Between Flexibility and Automation: An Evaluation of Web Technology from a Business Process Perspective

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Table of Contents

- Abstract
- Introduction
- Business-to-Business Transactions
- Information
- Negotiation
- Settlement
- After-sales and Transaction Analysis
- Settlement
- A Model to Evaluate Process Infrastructures:
  The Trade-Off between Flexibility and Automation
- Categorization of Information Systems
- One-directional flow of information
- Explicit Feedback Mechanisms
- Implicit Feedback Mechanisms
- User Modeling and Adaptivity
- Agent-Based Interactivity
- Summary and Conclusions
- References
- About the Authors

Abstract

Web information systems hold great potential to streamline and improve business-to-business-transactions. However, not all Web technologies are equally suited to support the different business processes throughout their distinct phases. In this paper, we outline a framework to improve the conceptual design of Web-based information systems to support business-to-business transactions. The framework consists of three parts. The first
part delineates the different phases of commercial transaction processes, part two introduces a model to evaluate process infrastructures, and part three categorizes Web technologies and underlying communication models. By combining the three parts, we can match available systems with the requirements of transaction processes in a structured way. This integration allows improving long-term process efficiency, and helps to identify areas where the information system functionality is currently inadequate.

**Introduction**

In the context of emerging technologies, developments in business-to-business applications have often been trailing the dynamics of consumer-oriented electronic commerce. Online buying systems, shopping portals, and Web-based auctions initially addressed retail transactions in business-to-consumer and consumer-to-consumer scenarios. When it comes to supporting the relationships with their peers, companies have been somewhat more hesitant to invest in new solutions. However, once the business case can be made, dynamics often become more powerful and thorough. This happened in the context of business-to-business electronic commerce. Based on emerging Web technologies, these applications link organizations with their business-partners, customers, and suppliers. They offer alternatives to traditional methods, such as electronic data interchange (EDI) or inter-organizational systems (IOS) that were often based on proprietary communication channels and technologies and that were expensive and cumbersome to implement. Forrester estimates that in the United States alone, inter-company trade of hard goods over the Internet hit $43 billion dollars in 1998, over five times the retail total. It also predicts that this figure will reach $1.3 trillion by 2003, or 9.4 percent of total business-to-business sales (http://www.forrester.com/). Instead of regarding the Internet as a mere sales channel, companies also utilize emerging technologies to cut costs out of the supply-chain by streamlining procurement processes and improving collaboration. In times of intense competition and increasingly open markets, the ability to achieve efficiency improvements can become key to commercial success.

The benefits of electronic commerce, however, do not come without careful planning (Jutla, Bodorik, et al. 1999). Companies willing to invest in emerging technologies face a daunting array of solutions and can choose from many different architectures and implementation possibilities. They need to decide on appropriate business models and frameworks for investing in electronic commerce. Factors to be considered include perceived costs and benefits, complexity, compatibility, connectivity between new technologies and existing systems, ease of implementation, and user-friendliness (Nambisan & Wang, 1999). The complexity of the decision process is aggravated as many technologies are still in their infancy, and widely adopted business practices have not yet emerged. At the same time, powerful electronic commerce systems require substantial investments. In a recent study, the Gartner Group estimates one million US-$ as the average cost of developing and launching a Web-based electronic commerce system (Legard, 1999).

In this paper, we look at business-to-business transactions and how they can be supported by Web-based information systems. We introduce a conceptual framework that can be applied to match available systems with
the requirements of transaction processes. The three components of the framework are outlined in the following sections. The first part describes interorganizational transactions from a process-oriented perspective. We distinguish between four phases: information, negotiation, settlement, and after-sales & transaction analysis, and put this categorization into perspective with other approaches (Section 2). The second part outlines a generic model to assess process infrastructures (Section 3). The model emphasizes the trade-off between process automation and flexibility caused by different types of infrastructure. It uses three primary variables to characterize a process: complexity, structure, and uncertainty. The model is then combined with the requirements of the distinct transaction phases. The third part provides a structured overview of different Web-based technologies (Section 4), which are grouped into five categories, according to the sophistication of the communication models that they support. By combining the three elements of the framework (transaction phases, process variables, and categories of Web information systems), we assess the suitability of different technologies to support business-to-business transactions, and recommend some areas for improvement.

**Business-to-Business Transactions**

Business transactions are generally viewed as processes to exchange goods and services for some form of compensation. Being at the core of all economic activity, transactions are the object of much research in business and economics. "A transaction occurs when a good or service is transferred across a technologically separable interface. One stage of activity terminates and another one begins" (Williamson 1985). Of the many features that can be used to characterize and analyze transactions, we concentrate on participants and transaction phases.

**Participants**

Transactions usually involve three categories of participants: buyers, sellers, and intermediaries. Buyers and sellers are the active groups in terms of exchanging goods and services (sellers) for some form of compensation (buyer). The third group, intermediaries, offers a variety of services to support and facilitate transactions. It includes financial institutions such as banks, credit-card companies, and insurance brokers; providers of shipping, logistics, and warehousing services; and consultants, industry associations, and market researchers offering advice, product data, or market information. Providers of information technology to automate transactions, or to help set up electronic marketplaces can be characterized as intermediaries as well.

