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EXPLORING INFORMATION ASPECTS OF NETWORK ORGANIZATIONS

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ABSTRACT

The problem of coordination within network organizations is an important issue that differs in major ways from coordination within hierarchies or markets. We contend that computer technology has a potential for usefully supporting coordination efforts in networks. As a basis for studying such potential in a systematic way, we introduce a model that formalizes some key aspects of network organization. At the heart of our formulation is a construct called reputation, which encapsulates the many attributes that can characterize participants' past behaviors in a network. The reputation construct is an explicit recognition of the idea that participants in a network let the history of their relationships influence the coordination of their activities. This idea constitutes a major distinction between networks and markets. We use the model to discuss possibilities for computer-based support of network organizations at managerial and strategic levels, as complements to transaction-level EDI systems.

1. Introduction

The business environment has changed rapidly over the past decade. To stay responsive to this turbulent environment, the new advocacy for many business organizations today is to do fewer things better with fewer accumulated resources [Miles, 1989]. To cope with the increasing, global competitive pressures, many organizations are evolving toward smaller and more specialized firms. Meanwhile, the prevalence of computer technology has also contributed to the ongoing reforming of organizations and changing inter-organizational relationships [Applegate, Cash and Mills, 1988]. Malone, Yates, and Benjamin [1987], for example, have discussed how information technology may lead to a firm's greater use of markets to coordinate economic activities and reduce coordination costs relative to hierarchies.

Network arrangements provide more use of markets and more flexibility to individual firms. Because of increasing use of markets, boundaries among firms are becoming ambiguous as essential interdependencies grow. Williamson [1985] has proposed that the actual boundaries among organizations be explained in terms of the trade-off between the administration cost a firm incurs and the production efficiencies of market relationships. According to an economic criterion, a network organization consists of a group of separate firms, each of which maintains its own authority in primary budgetary and policy matters [Estrin 1985]. This definition indicates the difference between a network organization and a multi-division firm, which employs market-based transfer pricing to mediate divisions. Miles refers to the latter as an 'internal network'. In terms of administrative boundary, a network organization is in fact a set of individual firms. Once these individual firms are participating in a network arrangement, they are well coordinated by a core firm, each of them is functioning as an integral part to the network. The prevalence of network organizations suggests not only the increasing importance of adaptivity as perceived by modern organizations, but also the new arrangement's strategic implications in terms of competitive advantage.

Researchers have studied inter-organizational information systems that can facilitate various aspects of inter-organizational cooperation and coordination. Johnston and Vitez [1988], for example, have studied how competitive advantage can be created with inter-organizational information systems. Beloss [1991] has analyzed two different types of systems, information links and electronic markets, to explore how economic models may be used to study these systems' implications in terms of coordination, efficiency, and competitive advantage from each individual firm's point of view. Yet, to ensure the long term effectiveness of network organizations, we need not only sophisticated linkages and markets, but also a way to accumulate and disseminate knowledge produced in the process. This may be used as a measure of a network's long term effectiveness. In other words, a network organization sustains its effectiveness in the long term through effective learning.

From a long term perspective, a network organization relies on mutual trust, cooperation, and efficient communication between a core firm and its inter-organizational partners (IOP). But, a long term perspective does not guarantee a long term relationship, as the value of an IOP to the network may diminish over time and a network organization is sufficiently flexible to accommodate its replacement. To assure the effectiveness of a network organization, the core firm needs a way to measure long-term effectiveness of its IOPs and a related mechanism for the use of markets. Such a measure also gives the core firm a basis for replacing some IOPs in due time. Such issues have earlier been examined within organizations featuring intra-organizational specialization, such as in an advocacy [Ching 1988; Ching, Holmapple, and Whinston 1990]. Here, we address these issues by adapting their work and applying to network organizations. We further suggest computerization possibilities for enhancing inter-organizational specialization and cooperation through effective learning.

