitment in turn will facilitate the processes of knowledge sharing, participative decision making and conflict resolution, which further enhances trust and commitment of the participants and ultimately yields better joint performance. Performance outcomes for knowledge-intensive work can be gauged in several ways: productivity, agility, innovation, and reputation (Holsapple and Singh, 2001). Collectively, improvements on these four dimensions are avenues for collaborative advantage.

Therefore, the model asserts that knowledge sharing, shared decision making, and conflict governance are three key elements underlying effective interorganizational collaboration. By fostering trust and suppressing power plays, they not only can buttress the motivations of

Figure 1 A model of IOS collaboration



Performance outcomes for knowledge-intensive work can be gauged in several ways: productivity, agility, innovation, and reputation.

organizations to collaborate via IOS, but also make for sustainable collaborative advantage. We next use these three elements in developing a collaboration-oriented IOS framework.

4. IOS frameworks

The forgoing model identifies several variables (and their relationships) that will need to be managed or addressed to improve the chance of success for an IOS-based knowledge management effort aimed at interorganizational collaboration. It is also important for the leader of such an effort to have a framework for appreciating the nature and possibilities of IOS options in accomplishing this knowledge work.

4.1 Limitations of Some IOS Frameworks

Several frameworks for understanding interorganizational systems have been proposed. For example:

- Barret and Konsynski (1982) classify IOS into five levels based on an increasing degree of the participant's responsibility, cost commitment and complexity of operating environment. At level 1, a firm only serves as a remote input/output node for one or more higher level nodes. Level 2 participants design, develop, maintain, and share a single system such as inventory query system. Level 3 participants develop and maintain a network linking itself and its direct business partners. Level 4 participants develop and share a network with diverse application systems that may be used by many different types of participants. At level 5, any number of lower-level participants may be integrated in real time over complex operating environments.
- Johnston and Vitale (1988) propose a framework using three dimensions: business purpose, relationships with participants, and information function. Business purpose indicates why an IOS is needed; it could be either to leverage present business or to enter a new information-driven business. Relationships refer to those participants linked by an IOS; they could be customers, dealers, suppliers, or competitors. Information function is concerned with the functionality that an IOS is intended to perform; it may handle boundary transactions, retrieve and analyze shared information, or be designed to manipulate information as part of "back office" operations in the participants' organizations.
- Meier and Sprague (1991) classify IOS into three categories: ordering systems that connect a manufacturer with its suppliers or a retailer with its customers; electronic markets that substitute the traditional means of trading with the electronic means of trading; and online information dissemination systems.
- Hong (2002) classifies IOS into four types based on the role linkage (vertical vs horizontal) and the system support level (operational vs strategic) of the IOS participant: resource pooling, operational cooperation, operational coordination, and complementary cooperation. A resource pooling IOS links participants to perform common value activities in order to permit risk/cost-sharing by pooling resources. A complementary cooperation IOS represents a form of cooperation between firms playing different roles in an industry value chain. An operational cooperation IOS brings together firms in a common value chain primarily to improve the quality of customer service or to share information of common interest. An operational coordination IOS is used to link different roles of participants serving an industry value chain to increase operational efficiency.

Although these frameworks enhance an understanding of the uses and impacts of IOS, they do not focus on IOS collaboration:

- According to the *American Heritage Dictionary* (1997), collaboration is defined as working together, especially in a joint intellectual effort. Working together implies managing interdependencies among participants toward some common end. Joint intellectual effort recognizes that collaboration is a knowledge management episode comprised of knowledge flows among participants who process knowledge resources in various ways and under various influences in pursuit of the common end (Holsapple and Joshi, 2000). Together with the three elements identified in the collaboration model in Figure 1, we thus contend that a good understanding of IOS collaboration requires the examination of four elements: managing interdependencies among knowledge processors, knowledge sharing, participative decision making, and conflict governance. However, these elements are not explained sufficiently by any of the above IOS frameworks.
- The above frameworks tend to focus on the roles of IOS as competitive weapons for achieving power and efficiency. For example, Johnston and Vitale's framework (1988) advances the concept of competitive advantage to explain the emergence and impact of IOS. It regards IOS as instruments that, by locking in customers and dominating suppliers, increase an organization's bargaining power over them. The framework suggests that, in the drive to optimize its self-interest, the objective of an organization is to minimize its dependence on other organizations while maximizing the dependence of other organizations on itself (Kumar and van Dissel, 1996). Thus, such frameworks appear to be inconsistent with the spirit of interorganizational collaboration.
- Furthermore, underlying these studies is the assumption that humans produce errors while automation produces reliability. These studies view IOS as technologies designed and implemented to automate the relationships between firms. They fail to acknowledge the part human ingenuity plays in the work practice and the importance of learning (Sachs, 1995). The work is viewed as a process flow or the sequence of tasks in operations that can be structured or coded, whereas the tacit, less structured learning process whereby people discover and solve problems is omitted. In this regard, many innovative opportunities of performance improvement by exploiting IOS potentials for learning and utilizing knowledge resources distributed across organizations are likely to be overlooked.

Kumar and van Dissel (1996) propose a framework that classifies IOS based on Thompson's (1967) typology of interorganizational interdependencies. As described in section 4.2.2 below, by highlighting IOS's role in managing inter-firm dependencies and stressing trust building through reducing potential conflicts for sustained collaboration, Kumar and van Dissel's framework addresses some of the limitations of the above frameworks and provides a good basis for our collaboration-oriented IOS framework introduced here.

4.2 A Collaboration-oriented IOS framework

The collaboration-oriented IOS framework is summarized in Table I. It adopts Kumar and van Dissel's (1996) notions of using IOS for managing pooled, sequential, and reciprocal interdependencies. It also incorporates the IOS collaboration model's three behavioral processes: knowledge sharing, participative decision making, and conflict governance, and expands the classification of IOS technologies based on practices for enhancing collaboration. We now explain the framework in detail.