In the case of business-to-business transactions, both buyers and sellers are business organizations, whereas business-to-consumer and consumer-to-consumer transactions involve end-consumers or private households as buyers or sellers, respectively. In this paper, we focus on business transactions from the perspective of the buying firm. Accordingly, the group of the sellers includes manufacturers, producers, and other organizations providing goods and services as the objects of a transaction, including wholesalers and distributors.

**Process Phases**

Business transactions consist of a number of sub-processes. While there is generally consensus on what a business transaction is all about and whom it
involves, the approaches to delineate their sequence show some variety. As with any definition, the task largely depends on the research objective and perspective that is taken.

Comparatively simple models (e.g., Gebauer, 1996; Schmid, 1993) distinguish between three stages: information, negotiation, and settlement. In the first phase, prospective buyers identify and evaluate their needs as well as alternative sources to fulfill them, while sellers arrange to provide their goods and identify potential customers. Subsequently, prospective customers and sellers negotiate the terms of a deal, finalized by a contract. Eventually, the contract is executed and the objects of the transaction are exchanged according to the conditions previously stipulated.

Nissen (1997) outlines a commerce model for the electronic redesign of inter-organizational processes and divides transactions into five steps as shown in Figure 1. From the buyer’s perspective, the process begins with the identification of some need, while the seller arranges to provide a product, service, or information. For the buyer the process then proceeds through sourcing and purchasing to the use, maintenance and ultimate disposal of the purchased good. The seller proceeds through marketing and sales to customer support. Throughout the process, buyer and seller exchange money, goods, information, and even “influence” as delineated at the negotiation stage. Nissen proposes to examine information being exchanged at each process stage in order to acquire insight into those process activities that offer good potential for support through digital and network technologies. While the first four stages relate to the simpler model depicted above, the fifth stage adds an additional perspective that occurs after the exchange process itself.

**Commerce Model**

![Commerce Model Diagram](image)

**Figure 1.** Process flow of a transaction (Nissen, 1997)

In their empirical work to determine the impact of electronic networks on an organization’s degree of virtualization, Kraut et al. (1998) identify six...
separable stages of a transaction: 1) searching for and selecting a supplier; 2) developing the specifications of the key input; 3) negotiating the terms of the acquisition such as price, delivery date, and so on; 4) ordering the input; 5) monitoring the quality of the good or service; and 6) fixing problems after the order. Here, the focus is on the importance of electronic links throughout the different stages, as compared to personal relationships.

Schmid (1998) discusses the characteristics, organizational structures, and potentials of electronic markets. He uses a four-step approach to outline transaction processes as the core activities that take place in (electronic) marketplaces: 1) knowledge, general information gathering; 2) intention, definition of transaction objective; 3) contracting and negotiation; 4) settlement and contract execution. In his perspective, an electronic market at minimum needs to provide electronic support for the intention phase of a transaction (phase 2). In this step, market players start to interact and communicate their intentions to participate in a transaction - e.g., sales talks on the basis of product catalogs.

The purchasing literature analyzes transactions at a higher level of granularity, as it puts its main focus on the management of internal activities at the buying organization. Dobler and Burt (1996) name eight steps and subsequently reconsider them in more detail (similarly Hough & Ashley, 1992; Perlman, 1990; Zenz, 1994): 1) recognize, define, and describe the need; 2) transmit the need; 3) investigate, qualify, and select the supplier; 4) prepare and issue the purchase order; 5) follow up on the order (including expediting and de-expediting); 6) receive and inspect the material; 7) audit the invoice; 8) close the order.

In the remainder of this paper, we use a four-phase model to describe transactions, including information, negotiation, settlement, and after-sales and transaction analysis. As mentioned before, the discussion focuses on transaction processes from the perspective of the receiving side (buying processes). Alternative perspectives include the viewpoints of the sellers (suppliers, manufacturers, distributors, etc.), and intermediaries.

Figure 2. Transaction process models

In the following, each of the phases is summarized (Figure 2 provides an
overview and contrasts our approach with other concepts). We also provide examples of how information technology is used to support the different phases.

**Information**

In the information phase of a transaction, both buyers and sellers reach out to the world in search of information. Buyers locate information sources such as product catalogs, use them to scan product listings, obtain offerings from prospective suppliers by issuing Requests for Information (RFI), and gather additional information about products, vendors, or transaction-specific requirements. Before a purchasing transaction can be performed, internal approval frequently has to be obtained from upper level management.

The information phase comprises both searching for a particular electronic catalog or source of information and locating required information and commodities within the information repository. In this phase, buyers and sellers are not yet focused on specific transaction partners. Information gathering and knowledge creation are at the center of attention, and information is the primary object of exchange between prospective transaction partners.