In the following section, we briefly review the notion of network organizations and examine the Electronic Data Interchange Systems that currently facilitate communication among different companies. The formal model of network organization is introduced in Section 3. Then in Section 4, we discuss such issues as the IOP's value recognition, performance review and progress update, and the possibility of computer-based enhancement of organizational learning in a network organization. We conclude with a summary in Section 5.

2. Review of Network Organizations

Miles [1989] has distinguished three kinds of network organizations: internal, stable, and dynamic networks. Others have variously referred to these kinds of arrangements as organic network [Morgan 1989], hybrid arrangement [Borys & Jemison 1989], and Value-Adding Partnership (VAP) [Johnston and Lawrence, 1988]. Here, we review network organizations in terms of three aspects: the formation of a network, the stability of a network, and EDI systems that facilitate networking of individual firms. This review gives a basis for appreciating the formal model introduced in Section 3.
2.1 Formation of Networks

There are two major ways in which existing network organizations have been formed: top-down and bottom-up. Top-down networking is usually initiated by large company which seeks to reduce its enormous overhead by downsizing and outsourcing. It, therefore, teams up with other separate firms that can provide services or goods in a more economic way. Some once largely integrated firms have come to realize that they are no longer better off through transaction costs savings that result from scale economies. Rather than sustain a large amount of fixed assets and employ a large number of people, they have increasingly adopted market exchanges to modulate interfaces among their integrated components. Moreover, by outsourcing, they have evolved toward a network of separate but interdependent firms, and becoming the cores of such networks.

Many organization researchers have observed that more and more companies are outsourcing activities that can be performed more effectively or more economically by other firms. Outsourcing generally means transferring some operations to an outside organization by subcontracting, licensing, partnering, or leasing. A good example is the outsourcing of information processing activities. The purposes of outsourcing are twofold: to cut down long term costs associated with fixed assets and to maintain a focus on key operations. As a result, those companies who successfully outsource become slimmer and more adaptive.

For some giant vertically integrated companies, outsourcing has become the solution for increasing flexibility and responsiveness. For example, Ford Motor Company, which once was so integrated that it made its own steel, is now outsourcing the fabrication of more than half of the components for its cars [Hendriker and Martin, 1991]. Firms that rely heavily on outsourcing are not likely to have many long term assets (e.g., plant, property, equipment) on their balance sheets. For a long standing large corporation, outsourcing may only take place partially to replace some in-house operations to cut down long-term fixed costs. The three major U.S. auto makers, for example, increased their outsourcing by five to ten percent between 1980 and 1985 [Morgan 1989].

The bottom-up approach to network formulation is usually taken by smaller firms in the interest of seeking strategic alliances. In order to compete against dominant vertically integrated firms, some smaller and more specialized firms have chosen to participate in value-adding partnership (VAP) [Johnston and Lawrence 1988]. That is, partnership with separate firms spread along the value-added chain (e.g., supplier, manufacturer, and distributor). McKesson Corporation, a major distributor of drugs and health care products in the U.S., has been highly successful in developing such value-adding partnerships. Without acquiring the ownership of those firms, the core firm of such a value-adding partnership (VAP) network is able to reduce its risk. Each of the participating companies in a VAP can also benefit from such confidence by achieving the adaptivity and responsiveness of small, specialized companies and also the scale economies of large and integrated firms.

2.2 The Stability of Network Organizations

Network organization stability varies in terms of the relationship between the core firm and its IOPs on a case-by-case basis and from industry to industry. In some industries, the operation of a network emphasizes reliable supply and close cooperation on scheduling and quality requirements. The core firm of such a network is typically large and serves as the major client (buyer or supplier) of its IOPs, so their relationship tends to be relatively stable. For example, BMW is the core firm of a stable network in which several manufacturers provide it with a steady supply of parts [Miles 1989].