4.2.1 Assumptions

Three assumptions underlie the framework. First, organizations are assumed to make conscious, intentional decisions as to whether to use and how to use IOS for specific reasons within the constraints of a variety of conditions that limit or influence their choices. Second, IOS collaboration is viewed from an organizational (top-management) perspective, even though an IOS may be used between subunits or individuals in the collaborating organizations. An organizational perspective is assumed throughout the paper. Third,

Table I A collaboration-oriented IOS framework

<i>Type of interdependency</i>	<i>Pooled interdependency</i>	<i>Sequential interdependency</i>	<i>Reciprocal interdependency</i>
Configuration Coordination mechanisms	Standards and rules	Standards, rules, schedules and plans	Standards, rules, schedules, plans and mutual adjustment
Structurability Amount of direct human interaction	High Minimum	Medium Intermediate	Low Highest
Type of IOS	Pooled knowledge resources IOS^a	Value/supply-chain IOS	Networked IOS
<i>Nature of knowledge exchanged</i>	<i>Structured</i>	<i>Structured</i> <i>Semi-structured</i>	<i>Structured</i> <i>Semi-structured</i> <i>Unstructured</i>
<i>Key issues in knowledge sharing</i>	<i>Design of interorganizational interfaces</i> <i>Compatibility</i> <i>Knowledge quality</i> <i>Privacy and confidentiality</i>	<i>Design of interorganizational interfaces</i> <i>Compatibility</i> <i>Knowledge quality</i> <i>Privacy and confidentiality</i> <i>Knowledge asymmetry</i>	<i>Design of interorganizational interfaces</i> <i>Compatibility</i> <i>Knowledge quality</i> <i>Privacy and confidentiality</i> <i>Knowledge asymmetry</i> <i>Knowledge-sharing routines</i>
<i>Key issues in decision making</i>	<i>Reduce uncertainty</i> <i>Inability to assimilate quality knowledge</i> <i>Loss of resource control</i>	<i>Reduce uncertainty</i> <i>Inability to assimilate quality knowledge</i> <i>Loss of resource control</i>	<i>Reduce equivocality</i> <i>Inability to assimilate quality knowledge</i> <i>Share understanding</i>
<i>Governance mechanisms for conflict resolution</i>	<i>Technological governance:</i> <i>Open standards;</i> <i>Industry-specific standards;</i> <i>Proprietary or company-specific standards</i>	<i>Technological governance:</i> <i>Open standards;</i> <i>Industry-specific standards;</i> <i>Proprietary or company-specific standards</i>	<i>Technological governance:</i> <i>Open standards;</i> <i>Industry-specific standards;</i> <i>Proprietary or company-specific standards</i>
	<i>Business governance:</i> <i>Classical contracts;</i> <i>Institutional norms</i> <i>Reputation</i>	<i>Business governance:</i> <i>Neoclassical contracts;</i> <i>Institutional norms</i> <i>Reputation;</i> <i>Interpersonal trust</i>	<i>Business governance:</i> <i>Relational contracts;</i> <i>Institutional norms</i> <i>Reputation;</i> <i>Interpersonal trust</i> <i>"Personalization"</i>
<i>Focus of implementation technologies</i>	<i>"Codification"</i>	<i>"Codification"</i>	<i>"Personalization"</i>
<i>Examples of implementation technologies and systems</i>	<i>E-mail</i> <i>Fax</i> <i>Instant messaging</i> <i>Voice mail</i> <i>Electronic bulletin board</i> <i>FAQs</i> <i>Call center</i> <i>EFTPoS</i> <i>Web site</i> <i>Wireless device</i> <i>Peer-to-peer communication</i> <i>Broadband communications</i> <i>Intranet/extranet</i> <i>Internet</i> <i>Wireless networks</i> <i>EDI</i> <i>XML</i> <i>SOAP/WSDL/UDDI</i> <i>Databases, data warehouses</i> <i>Documents, archives</i> <i>Web browser</i> <i>Expert Finder tool</i> <i>Meta/web-crawler</i> <i>Taxonomy/ontological tools</i> <i>OLAP/simulation/modeling</i> <i>Data/text mining</i> <i>Intelligent agents</i> <i>Case-based reasoning</i> <i>Neural networks/genetic algorithm</i> <i>Rule engines</i>	<i>Scheduling techniques</i> <i>Customer relationship management</i> <i>Supply chain management</i> <i>EDI systems</i> <i>Collaborative planning, forecasting and replenishment systems</i> <i>Workflow systems</i>	<i>CAD/CAM</i> <i>Collaborative authoring</i> <i>Calendaring systems</i> <i>Computer conferencing</i> <i>Threaded discussion</i> <i>Group decision support</i> <i>Organizational decision support</i>

Note: ^aKumar and van Dissel (1996) refer to this type of IOS as "pooled information resources IOS"

Source: Adapted from Kumar and van Dissel (1996, p. 287). Italicized areas indicate extensions introduced here

knowledge sharing in this paper is considered in its broadest sense, including flows involved in knowledge transfer, knowledge generation, and/or related knowledge application.

4.2.2 Types of interdependencies and IOS classes

Thompson (1967, pp. 54-55) distinguishes three different ways in which companies can be interrelated:

- (1) Pooled interdependency.
- (2) Sequential interdependency.
- (3) Reciprocal interdependency.

In pooled interdependency, companies share and use common resources; "each renders a discrete contribution to the whole and each is supported by the whole" (e.g. the use of a common data processing center by a number of firms). Sequential interdependency refers to the situation where companies are linked in a chain with direct directional and well-defined relations, where the outputs from one task processor become inputs to another (e.g. the customer-supplier relationship along a supply chain). Reciprocal interdependency describes a relationship where each company's outputs become inputs for the others (e.g. a concurrent engineering team consisting of customers, suppliers, distribution centers, dealers, shippers, and forwarders) (Thompson, 1967; Kumar and van Dissel, 1996).