A variety of Web-based information systems and other applications are available to provide support for the information phase of a transaction. Electronic catalogs, for example, feature comprehensive product descriptions and search tools, configuration support for complex purchases, workflow routing for approval processes, and access to additional information such as market research data and product reviews. Catalogs can be provided by suppliers, set up by the buyer, or developed by a third party. They can be hosted on the organization's Web server, or be integrated into internal systems. Links to back-end systems provide access to human resources data, as they are required to manage purchasing authorization, and contract information in cases where procurement agreements are already in place.

**Negotiation**

Of all transaction phases, the negotiation phase shows the broadest range of variations ranging from simple processes to very complex arrangements. Negotiations are often perceived as processes where a small number of prospective customers and sellers (often only one participant on each side) bargain on product prices and other terms of a deal. The parties jointly identify possible solutions with the goal of reaching a consensus, usually in the form of a contract. Bargaining processes alter with decisions whether to accept or reject the offerings, and with the outlining of countersuggestions until a mutually satisfactory agreement is reached. As prospective buyers and sellers start communicating directly with each other, interaction is at the center of attention. In this phase, influence is the primary object of exchange between the transaction partners. Not every transaction process features such complex negotiations. In fact, the negotiation phase is very often quite simple or even non-existent, such as in the case of retail buys and pre-negotiated contracts. Traditionally, auctions form a well-defined form of negotiations, confined to price alone and relatively easy to
Recently, multi-attributive auctions have been developed that account for a broader set of variables (Che, 1993; Bichler, Kaukal, et al., 1999; Bichler & Scharl, 1999).

Negotiations can be distinguished according to their validity, ranging from a single transaction to multiple-year contracts. The longer the time span that is covered, the more complex the bargaining process tends to be structured. In the following, we focus complex forms of negotiations (be it for one transaction or a larger number), but acknowledge the simpler forms as well.

Information systems support negotiations in a number of ways. They can provide transaction information and decision support by assessing the value of specific offerings, by identifying new bargaining options, and by increasing the negotiation's productivity. Participants may improve their bargaining positions through additional online information, such as the volume of previous business, supplier performance, or spending patterns. Currently, available technologies frequently do not adequately capture, locate, and display the full value of complex products and services. A notable exception in the business-to-consumer space is Frictionless Commerce (http://www.frictionless.com/), actively commercializing the value-based comparison shopping technologies of Tête-à-Tête (T@T; http://ecommerce.media.mit.edu/tete-a-tete/), which uses multi-dimensional matchmaking to rank individual merchant offerings by their overall value to the customer.

**Settlement**

Upon execution of the contract the objects of the transaction are exchanged according to the conditions previously stipulated. In addition, the settlement phase regularly includes some form of mutual performance monitoring. After the rather unstructured negotiation phase, the process of executing a transaction can be relatively straightforward. It is formally initiated as soon as a purchase order is confirmed by the supplier. The supplier ships the goods (often in collaboration with a third party, for example a local provider of logistic services), announces the shipment, and sends out a corresponding invoice. At the buyer side, orders are tracked, items are received, and payment is initiated after matching the invoice with the delivery. Naturally, there are many variations of this standard scenario. Consider, for example, the differences between the shipment of physical goods and the on-line delivery of information goods.

In the settlement phase of a transaction, activities and procedures are comparatively well defined, as they are part of the contract. Thus attention centers on execution and efficiency. At this point, the main objects of exchange are goods and services. Information technologies to support transaction settlement include EDI systems, and various tools to process orders internally and between transaction partners, facilitate order tracking, and support payment processes.

**After-sales and Transaction Analysis**

After a transaction has taken place, both sellers and buyers store the transaction data to provide after-sales support (seller), or to assess supplier performance and analyze internal buying patterns (buyer). At the buyer side,
the information flow is often split. While the purchase data is stored with central procurement, the end user keeps the product-related documentation. In case of unexpected irregularities, it is often the end user who contacts the supplier (e.g., to request a repair). Without proper access to the transaction file, communication problems and delays can occur. Capturing, storing, and managing data are vital at this point. Similar to the first phase (information), it is mainly information that is being exchanged between buyer and seller.

The electronic support of after-sales activities is heterogeneous and ranges from simple electronic mail services to automated helpdesks and sophisticated electronic maintenance manuals. Ideally, systems to support after sales and transaction analysis provide central access to the transaction information. Data warehousing applications support the storing, accessing and processing of large amounts of data. They allow the buying firm to assess supplier performance, analyze internal buying patterns, provide the basis for consolidating corporate buys, and improve future bargaining positions with suppliers. At the supplier side, data about past transactions - including information of system configurations, preferred payment options, and so forth - support the maintenance process and subsequently improve the quality of the information phase of future transactions.

Figure 3 summarizes the four transaction phases and their characteristics.

In general, we can distinguish between setting up a business relationship between a buyer and a seller, and its subsequent "utilization" on a day-to-day basis. This distinction is touched upon in the next section, when we introduce a model to evaluate different process infrastructures. Although the model primarily refers to the implementation and use of information systems, it can also be applied to other forms of infrastructure, such as the setup and use of long-term relationships.