In some industries where the competition is keen, and/or the product development cycle is relatively short, and/or the rate of change is fast (e.g., fashion, toys, and publishing), the relationship between the core firm and its IOPs tends to be more dynamic. The core firm in a dynamic network organization may operate as a broker who puts everything together by identifying and assembling assets owned by various firms in the network [Miles 1989]. Simultaneously, those IOP firms from which the core firm outsources are constantly looking for better opportunities in other networks as well. That is, the interdependencies between a core firm and its IOPs is relatively low compared with that in a stable network.

In either case, the core firm needs to learn how to sustain long-term effectiveness in dealing with its IOPs. In a stable network, the core firm needs to be alert of the kind of inertia that will prevent it from switching partners in due time. On the other hand, in a more dynamic network, an up-to-date measure of IOPs' values perceived by the core firm is crucial to the replacement or termination of IOPs in a timely manner. The issue of appropriately exercising the flexibility of changing partners in a network organization is therefore an important one and is a central concern of this research.

2.3 EDI: A start for supporting network organizations

The firms in a network, which may be geographically dispersed, need to communicate with one another in an efficient and effective manner. Technologies such as telefax, local area network (LAN), and electronic mail have been available for a long time and have been the precursor for electronic communication in network organizations.

Electronic Data Interchange (EDI) systems which facilitate data interchange (e.g., inventory, orders, and payments) by direct computer-to-computer transmissions using standard formats among firms (e.g., between suppliers and customers) have been around for years. EDI is poised to be the cornerstone of inventory control programs during the 1990s from the pharmaceutical industry to the Department of Defense. EDI also enables a core firm of a network to efficiently communicate with its IOPs, such as buyers and suppliers, with reduced response time and increased communication channel capacity compared to traditional mail or telephonic communication. By enforcing standard data formats, EDI allows two companies to use the same network to transmit information from computer to computer across organizations. For example, the Defense Department and General Motors, have set the standards and rules for participation in their network. What is usually communicated via an EDI system is inquiries about and information on products (e.g., inventory) and services (e.g., delivery) to reduce the possible time lags between actions taken and the overhead of paperwork processing. As a result, EDI has practically shortened the distance between firms and improved the operational environment for inter-organizational cooperation.

Although EDI has provided a foundation of computer support of network organizations at an operational level, a complete implementation of EDI cannot by itself guarantee success of a network organization. The participating firms need to be well coordinated to enhance the network's efficiency and effectiveness, and be able to sustain them in the long term. To achieve this goal, we need to consider the possibilities of full-blown computer-based support at managerial and strategic levels, in addition to the operational level addressed by EDI. For example, organizational memory and some kind of effective coordination mechanism can be integrated with the existing EDI technologies.

Before proposing an information support architecture for a network organization, we first introduce a formal characterization of a network organization. The formalism and architecture it suggests give a basis for potential implementation of computer-based support system for network organizations, allowing us to view the operation of a network organization as an instance of distributed problem solving.
3. Modeling the Network Organization

A network organization (NO) can be characterized in terms of its participating firms (i.e., the core firm and its IOPs), the role(s) each of them can fill, and a set of tasks which trigger the transactions between the core and its partners. In the following subsections, we present a formal model of a network organization in terms of its: (1) Membership (i.e., its participants) (2) Role scheme (i.e., the various roles played by its members) (3) Tasks to be carried out in the network, (4) Labor division (i.e., how tasks are awarded to various members), and (5) Coordination confines. Similar characterizations may be applied to modeling a multi-divisional firm that acts like an internal network. For simplicity, our notation is based on the assumption that we are analyzing only one network, NO_a, with a being its core.