Pooled interdependency involves minimal direct interaction among the units, and coordination by standardization is appropriate. Sequential interdependency involves an increasing degree of contingency because each position in the chain must be readjusted if an upstream position fails to fulfill its expectation, and coordination by plan is appropriate. Reciprocal interdependency involves the highest degree of interaction because actions of each position in the set must be adjusted to the actions of many interacting positions, and coordination by mutual adjustment is needed (Thompson, 1967; Kumar and van Dissel, 1996).

In correspondence with pooled interdependency, sequential interdependency, and reciprocal interdependency, Kumar and van Dissel (1996) suggest a three-part typology for IOS:

- (1) Pooled information resources IOS.
- (2) Value/supply-chain IOS.
- (3) Networked IOS.

They regard interorganizational systems as technologies designed and implemented to operationalize the interorganizational relationships. They assume that the structure of the relationship influences the degree to which the relationship can be programmed and embedded in the IOS.

- (1) *Pooled information resources IOS* involve interorganizational sharing of a technological system, such as common repositories (e.g. databases, digital archives), common communication networks (e.g. internet, extranet, broadband networks), common communication protocols and standards (e.g. EDI, XML), common application systems (e.g. data/text mining systems), and electronic markets which may include some combinations of common databases, common application procedures and software, and/or common communications infrastructure. Here, we suggest that extending the notion of pooled information resources IOS to pooled knowledge resources IOS allows for a better understanding of IOS collaboration. We thus use the term of pooled knowledge resources IOS in the extended collaboration-oriented IOS framework.

For instance, the Amico Library (www.amico.org) is an internet-based archive with digital copies of more than 100,000 paintings, sculptures and photographs initiated and shared by 39 museums from goliaths like the Metropolitan Museum of Art to smaller institutions like the Newark Museum (Mirapaul, 2003). The National Virtual

Observatory is another initiative to create a common internet-based cosmic database for nation-wide collaboration in astronomy. The project is building sophisticated data/text mining systems and intelligent searching tools, and is creating an Internet-based registry of astronomical resources (Schechter, 2003).

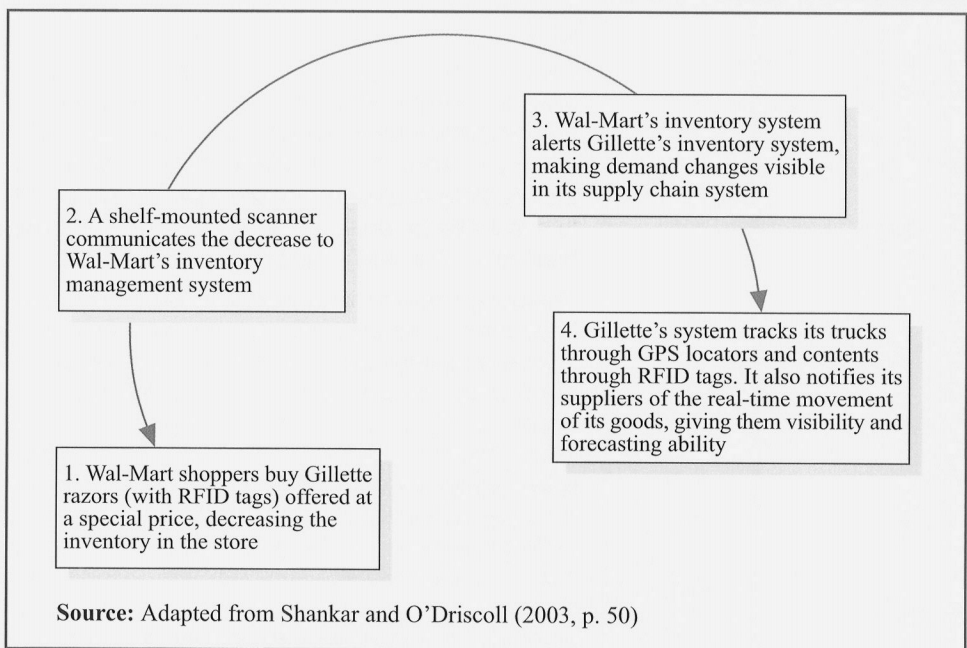
Another example of pooled knowledge resources IOS is Cisco's eHub. eHub is a private electronic marketplace where participants share an extranet infrastructure that uses XML standards, and a central repository that pools together supply chain information for planning and executing tasks (Grosvenor and Austin, 2001).

- (2) *Value/supply-chain IOS* support structured and semi-structured customer-supplier relationships, which are likely to be coded and implemented through automation, and institutionalize sequential interdependency between organizations along the value/supply chain. The Collaborative Forecasting and Replenishment (CFAR) project initiated in 1995 presents an example of value/supply-chain IOS between Wal-Mart store and Warner-Lambert (now part of Pfizer) for forecasting and replenishing pharmaceuticals and healthcare products. CFAR is an internet-based EDI system that allows both companies to jointly create sales forecasts that include information, such as expected alterations to store layouts and meteorological information (King, 1996).

Wal-Mart is also testing a wireless supply chain system with its suppliers including Pepsi, Bounty and Gillette. Wal-Mart uses radio frequency identification (RFID) to track shipments of Pepsi soft drinks, Bounty paper towels, and Gillette razors at a Sam's Club store in Tulsa, OK, from manufacturer to warehouse to store to checkout counter. The process is illustrated in Figure 2. Information from RFID tags on each item in a Wal-Mart store goes into Wal-Mart's 101-terabyte sales transaction database. Thus, suppliers can get a real-time view of what is happening at the store shelf level (Shankar and O'Driscoll, 2002).

- (3) *Networked IOS* operationalize and implement reciprocal interdependencies between organizations. Networked IOS provide a shared virtual space where people collaborate for emerging relationships and learning (Nonaka and Konno, 1998). They focus on supporting informal exchange of semi-structured or unstructured knowledge, which sometimes cannot be described as a business process, such as posting a question on the electronic bulletin board, asking an expert for a solution, and directly contacting customer to elicit needs or problems.