**A Model to Evaluate Process Infrastructures:**

The Trade-Off between Flexibility and Automation

Transactions are quite amenable to the deployment of information technology, as they include a significant amount of information processing and communication between the participants. For many years, the exchange of transaction-related documents has been automated with electronic data interchange systems (Emmelhainz, 1993; Sokol, 1995). In the context of omnipresent global connectivity, the functionality of business-to-business transaction systems has widened; their numbers and diffusion have increased. The range of products reaches from simple online catalogs (the equivalent of paper-based catalogs) to complex applications for managing all aspects of procurement and selling processes, and for providing deep integration with other business functions.

According to the schema by Farbey et al. (1995), applications to support and automate (parts of) transactions rank low in terms of complexity and overall impacts on businesses compared to applications with more strategic implications (Banker, Kauffman, & Mahmood, 1993). They primarily serve tactical objectives, e.g., to improve process lead-times or cut operating costs. Although the setup and implementation of such systems can require significant resources, their evaluation is often considered straightforward, e.g., by measuring process cost and time savings, and applying traditional return on investment (ROI) methods (Hornback, 1995; Remenyi, Money, et al., 1993).

On the other hand, researchers generally acknowledge the impact of information technology on process structures and relationships (Powell, 1992). To account for changes beyond the mere automation of paper-based procedures, more comprehensive and sophisticated methods have been developed to assess costs and benefits of information systems. The Gartner Group propagates a Total Cost of Ownership approach to calculate the (total) cost of desktop PCs, while McKinsey developed a method to assess the Total Benefits of Ownership.

Research in the field of business process reengineering includes attempts to measure the changes in process lead times and operation cost that come along with the implementation of information technology applications (Hess & Brecht, 1995). In line with the primary research objective, however, the emphasis is on the design and evaluation of reengineering efforts, not necessarily the development of information systems. Although short-term results of information technology-related restructuring projects are being accounted for, longer-term impacts are usually not part of the analysis, such as a firm’s ability to react to changing transaction requirements and interorganizational business relationships. In the context of increasingly dynamic business environments, this lack of strategic thinking can become significant. The impacts of automation on flexibility have been addressed in other fields, though, such as in the arena of advanced manufacturing systems (see for example Parthasarthi & Sethi, 1993). In addition, research in organizational design can also provide insights as it assesses the impacts of corporate structures (e.g., decision making structures) on organizational efficiency (Perrow, 1977).

In the following, we propose a conceptual model to complement current methods of information technology and process evaluation. Based on the
assumption that automation ultimately impacts the flexibility of a process, we implicitly assess two questions: 1) how much automation is feasible; 2) if total automation of a process is not desirable, how can information technology be used to improve or achieve process flexibility (see also Gebauer, 1997). By taking into account both short-term effects from the automation of operations as well as the long-term impacts in terms of process flexibility, the overall efficiency of a process throughout its lifetime can be gauged.

Outline

The model considers business processes as corporate subsystems that serve a certain task (output) such as the purchase of office supplies. The result of a process is specified up front, in quantitative terms by identifying transaction volumes or time of delivery, but also by establishing certain quality standards. It is assumed to be constant thereafter. This postulation is important as a working assumption to facilitate the evaluation and comparison of different process infrastructures ("other things being equal").

The infrastructure underlying a process represents the key issue and main decision variable of the model. In a broad sense, the deployment of process infrastructure refers to all activities that are done up front and then repeatedly leveraged for day-to-day process operations. It includes organizational measures such as formulating and introducing purchasing rules, establishing long-term purchasing agreements with suppliers, or all measures of standardization (Buxmann, 1996). In the context of Internet-supported transactions, infrastructure-related measures often refer to the flow of information and imply the introduction of additional communication channels, the set-up of EDI connectivity, or the development of online ordering systems.

In the following, we focus on infrastructures to set up information systems for business-to-business transaction support. Throughout its entire lifetime, the informational infrastructure has a substantial impact on process efficiency by simultaneously determining the levels of automation and process flexibility. The objective is to choose an infrastructure that maximizes the efficiency of a process throughout its lifetime. Figure 4 provides an overview of the model, which is explained in more detail below.
In order to facilitate the comparison of different process infrastructures, the output of a process is assumed to be invariable (see above). As a result, maximizing process efficiency is equivalent with minimizing the overall costs (input) to reach a particular level of output. Infrastructure-related activities determine the costs of subsequent day-to-day operations, such as processing the order of an individual customer. They also define the range of situations that the infrastructure is valid for.

Day-to-day operations can be divided into two groups, standard situations and exceptions (Kieser & Kubicek, 1992). **Standard situations** allow the use of the infrastructure in its regular way, which ensures low costs of operation in the case of fully automated tasks (high short-term efficiency). Yet, every form of infrastructure has only limited validity, and the circumstances of each individual situation determine if and to what extent it can be leveraged. The more flexible it has been designed in the first place, the more situations are covered within a certain period.