3.1 Network Organization’s Membership

Each individual firm participating in a network is a member of the network organization. Depending on the nature of a network, membership is more or less static. Generally speaking, the core firm, due to the structural nature of a network, is given considerable flexibility in replacing its inter-organizational partners. This discretion is constrained by the pool of potential participants in terms of their abilities and willingness. The dynamics of a network’s membership constitutes one of the major characteristics of a network organization. We represent a network’s membership as a function of its core firm a:

\[ M(a, t) = \{ f_1, f_2, ..., f_n \} = M_a(t), \]

where a is the core firm. Applying the function M to the core firm of a network organization at time t generates the set of its inter-organizational partners (IOPs), M_a. When M_a is an empty set, we have a degenerate case where a network involves only one firm (a) that does not subcontract any of its tasks. Notationally, NO = M_a.\[ \{ a \}. \]

The set of a’s IOPs (M_a) is subject to change. In a network where the relationship between the core firm and its referent firms is steady, M_a remains stable. In the case of a more dynamic network, M_a varies over time as the core firm and its referent firms tend to look aggressively for alternatives outside the network (Figure 1).

3.2 Network Organization’s Role Scheme

The building blocks of organizational structure are roles. Roles constitute a scheme that is the basis for differentiating members of an organization. The role scheme delineates the set of roles available in a network and reflects what is demanded by the core firm for accomplishing its goals. When the current role scheme cannot fully accommodate the core firm’s needs, the role scheme must change. The core firm is likely to look for some new partner(s) to join its network to play the new role(s). Of course, M_a may change without a revision to the network’s role scheme.

We represent a network’s role scheme as a function of the core firm a:

\[ R(a, t) = \{ r_1, r_2, ..., r_m \} = R_a(t), \]

where m \( \geq 1 \). R_a includes the role(s) played by a. If we shift the level of analysis to regard some fi as the core of its own network, then M and R can be applied to it to obtain that network’s IOPs and roles, respectively. That is, we can apply R to say, i3 to get R_{i3}, which is the set of roles firm i3 defines in its own network.

Within an organization, roles are descriptive of such organization phenomena as division of labor and specialization. Note that for a given role, there is likely to be more than one firm in the network capable of filling that role. On the other hand, a firm may fill more than one role.

3.3 Tasks

The characterization of a network organization requires a recognition of the kinds of tasks that need to be carried out within it. A task, in the simplest form, may be just filling an order placed by a firm’s customer. The set of tasks facing the core firm a at time t can be represented as follows:

\[ T(a, t) = \{ j_1, j_2, ..., j_k \}, \]

where k \( \geq 1 \). The set of roles required for performing a task is represented as:

\[ \text{role}(j) = \{ r_1, r_2, ..., r_m \}, \]

where m \( \geq 1 \).

More generally, it is conceivable that alternative role sets could exist for a given task (Boczek, Hofstapp, and Whinston, 1979). In a network organization, the core firm conducts its business by initiating a multi-tasking behavior within the network. If the core firm cannot or does not choose to locate and independently complete a task, then it seeks to enlist the support of other firms. That is, the core firm, based on its task (e.g., filling an order) generates subtasks (e.g., producing necessary parts or semi-products) which, when completed, will enable it to accomplish its own task.

Such subtask requires some role(s) and is to be carried out by some IOP firm(s) that can play role(s). Here, task decomposition is specified with the G function:

\[ G_a(j) = \{ g_1, g_2, ..., g_n \} = G, \]

where G is a set of decompositions that are available to firm a for decomposing task j. The elements of G are disjunctive with one another. That is, the firm a will choose only one of them to decompose the task. If G_a(j) yields a null network’s G, this indicates that a does not decompose j into other tasks. Each decomposition g is in the following form:

\[ g = \{ j_1 \lor j_2 \lor ..., j_k \} \]

where j_m for m = 1 to k, are the subtasks generated by a and g is the conjunction of all these subtasks.