Figure 2 Wal-Mart's wireless supply chain system for tracking and replenishment



ComputerLink gives an example of the networked IOS. ComputerLink is a community health information network built in Cleveland for Alzheimer's caregivers. ComputerLink involves using the internet, an electronic bulletin board, a decision support system, as well as e-mail and electronic encyclopedia facilities to provide clinical and financial services, and deliver just-in-time knowledge among patients, physicians, hospitals, clinics, and home health agencies. The e-mail facility allows individual users to communicate anonymously with a nurse-moderator and other Alzheimer's caregivers. The nurse-moderator serves as technical liaison by providing systems and health support to ComputerLink users while maintaining all encyclopedia functions related to Alzheimer and care giving. The decision support system guides users through a myriad of scenarios allowing self-determined choices based on personal values. The bulletin board enables users to communicate through an electronic support-group public forum (Payton and Brennan, 1999).

The three types of IOS form a Guttman-type scale (Thompson, 1967). That is, value/supply-chain IOS may possess the characteristics of pooled knowledge resources IOS; and networked IOS are likely to possess characteristics of both value/supply-chain IOS and pooled knowledge resources IOS (Kumar and van Dissel, 1996).

4.2.3 Key issues in knowledge sharing

Knowledge sharing is a key aspect of IOS collaboration, as discussed for the collaboration model shown in Figure 1. Effective knowledge sharing can promote understanding, suppress opportunistic behaviors, and induce commitment and trust among partners, thus leading to greater collaboration. Knowledge sharing is primarily determined by two factors: transparency, and receptivity (Hamel, 1991). For each of these factors, we discuss implications for the three IOS technology classes that deserve consideration by leaders of interorganizational knowledge management initiatives.

4.2.3.1 Knowledge sharing transparency. Transparency refers to the "openness" of an organization to its partners (Hamel, 1991). It can be influenced by the design of interorganizational interfaces[2] (Malone, 1985; Hamel, 1991). In addition, knowledge quality, privacy and confidentiality can also influence transparency.

Pooled knowledge resources IOS.

- *Design of interorganizational interfaces:* in pooled knowledge resources IOS, the coordination structure in terms of the level of roles, obligations, rights, procedures, knowledge flows, as well as analysis and computational methods used, can be clearly specified and standardized (Kumar and van Dissel, 1996). The knowledge exchanged tends to be highly structured, such as product descriptions, customer characterizations, and transaction status. As such, interorganizational interfaces mostly can be designed as protocols, rules, and standards built in shared software, tools, and systems. The transparency of an organization regarding what knowledge to share with whom and how to share can be determined by the degree of "openness" inherent in the embedded protocols, rules, and standards.
- *Knowledge quality:* in pooled knowledge resources IOS, one or more users of the "commons" may treat the common as a free dumping ground and contaminate the shared knowledge archives by dumping/depositing corrupt knowledge representations, or allowing non-standard or unedited transactions onto the network, or even worse, unintentionally or intentionally infesting the system with viruses (Kumar and van Dissel, 1996). These contaminations will degrade the knowledge quality of the "commons," whose attributes such as validity and utility, are important for quality decision making (Holsapple, 1995) and transparent knowledge sharing.

Contaminations can be controlled by designing and enforcing representations and access standards through technological governance mechanisms for security, virus-scan, and access control (Kumar and van Dissel, 1996). Additionally, defining and measuring key knowledge quality attributes, such as validity and utility, and aspects

of each (Holsapple, 1995), and properly maintaining these quality-related measures as knowledge moves across systems and organizations is important (Madnick, 1995).

- *Privacy and confidentiality*: in pooled knowledge resources IOS, because the "commons" are a public resource among IOS users, some users may misuse the system by "poaching," "stealing," or "unauthorized snooping" (Kumar and van Dissel, 1996; Levitin and Redman, 1998). A user may collect and summarize contents from the entire archive; or monitor and analyze transactions over the common network to develop strategies for private use; or collect and infer confidential and private information about another firm's customers through lookups in a shared archive or through monitoring online transactions and then luring selected customers away from the current suppliers. Such misuses of the "commons" can pose serious issues of privacy and confidentiality, thus impeding transparent knowledge sharing while increasing the potential for opportunistic behaviors and free riding among IOS users.

Misuses of the "commons" can be controlled by imposing security mechanisms, such as software safeguards, access control, and transaction logs (Kumar and van Dissel, 1996). Additionally, fostering norms or spreading values among IOS users that encourage transparent knowledge sharing, may also provide effective governance against misusing the "commons".

Value/supply-chain IOS. In value/supply-chain IOS, roles and mutual expectations between adjacent parties in a value/supply chain can be structured. Structured interactions could range from tracking EDI-based orders, to looking up databases of adjacent partners in the chain for sales forecasting, to transferring CAD-based specifications from customers to suppliers (Kumar and van Dissel, 1996). The knowledge shared can range from structured data, such as ordering and customer data, sales data, and production and inventory data, to semi-structured representations, such as market research, category management, and cost-related descriptions (Simatupang and Sridharan, 2001). As such, interorganizational interfaces in value/supply-chain IOS also can be largely designed as protocols, rules, and standards embedded in the software, tools, and systems (e.g. automated workflow systems), determining the transparency of an organization in terms of what knowledge to share, how much to share, with whom to share, and how to share.

Similar to a pooled knowledge resources IOS, knowledge quality and privacy and confidentiality in a value/supply-chain IOS also influence the transparency of an organization. In addition, knowledge asymmetry presents another issue influencing the "openness" of an organization in a value/supply-chain IOS.

Knowledge asymmetry^[3] refers to the situation where different players in a value/supply-chain IOS are likely to have different states of private knowledge about resources (e.g. capacity, inventory status, and funds), various data-related costs, chain operations (e.g. sales, production and delivery schedules), performance status, and market conditions. This knowledge asymmetry can lead to misunderstanding among chain members about their mutual efforts at collaboration. Because of their different roles, positions, and objectives in the chain, conflict and suboptimal decisions may result, such as unproductive allocation of resources (Lee and Whang, 2000; Simatupang and Sridharan, 2001).