**Exceptional situations** prohibit the use of the infrastructure at justifiable costs. This means that activities have to be handled "manually", and implies internal adjustments or extended negotiations. Exceptions also apply to situations where the actual use of the infrastructure leads to poor results that have to be improved ex post in order to match desired standards. The more flexible a system, the lower the costs that unforeseen (exceptional) situations may cause.

Figure 4 provides an overview of the elements of the model and the assumed interrelations between them. The overall (long-term) efficiency of a process is determined by all three kinds of expenses (infrastructure, management of standard situations, and exception handling) throughout the
entire period that the infrastructure is used. The length of the period plays an important role and is determined, among others, by the dynamics of the process environment. The notion of this time factor is usually not included in the evaluation of process performance. It is assumed that the expenses necessary to build up a certain level of process infrastructure mainly depend on three features of a task (also triggering feedback reactions): complexity, internal process conditions, and uncertainty.

- **Task complexity** is determined by various factors, such as the number of sub-processes and organizational units, as well as their possible interactions, interdependencies and relationships with the process environment. Building an infrastructure for subsequent use by individual operations deals with complexity ex ante, and thus reduces it for later operations. The quality of the infrastructure determines the quality of the feedback: in cases where process elements are integrated and more closely interlinked, interdependencies are enforced. Creating interfaces that can subsequently be combined with each other in a flexible way reduces interdependencies and enables the participating elements to act autonomously.

- The **structure** and complexity of the underlying tasks determine requirements regarding infrastructure quality. According to Picot and Reichwald (1987), three types of tasks are distinguished: routine tasks, innovative tasks, and administrative tasks as a hybrid category. **Routine tasks** occur regularly in similar form, like wage accounting or ordering processes. Since they usually do not have to respond to unforeseen events they easily can be structured, even in rather complex settings. In the extreme case, operations can be fully automated. At the other end of the scale, **innovative tasks** occur, for example in the context of strategic management. Due to their flexibility requirements, these highly individual tasks limit automation in terms of determining operational steps ex ante. The third form, **administrative tasks**, shows a combination of the aforementioned characteristics and infrastructure requirements.

- **Uncertainty** results from the instability of the process environment, and from unpredictability regarding the dynamic behavior of the organizational elements. The probability for changes of the situation and behavior as well as the extent to which they occur play a central role. Through the establishment of rules (infrastructure), uncertainty is reduced via feedback loops, since specific patterns of behavior are prescribed for certain situations. The more difficult it is to predict future developments and situations, the higher the costs to build up a useful infrastructure tend to be.

The model described above reveals a certain trade-off between long-term and short-term efficiency and draws on the assumption that there is an "optimal degree of integration" - i.e., a balance between complete automation and maximum flexibility with no structuring at all. It demonstrates the need to find the optimal ratio between expenses for infrastructure and operational activities, simultaneously taking into consideration standard situations, changing requirements, and possible exceptions.

**Process Requirements**
To apply the process model to different Web-based technologies, we first assess typical transaction processes with regards to the model variables, complexity, structure, and uncertainty. Additionally, some general requirements of supportive information systems are outlined. The values that we assign in Table 1 should be viewed as representative parameters depicting a typical transaction process and demonstrating the applicability of the model, rather than absolute measures. In reality, divergent contingencies and situational variables might suggest a different evaluation. This does not affect the general applicability of the model.

Table 1. Applying the model variables to assess the requirements of different transaction phases

<table>
<thead>
<tr>
<th></th>
<th>Complexity</th>
<th>Structure</th>
<th>Uncertainty</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>XXX</td>
<td>XX</td>
<td>XXX</td>
<td>8</td>
</tr>
<tr>
<td>Negotiation</td>
<td>XXXX</td>
<td>XXXX</td>
<td>XXXX</td>
<td>14</td>
</tr>
<tr>
<td>Settlement</td>
<td>X</td>
<td>X</td>
<td>XX</td>
<td>4</td>
</tr>
<tr>
<td>After-Sales</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
<td>9</td>
</tr>
</tbody>
</table>

All three process-variables together show how amenable subprocesses are with respect to automation (low values), respectively flexibility requirements (high values). Medium values point into the direction where both automation and flexibility are of significant importance.

The information phase is characterized by medium to high complexity, dependent on market allocation mechanisms, specific business sector, type of product and whether support for internal approval is included in the model, as the rules describing the latter might be quite complicated. Business processes during the information phase show medium structurability. While best practices can be established, heterogeneous products, organizational framework conditions, and changing situational factors introduce uncertainty. The requirements of the information phase can be summarized as follows:

- Fast access to a broad range of information, such as product listings included in internal catalogs and external sources, as well as additional information,
- Strong search functionality and navigational aids,
- User interfaces that are easy to operate even for occasional users,
- Configuration support for complex buys (e.g., computer systems), and
- Support for internal functions (approval processes, back-end connectivity).