Asymmetric knowledge may also cause difficulties among chain members in dealing with market uncertainty. For example, when the downstream players poorly estimate or distort demand conditions, the upstream players may experience larger variance of customer demand, producing difficulties in managing genuine levels of production and inventory. This can also produce difficulties in designing products that might be desirable, especially for innovative products (Simatupang and Sridharan, 2001).

Furthermore, asymmetric knowledge can inhibit transparent knowledge sharing and increase the potential for opportunism, either prior to the contract or after the contract (Molho, 1997). Adverse selection can occur before a contract is signed; it involves misrepresentation or concealment of true capability, resource, and demand conditions that need to be shared. Moral hazards can occur after a contract is signed; they involve

providing misleading characterizations of performance status, lowering of service level efforts, and committing only a minimum level of resources.

To reduce knowledge asymmetry, it is necessary to develop clear performance measures and also promote mutual interests and trust among IOS participants. Additionally, financial incentives, such as productive-behavior-based incentives, pay-for-performance, and equitable arrangements (Simatupang and Sridharan, 2001), may be employed to promote transparent knowledge sharing and discourage dysfunctional behaviors. The use of technology may also help increase control by facilitating performance measures and monitoring (Gallivan and Depledge, 2003).

Networked IOS. With networked IOS, the form, direction, and content of the relationships among participants are much less structured than with the other two types of IOS (Kumar and van Dissel, 1996). Reciprocal relationships can be viewed as consisting of exchange processes and adaptation processes; exchange processes represent "the operational, day-to-day exchanges of an economic, technical, social, or informational nature occurring between firms;" adaptation involves the processes whereby firms adjust and maintain their relationships by modifying routines and mutual expectations (Kumar *et al.*, 1998, pp. 215). A networked IOS thus involves an increasing degree of human interaction and requires mechanisms such as trust to identify, assess, and manage the dynamically occurring equivocality and risks in the situation. The nature of the knowledge exchanged can range from structured (such as product data), to semi-structured (such as reports about industry trends), to highly unstructured (such as expertise and know-how, problem-solving skills, and ideas about a new product design). As such, many parts of interorganizational interfaces in networked IOS, unlike those in the other two types of IOS, cannot be designed as built-in protocols, rules, and standards. Instead, human processors positioned at organizational boundaries tend to interface with each other, with the aid of IOS. Thus, the "openness" of those individuals can greatly influence the transparency of knowledge sharing, in addition to the embedded rules and protocols, knowledge quality, and privacy and confidentiality. This "openness" can be enhanced through nurturing knowledge sharing routines.

Knowledge sharing routines can be viewed as regular patterns of interorganizational interactions that permit the transfer, application, or generation of specialized knowledge (Grant, 1996; Dyer and Singh, 1998). These routines are largely dependent on an alignment of incentives to encourage transparent knowledge sharing and discourage opportunistic behaviors and free riding (Dyer and Singh, 1998). Financial incentives or informal norms of reciprocity may be employed to promote mutual interests and highlight common goals (Lewis, 1990; Badaracco, 1991), thus motivating transparent knowledge sharing (Mowery *et al.*, 1996; Dyer and Singh, 1998). Technological governance mechanisms for knowledge security and system security may also be employed (Venkatraman, 1991; Kumar and van Dissel, 1996) to discourage dysfunctional behaviors.

4.3.2.2 Knowledge sharing receptivity. Receptivity is also termed assimilative ability (O'Leary, 2003), or "partner-specific absorptive capacity" (Dyer and Singh, 1998). It refers to an organization's ability to assimilate knowledge and skills from its partners. Receptivity involves "implementing a set of interorganizational processes that allow collaborating firms to systematically identify valuable know-how and then transfer it across organizational boundaries" (Dyer and Singh, 1998, p. 665). It is a function of the compatibility between partners and the absorptiveness of receptors/processors (Hamel, 1991).

Compatibility. Across all three types of IOS, incompatibility and inconsistency can result from geographically and functionally dispersed business operations, as well as differences in work processes and underlying cultures of organizations. There may be different semantics for the same term, or different identifiers for key business entities, such as customer or product, or different schemes for aggregating key indicators, such as sales or expenses, or different ways of calculating key concepts, such as profit or return on investments (Goodhue *et al.*, 1992; Madnick, 1995).

In addition to knowledge incompatibility, there may also exist incompatibilities of technological infrastructure across organizational boundaries. These incompatibilities not

only can thwart an organization's ability to identify and transfer valuable knowledge to/from its IOS partners, but may also increase the potential for mistrust and conflict.

To enhance compatibility, common technological standards and knowledge representations with standard definitions and codes need to be shared, and a common language for communicating about business procedures and events must be established across IOS users.

Absorptiveness of receptors/processors. In pooled knowledge resources IOS, given a low level of direct human interaction, patterned interorganizational interactions are mostly between human processors and computer processors, or computer processors and computer processors. Thus, the absorptiveness of receptors/processors can be largely determined and enhanced by the use of knowledge technologies that focus on "codification" (Milton *et al.*, 1999), or the "storing," "massaging," "structuring," "integrating," "filtering," "navigating," and retrieving of reusable knowledge assets from/to shared repositories (O'Leary, 2003). Examples of such technologies may include artificial intelligence tools, meta/web crawlers, and taxonomy/ontological tools (Tsui, 2003). Additionally, technologies that facilitate "discovery," and "capture/monitor" (Milton *et al.*, 1999) across organizational boundaries, such as data/text mining, could also provide effective means for increasing an organization's receptivity (Upton and McAfee, 1996; Majchrzak *et al.*, 2000; Tsui, 2003).

In value/supply-chain IOS, contacts between chain members can be largely patterned into human-computer and computer-computer interactions that employ interface standards. Besides standards, plans and schedules are also used for interorganizational coordination, increasing the degree of direct human interaction. Thus, in addition to the use of technologies for enhancing "codification," shared knowledge backgrounds and common skills of human processors are also important in increasing the absorptive ability of an organization.

In contrast with the other two types of IOS, networked IOS involve a high degree of human-human interaction. A large proportion of the critical knowledge handled by a networked IOS can be tacit and unstructured. As such, the receptivity of an organization can be greatly influenced by the absorptive skills of individual human processors. Technologies are used to provide process support for enhancing human absorptive skills:

- by connecting and locating people (Tsui, 2003) and optimizing the frequency and intensity of socio-technical interactions (Dyer and Singh, 1998);
- by facilitating the sharing of context (Nomura, 2002) and development of common knowledge bases;
- by increasing the capability of capturing and locating tacit and unstructured knowledge (Majchrzak *et al.*, 2000; May and Carter, 2001); and
- by improving analytical and decision-making capabilities.

Thus, technologies that focus on "personalization" (Milton *et al.*, 1999; Tsui, 2003) and support learning, such as collaborative construction tools (e.g. CAD/CAM, collaborative authoring), computer conferencing, and group decision support systems are important in enhancing an organization's receptivity.

4.2.4 Key issues in decision making

Decision making is another key behavioral process that influences the outcome of interorganizational collaboration (recall the collaboration model in Figure 1). Imbalance in decision-making authority may lead to perceived injustice and mistrust, and create an environment prone to opportunism and conflict, while shared decision making can facilitate perceived equality and trusting relationship, thus enhancing interorganizational collaboration (Sarkar *et al.*, 1998).

In pooled knowledge resources IOS, the parties sharing the resources do not need to directly interact with each other, and the decision-making process of each party is relatively

independent from that of others. However, perceived inequality and mistrust in decision making could arise from one party's possession and control of the shared resources. For example, in the airline industry, American and United attempted to bias screen displays of their computer-based reservation systems to discourage price comparisons (Bakos, 1991), or to restrict travel agents from booking tickets from the other airlines (Malone *et al.*, 1987).

In those situations where shared knowledge resources are controlled by one of the partners and the controlling party is also a competitor of the other parties, this dominant party may use its controlling position to intentionally damage other parties (Copeland and McKenney, 1988). As a result, distrust in the system controls and perceived loss of power in decision making are likely to arise (Kumar and van Dissel, 1996), increasing conflict potential and inhibiting cooperative behaviors. One way to address this issue is to place control of common resources in the hands of a neutral third-party (such as a trade association, government agency, or joint venture company) (Konsynski and McFarlan, 1990; Kumar and van Dissel, 1996) in order to increase the participants' perceived justice and control in decision making, thus increasing trust and collaborative effectiveness.

In value/supply-chain IOS, particularly in a proprietary network, the loss of resource control or an inability to access to quality knowledge may induce perceived inequality and loss of power in decision making, thereby impeding trust building and retarding collaboration success. For example, in the mid-1980s, Ford Motor established a proprietary EDI system, Fordnet. In pursuing its agendas for reducing market uncertainty, or simply for locking trading partners into its trading relationship, Ford imposed its information handling practices on all of its European trading partners, extending its own hardware systems into its suppliers' premises, dictating product and inventory coding according to its own propriety system, and dictating the type and frequency of data to be exchanged (Webster, 1995). Consequently, many Fordnet users experienced decreased trust arising from a perceived loss of decision power in the trading relationship. Additionally, the transaction-specific investment in the Fordnet EDI also increased the risk of suboptimization perceived by the Fordnet users, further impeding the collaboration between Ford and its partners.

As suggested by the case of Fordnet, the use of more open standards and migration from a proprietary network to a more open network may provide a viable solution for promoting participative decision making and increasing perceived justice and reciprocity. Furthermore, promoting shared understanding and mutual interests among participants would also enhance perceived equality and decision power, facilitating the growth of trust and collaboration.

In networked IOS, decision making is quite different from that in the other two types of IOS. It involves highly interrelated processes and intense interactions among participants. Many studies have indicated that use of interactive technologies can greatly enhance the shared processes in decision making (Bowker and Star, 2001). Some have found that technologically mediated communication creates less role differentiation among the participants than does face-to-face communication (Kiesler and Sproull, 1996). Others have found that for groups communicating via e-mail, there tends to be uninhibited communication, more communication among participants of different status, and more equal participation (Kiesler *et al.*, 1984; Rice and Rogers, 1984; Siegel *et al.*, 1986).

However, in networked IOS, the increased degree of human interaction and mutual adaptation may also increase performance equivocality and human misunderstanding. Thus, reducing such misunderstanding becomes important in facilitating the decision-making process in networked IOS. One approach to reduce misunderstanding is to foster trust. Another approach involves central repositories that provide a common knowledge base for sharing visions and contexts among the participants, such as discussion forums, frequently asked questions (FAQs) facilities, and electronic libraries with problem definitions, successful experiences and best practices (Majchrzak *et al.*, 2000; May and Carter, 2001).

4.2.5 Governance mechanisms for conflict resolution

Besides transparent knowledge sharing and participative decision-making, the model portrayed in Figure 1 identifies conflict governance as a third key element underlying effective interorganizational collaboration. In an IOS network, conflict could arise from opportunistic behaviors, impeding the success of interorganizational collaboration. Opportunistic behaviors may occur when managing shared technology-based resources, such as shared archives. Or, they may take place in the transactional activities that are handled by the IOS. Thus, both technological governance and business governance are needed for preventing opportunism and resolving conflict so as to foster trust and enhance collaborative advantage.

Technological governance: this includes various technical protocols, standards, system security controls, and knowledge security controls. Technological governance can be decomposed into three subtypes:

- (1) Open standards, such as XML.
- (2) Industry-specific standards, such as the SWIFT standard used in the international banking industry (Keen, 1991) and universal product code (UPC) in the grocery industry (Cash and Konsynski, 1985).
- (3) Proprietary or company-specific standards, such as the manufacturing automation protocol (MAP) used by General Motor (Keen, 1991).