As was outlined above, the negotiation phase shows a wide range of different instances, ranging from very simple processes, characterized by little uncertainty and high structurability (pre-defined contracts, retail transactions), to very complex arrangements. As the simpler forms of negotiations show strong resemblance to the settlement phase (see below)
and given the role that complex negotiations play in business-to-business settings, we emphasize these instances of higher complexity.

As complex negotiation processes comprise numerous offers and counter-offers they pertain a high degree of uncertainty and it is difficult to structure them in advance. At this point, real-time interactivity between user and information system becomes most critical. A powerful system enables the user to access large amounts of data instantly, such as spending volumes, buying patterns, and supplier performance data. It also helps process the data, and provides support for situation-specific requirements.

During the settlement phase, a number of structured business documents are being exchanged between the trading partners. Compared to the other phases, the settlement phase is characterized by the least amounts of complexity and uncertainty and by high structurability, as procedures are often part of the contracts. Efficiency and precision of executing the processes are essential, as are means to handle exceptions if necessary. In addition to secure and fast connections and the possibility of exchanging data across organizational boundaries, efficient links between the procurement applications and back-end systems have to be implemented.

Provided that occasional users utilize the systems, interfaces have to incorporate graphical elements and intuitive navigational aids. A certain level of flexibility is necessary to support business transactions in an ad hoc-manner, either with new business partners, or to exchange new types of documents.

Information requirements of the after-sales and transaction analysis phase resemble the information phase in terms of complexity, uncertainty, and structurability. However, at this point, the split of the information stream between the end user requisitioner and the central purchasing departments could become an issue, as both groups may have diverging requirements and communication patterns. While the end user requisitioner may need information to support the ongoing use and maintenance of an item, corporate purchasing is regularly more concerned about storing purchasing records and managing assets and inventory. Support includes tools to capture, analyze, and manage purchasing data in order to evaluate supplier performance, and to comply with reporting needs. Real-time access to inventory information can help automate the initiation of future transactions. Flexibility is needed to support exceptional situations, in cases where customer support becomes necessary. At this point, transaction systems that provide administrative support need to be linked with information systems to support the organization's core processes. Powerful applications accept a wide variety of different user requests without compromising response time.

As a result of contrasting the four transaction phases with their specific process requirements, we derive the following conclusion. While both the information and after-sales phases show mixed results in the sense that they combine certain flexibility requirements with opportunities for automation, information technology support for complex negotiation phases must provide for extensive flexibility needs. The settlement phase is most amenable for automation, which serves an intuitive explanation of why early systems concentrated on tasks related to EDI or online ordering. In the
next section, we will take a closer look at how different forms of information systems, in particular Web-based applications, fit with the requirements of the different transaction phases.

**Categorization of Information Systems**

Based on the requirements of business-to-business transactions and the framework to evaluate process infrastructures, the ability of emerging technologies to support the different phases of transaction processes can be assessed. Available technologies are differently suited to support the transaction phases and their individual requirements. Numerous approaches have been developed to categorize information systems. Farbey et al. (1995) identify eight rungs of information systems according to their sophistication. Systems to support transactions fall into the lower ranks in terms of their complexity.

Scharl (1997), and Bauer and Scharl (1999) use the sophistication of communication patterns supported by information technology as the main criterion to categorize different forms of Web-based information systems (also compare Scharl & Brandtweiner, 1998). According to their model, communication occurs on two levels. On the first level, users interact with each other or with the machine to perform specific tasks, such as buying processes. On the second level, users indirectly interact with system designers to provide feedback. This process leads to iterative improvements of the system and the alignment of its functionality with changing requirements. The consideration of feedback mechanisms adds a perspective of flexibility that is not perceived in other categorization approaches (e.g., Farbey et al., 1995).

Two modes of interaction are being distinguished: explicit and implicit modes of communication. Explicit methods of communication include questionnaires and other forms of conscious feedback from the users. Implicit means of communication are embedded in the system and allow analyzing user behavior on the basis of clickstreams, persistent client state HTTP cookies, and similar technologies. The evolutionary model is based on the assumption that the development of Web-based technologies generally follows a particular path, leading from the support of simple one-way broadcasting and general messaging to applications that can handle complex patterns of interaction between system users (e.g., buyers and suppliers). Systems of higher complexity usually incorporate the features of the preceding stages. At the highest level of sophistication, both automation and flexibility requirements are being addressed simultaneously. At same time, the costs to deploy such systems increases.

Specifically, five categories of Web information systems are being distinguished (Figure 4). The implications of the different categories on explicit and implicit flows of information are visualized, together with their impact on system design (D), feedback analysis (A), and negotiation support (N). The underlying communication models range from one-directional flow of information (I) to explicit feedback mechanisms (II), integrated solutions for gathering implicit and explicit feedback (III), to adaptivity (IV), and agent-based interaction (V). The corresponding categories of Web information systems range from simple, associatively linked collections of static hypertext documents (I) to interactive,
integrated, customizable solutions (II-IV), and agent-based negotiation support (V). Although the schema was originally developed to address the development of consumer-oriented Web-based information systems, it effectively can be applied in business-to-business settings as well.