Open standards and industry-specific standards are likely to be used in pooled knowledge resources IOS because of a large number of participants involved. Proprietary or company-specific standards may be used in value/supply-chain IOS and networked IOS (Li and Williams, 1999). Recent trends indicate that value/supply-chain IOS and networked IOS are moving toward the use of more open standards:

- *Business governance*: business governance involves formal governance, such as legal contracts (Macneil, 1974, 1978; Ring and van de Ven, 1992), and informal governance, such as institutional norms (Zucker, 1986), reputation (Zucker, 1986; Resnick *et al.*, 2000; Adler, 2001), and trust (Arrow, 1974; Ouchi, 1979; Bradach and Eccles, 1989; Williamson, 1993).
- *Formal governance*: based on characteristics of the transactions to be conducted for the three IOS classes, three types of legal contracts can be applied. With pooled knowledge resources IOS, arms-length market transactions are likely to be involved, and thus a classical contract[4] would be appropriate. With value/supply-chain IOS, recurrent transactions are likely to occur between the chain members, and thus a neoclassical contract[5] would be appropriate. With networked IOS, relational activities take place, and thus a relational contract[6] is suitable.
- *Informal governance*: with pooled knowledge resources IOS, given the minimum amount of interaction, institutional norms that define each other's behaviors (Zucker, 1986) and reputation that is established through a network of trusted third parties (Zucker, 1986; Resnick *et al.*, 2000; Adler, 2001) may serve as effective governance mechanisms supplementing the classical contract. In value/supply-chain IOS and networked IOS, with an increasing degree of human interaction, trust assumes a greater role as an effective mechanism for governing opportunistic behaviors and resolving conflict (Arrow, 1974; Ouchi, 1979; Bradach and Eccles, 1989; Williamson, 1993). Reputation and norms of reciprocity can also provide useful governance, as well as further facilitate the growth of trust.

4.2.6 IOS technologies

Based on the characteristics and roles of each type of IOS as well as the practices involved in knowledge sharing, decision making, and conflict governance, we next classify a variety of candidate IOS technologies and application systems:

- Pooled knowledge resources IOS usually involve a large number of participants, highly structured interactions among participants and a relatively low degree of human contact.

They are used to provide shared knowledge resources to reduce uncertainty, achieve economies of scale and scope by sharing costs and risks among participants (Konsynski and McFarlan, 1990). Implementation technologies require a focus on "codification" (i.e. "capturing existing knowledge and placing this in repositories in a structured manner") (Milton *et al.*, 1999, p. 619; Tsui, 2003). Thus, technologies for communications (e.g. communications networks, standards and protocols) and for content management (e.g. shared repositories, knowledge acquisition and retrieval) can serve as good application candidates. Table II shows some examples.

- Value/supply-chain IOS involve relatively structured and linear relations between adjacent chain members, whose interaction interfaces can be largely standardized. They are used primarily for purposes of reducing uncertainty, streamlining flows of knowledge, services, and products, and increasing efficiency. Implementation technologies also focus on "codification." It is worth noting that interdependencies between firms are different from the ways in which tasks/activities are interrelated. For example, sequential dependency between firms along a supply chain may involve many different tasks/activities relationships, such as "sharing," "flow," "fit," concurrent tasks, task-subtask (Malone and Crowston, 1999, p. 429; Holsapple and Whinston, 2001, p. 585). "Sharing" relationships occur when multiple activities use the same resource. "Flow" relationships arise when one activity produces a resource that is used by another activity, involving sequencing, transfer, and usability. "Fit" relationships occur when multiple activities collectively produce one resource. Concurrent tasks arise when multiple activities occur simultaneously. Task-subtask relationship arises when one activity involves multiple subactivities.

Table II Pooled knowledge resources IOS: implementation technologies and applications

Interfirm communication	Messaging services	E-mail Fax Instant messaging Voice mail Publishing services Open posting (e.g. electronic bulletin board) Controlled posting (e.g. FAQs)
	Channel management	Call center Electronic funds transfer at point-of-sales (EFTPoS) Web site Wireless device
	Communications network	Peer-to-peer communication Broadband communications Intranet Extranet Internet Wireless networks
	Communication standards and protocols	Electronic data interchange (EDI) Extensible mark-up language (XML) Simple object access protocol (SOAP) Web services description language (WSDL) Universal description, discovery, and integration (UDDI)
Content management	Shared repositories	Databases, data warehouses Digital documents, archives
	Knowledge acquisition and retrieval	Knowledge navigation (e.g. web browser) Knowledge search (e.g. expert finder tool, meta/web-crawler, taxonomy/ontological tools)
	Knowledge discovery and generation	Analytics (e.g. OLAP, simulation, modeling) Mining (e.g. data mining, text mining) Artificial intelligence (e.g. intelligent agents, case-based reasoning, neural networks, genetic algorithm, rule engines)

Therefore, the coordination technologies that focus on supporting structured and semi-structured tasks/activities along the value/supply chain may serve as good candidate technologies for value/supply-chain IOS. These technologies may include scheduling resources and tasks across companies (Malone and Crowston, 1999; Holsapple and Whinston, 2001, p. 585), managing customer-supplier relationships (Holsapple and Whinston, 2001, p. 585), and interorganizational workflow automation (van der Aalst, 2000). Scheduling techniques involve managing the "sharing" relationships based on the mechanisms, such as "first come/first serve," priority order, budget, managerial decision, and competitive bidding, and also the "flow" relationships, such as CPM and PERT for project management. Managing customer-supplier relationships focuses on the "flow" relationships between activities along a value chain. Technologies may involve customer relationship management, supply chain management, EDI systems, collaborative planning, forecasting and replenishment systems. Workflow automation is used for structured business processes across firms with a predefined set of tasks and routing constructs. Workflow automation involves managing concurrent tasks, task-subtask relationships, and multi-participant tasks. Table III lists some examples of candidate technologies and applications.