Figure 5. Web communication models (see also: Bauer & Scharl, 1999)

**One-directional flow of information**

In their simplest form, Web-based information systems provide support for one-directional flows of information only. Hosted on stand-alone servers and not integrated with other applications, they deliver static information in the form of basic hypermedia compound documents that are displayed by a browser. In the context of business transactions, such documents may contain catalog and product information to provide the electronic equivalent of paper-based product catalogs or manuals. In addition, general information can be published, such as company data, legal instructions, press releases, broadcast messages about new product releases and more specific messages, such as the callback of defective products.

As there is no online interaction with the users of the system and instant user feedback is not processed, the system has to be designed ex ante to provide for all instances that might occur. This constraint limits the use of such applications to simple, well-structured, and stable tasks where online interaction is not required. Static Web-based systems provide a cheap and efficient way to broadcast information and messages to existing and prospective business partners as they occur predominantly in the information and after-sales phases. However, traditional means of communication (phone, fax, postal mail) have to be in place to support the interaction between sellers and buyers, as they occur during negotiation and
ordering processes. Given the limited scope of the applications, the effect on standardization costs is limited as well. Similarly, as there are no (formal) feedback channels, the redesign usually requires substantial additional investments and time. As a means of communication, static Web-systems are suitable only for tasks that are well structured, simple, and stable in terms of content and business procedures.

**Explicit feedback mechanisms**

At the second stage, explicit interaction between the initiator of a Web information system and its users is supported through the use of HTML forms, database and application interfaces on both the server and client side. Technologies that are implemented include CGI, Perl, Java, Tcl/Tk, and ActiveX. This allows online interaction between the users of the system and supports tasks of higher complexity, less structure, and somewhat more uncertainty, as compared to systems of one-directional flow of information.

The range of applications includes online catalogs that provide sophisticated search functionality, and online-ordering systems that are based on HTML forms or electronic mail. At this point, pre-defined interactive dialogues and customized services become feasible, similar to traditional EDI systems.

User feedback regarding the system itself is collected through explicit means of communication only. These include online questionnaires and traditional offline interaction with end users. As feedback loops are comparatively slow and cumbersome, the flexibility to handle exceptions from standard patterns of interaction is very limited. The basic functionality of online forms has to cover all situations that might occur, or provide for traditional means of communication in case of exceptions.

As a result, such systems are best suited for predefined situations that allow for extensive automation and emphasize efficient operation processing, such as settlement procedures in mass markets for homogeneous products, or online ordering systems that are offered by large distributors (http://www.orderzone.com, http://www.works.com). Compared to the static one-directional flow of information flexibility is gained, mostly in terms of the data and information content that is exchanged between server and client. Flexibility regarding procedures and exceptional occurrences is limited. Similarly, support for negotiations is limited, as reaching a mutually satisfactory agreement requires real-time interaction, which is not provided in this stage. Also, the possibility to interact directly with the supplier and adapt to individual situations can be quite beneficial in the after-sales phase, as related efforts can be targeted more precisely.

**Implicit feedback mechanisms**

In addition to explicit mechanisms, user feedback is gathered through implicit methods, such as tracking techniques for user clickstreams or analyses of online buying behavior. Technologies most commonly used include analysis of server log files and persistent cookies. They allow real-time interaction between users and provide instant feedback for system designers.

Effective support for higher levels of complexity, less structure, and higher
uncertainty becomes possible. Shorter feedback loops allow for more flexibility compared to the preceding stage, in particular regarding (limited) changes in process structures and unexpected user interaction. Besides customized support for information and after-sales processes, limited support for negotiation processes can be provided. Simple user profiles are established as a requirement for customizing the after-sales phase.

User Modeling and Adaptivity

At the next stage, feedback mechanisms become more sophisticated as parameterized functionality is introduced. This enables the reuse of documents and link structures, and results in adaptive applications such as granting different access privileges according to IP domain, personally addressing users with dynamically generated documents, including workflow elements into the applications, or determining purchasing conditions according to user category. Rules and detailed attributes of users are stored in profile databases of backend systems. Powerful server-side database and application interfaces, sophisticated technologies like neural networks, genetic algorithms, natural language generation (Milosavljevic, 1998), case-based reasoning (Finnie & Wittig, 1998), and related soft computing approaches provide the basis to keep track of user interaction and support the reasoning about user intentions. In addition, the Extensible Markup Language (XML) is likely to have significant impact on the customizability of Web-based documents (Ginsburg & Kambil 1999; Glushko, Tenenbaum, et al., 1999; Vasudevan & Palmer, 1999). The standardized settlement of communication model III, which only offers a limited area of validity, is considerably enhanced by the customized process control of model IV. Once again, the applications are improved with regards to the complexity, uncertainty and dynamics of a process that they can support, but they also require significantly higher set up costs. At this point, individualized support for information needs, complex settlement processes, and negotiations is provided, and in combination, all four phases of a transaction can now be covered.