- Networked IOS have a focus on people and their work styles, especially how they create ideas and what knowledge resources they use. Networked IOS are particularly instrumental in three aspects: agile problem solving by delivering just-in-time knowledge among individuals across organizations, expertise co-development by supporting deeper and more tacit knowledge sharing among professionals, and innovation by optimizing interactions with customers and utilizing their knowledge (Nomura, 2002). Each of these aspects highlights human ingenuity and involves a tacit and less structured learning process. Thus, implementation technologies focus on "personalization" (i.e. "locating and connecting people") (Milton *et al.*, 1999; Tsui, 2003, p. 6). Groupware, threaded discussions, computer conferencing, and collaborative construction tools (e.g. design, authoring) may serve as good candidates. Table IV lists some examples.

5. Conclusion

IOS are assuming an increasing role in facilitating and enabling interorganizational collaboration. Yet, the existing literature on IOS is fragmented and provides limited understanding of the relationship between IOS technologies and the knowledge-intensive phenomenon of interorganizational collaboration. In this paper, we introduce an integrative model of IOS collaboration and identify knowledge sharing, participative decision making, and conflict governance as three behavioral process elements underlying effective

Table III Value/supply-chain IOS: implementation technologies and applications

Interfirm coordination	Scheduling resources and tasks	e.g. "First come/first serve," priority order, budget, managerial decision, competitive bidding, CPM, PERT for project management
	Managing customer-supplier relationships	e.g. Customer relationship management, supply chain management, EDI systems, collaborative planning, forecasting and replenishment systems
	Workflow automation	e.g. Concurrent tasks, task-subtask relationship, managing multi-participant tasks

Table IV Networked IOS: implementation technologies and applications

Interfirm cooperative work	Collaborative construction	e.g. CAD/CAM, authoring
	Collaborative timing/meeting management	e.g. Calendaring, computer conferencing
	Threaded discussion	e.g. Community of practice
	Multi-participant decision support	e.g. Group decision support, organizational decision support

interorganizational collaboration. Extending Kumar and van Dissel's framework to directly recognize these elements, we develop a more complete collaboration-oriented IOS framework for characterizing key elements of interorganizational collaboration and classifying IOS technologies.

For researchers, this paper contributes to a deeper, fuller understanding of issues involved in achieving collaborative advantage with IOS technologies. Both the IOS collaboration model and the collaboration-oriented IOS framework provide a basis for further exploration of the uses and impacts of IOS technologies in interorganizational collaboration. They identify factors and relationships that researchers should consider in designing empirical studies, posing hypotheses about collaboration via IOS, and analyzing results.

For educators, this paper brings together diverse ideas into a systematic view of collaboration via interorganizational systems. It outlines IOS characteristics, classifies them, and highlights issues related to their deployment. As such, the model and framework can be used to identify and structure course content concerned with collaboration and IOS.

For practitioners, this paper provides useful guidance for IOS users by highlighting key elements of collaboration, presenting empirical examples and addressing key issues, practices, and solutions involved in the IOS collaboration. The model and framework serve as a checklist of considerations that need to be dealt with by leaders of collaboration-oriented IOS initiatives. The IOS framework and technology classification may also suggest ways in which IT vendors might provide better technological solutions, services, and software for interorganizational collaboration.

As more and more interorganizational system links are established between firms, the question of how to develop collaborative IT relationships and optimize the use of IOS grows in importance. The answer involves methods to promote such process behaviors as knowledge sharing and participative decision making among IOS users, while simultaneously aligning with effective governance mechanisms to facilitate these behaviors, inhibit opportunistic behaviors and power plays, and ultimately yield collaborative advantages in the directions of greater productivity, agility, innovation, and/or reputation.

Notes

1. This is an application of Oliver's (1990) contingency theory of interorganizational relationship formation. Oliver proposes six critical causes – necessity, asymmetry, reciprocity, efficiency, stability, and legitimacy – as generalizable predictors of interorganizational relationship formation across organizations, settings, and linkages. These are used to structure our examination of the IOS literature. Our examination yielded two additional motives: innovation and agility.
2. The notion of interorganizational interface comes from Malone's (1985) concept of "organizational interface." Malone (1985, p. 66) suggests that "the term 'interface' was originally used in computer science to mean a connection between programs or program modules;" later, the phrase "user interface" becomes common and is used to include the connection between a human user and a computer system; in the same spirit, this usage can be extended to include "organizational interface," which can be defined as "the parts of a computer system that connect human users to each other and to the capabilities provided by computers." Here, we further extend the concept of "organizational interface" to interorganizational interface to emphasize the parts of the computer systems that connect human users to each other and to the capabilities provided by computers shared by two or more organizations.
3. In the literature, a widely used term is "information asymmetry." In this paper, we extend this concept to knowledge asymmetry to emphasize that a less structured or more tacit knowledge dimension (e.g. vision and understanding about certain markets and demands) are involved in the interplay between different value/supply chain members.
4. Classical contract involves one-time, short-term, arms-length market transactions between autonomous and independent parties. "The conditions associated with these transactions are 'sharp in,' that is, they are accompanied by a clear-cut, complete, and monetized agreement. They are also 'sharp out,' i.e. the seller's debt of performance and the buyer's debt of payment are

unambiguous." "The property, products, or services exchanged tend towards the non-specific, and can be transacted among many traders" (Ring and Van De Ven, 1992, p. 485).

5. Neoclassical contract involves relatively short-term, "repeated exchanges of assets that have moderate degrees of transaction specificity. The terms of these exchanges tend to be certain, but some contingencies may be left to future resolution." "The parties see themselves as autonomous, legally equal, but contemplating a more embedded relationship" (Ring and Van De Ven, 1992, p. 487).
6. Relational contract involves "long-term investments that stem from groundwork laid by recurrent bargaining on the production and transfer of property rights among these legally equal and autonomous parties. The property, products, or services jointly developed and exchanged in these transactions entail highly specific investments, in ventures that cannot be fully specified or controlled by the parties in advance of their execution" (Ring and Van De Ven, 1992, p. 487).

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