Agent-Based Interactivity

With communication model V, the aspect of automated adaptation of Web-based systems is taken one step further by introducing agent-mediated architectures. They include negotiations (N) via mobile digital agents, enabling real-time negotiations on an individual level, as compared to a predefined set of conditional offers, which is typical for model IV. At this point, technologies such as Odyssey (Telescript), Safe-Tcl, KQML, or Aglets are being deployed to extend, replace, or interface with traditional systems.

Negotiation processes between business entities are characterized by high degrees of unpredictability, complexity, and strategic importance to organizations (Beam and Segev 1997). With full negotiation support, the seamless integration and effective automation of all transaction phases finally becomes a reality. This integration further increases flexibility and shows potential to change inherent characteristics of business-to-business electronic commerce radically. Characteristic attributes determining the usually cooperative behavior of digital agents are (Schubert & Zarnekow, 1998): Proactivity (ability to initiate processes and react to internal or
external events), **intentionality** (ability to actively choose appropriate methods for pursuing a certain goal), **autonomy** (ability to act in an independent manner without direct intervention by the principal), and **mobility** (ability to migrate between different information systems within the boundaries of complex software environments).

At this point, the distinction between standard and exceptional operations becomes less relevant as individual negotiations provide maximum flexibility. Digital agents consider the principal's preferences, employ predefined and standardized coordination mechanisms, and adapt to the situational requirements of their tasks. The "request-response" communication model characteristic for Models I-IV and the underlying protocol (HTTP) is dissolved by the direct interaction of equal partners in an agent-driven communication network environment. Nevertheless, every innovation in this specific segment will have to provide backward-compatibility and interoperability to enable seamless integration (Lindemann & Runge, 1998).

Implementing agents is a complex task, which initially requires a substantial investment in basic infrastructure, but also covers the widest possible area of validity. Agents behave less passively compared to the information systems belonging to one of the other four communication models, actively identifying negotiation partners in their specific transaction environment. Naturally, principals regularly evaluate the agent and critically review negotiation processes and their outcomes.

**Summary and Conclusions**

Information systems hold great potential to streamline and improve business-to-business-transactions. However, not all Web technologies are equally suited to support the different phases of a transaction. An evaluation framework has been described that helps assess the requirements of transaction sub-processes in terms of automation and flexibility (see Figure 5 for a summarizing overview). It can be used to combine different applications and the underlying communication models into a comprehensive infrastructure that maximizes the long-term efficiency of corporate processes.
The framework facilitates the transformation of business processes by matching process requirements with appropriate technologies. It can help identify weaknesses of current technologies, missing or inadequate software tools, and promising areas for extending the functionality of deployed applications.

The five stages to classify Web-information systems introduced in this paper are built on top of each other. More sophisticated categories provide simultaneous support for automation and flexibility, and therefore help ease the trade-off between these two contradictory goals of system design. More flexibility necessarily requires sophisticated feedback mechanisms, which usually involve high initial investments. Selective implementation of the components can provide optimal support for all requirements of a transaction in line with financial restrictions. An efficient strategy chooses the lowest category possible without compromising predefined requirements regarding flexibility and interactive functionality.

While lower categories are often sufficient for most of the information and after-sales phases, the settlement of transactions requires more advanced interactive functionalities. The support of complex interaction is most important in the negotiation phase, and not all desirable features are readily available (Figure 5).

We have outlined a generic process evaluation framework and applied it to business-to-business transactions. Other areas of application include business-to-consumer transactions and the evaluation of process structures in the context of process reengineering projects (Gebauer, 1997). Similarly, the model to classify information systems based on communication patterns is not restricted to Web-based information systems in the business-to-

Figure 6. The suitability of communication models I-V to support transaction processes
business context.

Nevertheless, there are a number of limitations to the framework. As we assume static process output, the framework needs to be extended in cases where changes in cost and output occur simultaneously. Currently, this situation is accounted for by assuming that identical output can be achieved via (sometimes costly) ex post adjustments. In particular, in the context of applications with strategic objectives, this assumption will have to be dropped. The perspective of partners and intermediaries are not included, although they might play a significant role in determining the success and overall value of the systems. In addition, we concentrated on information technology infrastructure to support transactions and did not take into consideration other methods of communication, such as face-to-face meetings. In real life settings this omission can be limiting, as Kraut et al. (1998) found that over-reliance on information systems can lead to poorer transaction outcomes. The model itself, however, is rather generic and, in fact, allows evaluating and comparing many different forms of infrastructures, including alternative channels of communication and interaction. Finally, we have not tested the inherent assumptions of the model or its implications in an empirical way. Case and field studies will have to be developed to assess the practical usefulness of our approach.

Given the importance and significance of investments into Web-related technologies evaluation cannot be done carefully enough. Our model provides a first step in this direction, but much work still remains to be done.

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