It is the responsibility of the core firm to coordinate these subtasks. This coordination includes planning, control, and review. Planning involves the application of G to determine subtasks, the identification of task type for each, and scheduling the associated task allocation activities. Control is concerned with actual execution of task allocation activities (e.g., contracting with an entity to fill the role that would complete some type of subtask). Review involves the assessment of supporting entity performances in completing the subtasks. This review may well influence the future coordination behavior of a. In addition to its coordination efforts, a may also need to assemble, synthesize, or otherwise employ the subtask results to complete task j unless a acts strictly as a wholesaler, adding no value to
3.4 Division of Labor in a Network Organization

Within a traditional organization, roles are descriptive of such organization phenomena as division of labor and specialization. In a network organization, the division of labor is across the participating firms. For a given role, there is likely to be more than one firm in the network capable of filling that role, and one firm may fill more than one role. The mapping of various firms in NO to the role scheme R, and vice versa, can be represented by the following two complementary functions showing division of labor and specialization, respectively.

\[ D_{rj} = \{ f_0, f_1, \ldots, f_j \} = D_{an} \]

\[ S_{rj}(f_j) = \{ r_0, r_1, \ldots, r_n \} = S_{aj} \]

Given a role \( r_m \) in network NO, the division function \( D_{r_m} \) yields the set of firms in NO capable of filling that role. On the other hand, given a firm \( f_j \) in network NO, the specialization function \( S_{r_j} \) results in the set of roles fillable by \( f_j \).

3.5. Network Organization’s Coordination Concerns

In traditional organizations, coordinating the subunits of an organization is achieved via some kind of administration hierarchy. For markets, some argue that it is the price system that “provides a coordination mechanism which, without involving a central authority, induces individuals toward their self-interests to achieve goals...” (Gurbaxani & Whang 1991).

A network organization, which differs from the traditional organization forms because it is composed of a set of independent firms, also deviates from a market. That is, it is a structured organization arrangement as a whole. Its operations and even the entry and exit of firms are mainly under the control of the core firm, rather than simply a price system.

In a network arrangement, IOP firms that have the same required specialties will compete with one another to provide services for the core firm. An IOP firm serves as a supplier to the core firm a in network NO, it may have its own network where it can subcontract the task awarded by a, and may participate in more than one network simultaneously as an IOP supplier. As a result, the coordination process initiated by the core firm of one network may activate a similar kind of process in other networks as a “ripple effect.” This new form of the coordination process initiated by a, the core firm of network NO, can include more firms than the ones defined in \( M_a \). We define the community of NO in terms of a recursive function as follows:

\[ C(a, r) = [a], \text{where } M_a = \{ \}, \text{and} \]

\[ [M_a] \]

\[ C(a, r) = \bigcup C(f_k, r), \text{where } f_k \in M_{a_j}, j \neq i, \text{and} \]

\[ k=1 \quad [M_a] = \text{number of firms in } M_a \]

Coordinating multiple firms in a network revolves around the issue of task allocation. When confronted with a task, the core firm can either execute it by itself (in-house) or seek the service on the market (i.e., in the network). In the latter case, the core firm decides to whom this task is assigned. Therefore, it is important for the core firm to be able to identify which participating firms in its network are currently available and assess their respective qualifications for some request (service or product order). This is the necessary foundation for making a good or the best selection from among candidate firms. Such selections influence not only the results of the underlying economic transactions, but also subsequent coordination activities in other networks.

In next section, we examine the computer-based support possibilities suggested by the formal model and explore the informational aspects of a network organization at operational, managerial and strategic levels.

4. Information Support for Network Organizations

As described in Section 2.3, electronic data interchange (EDI) systems provide a starting point for computer-based support of network organizations and multi-division firms. They can facilitate message passing among firms of the same network at the operational level. For example, submitting orders, checking inventory, and confirming orders can all be done via an EDI system. Even so, EDI does not fully support informational needs at other levels within the firm in information retrieval. The informational aspects that are unique to a network organization include not only information interchange between the core firm and its IOPs, but also decision making pertinent to network coordination and organizational learning. Here we propose a computerized information support architecture for a network organization as shown in Figure 2.

![Figure 2: Information Systems Support for a Network Organization](image)

We consider the potential of computerized information support for a network organization at three levels: the operational, managerial, and strategic levels. Such an architecture is proposed for every firm in a network, although we depict only the details for the core firm in Figure 2. At the operational level, computerized support concerns the ease and efficiency of communication among members of a network organization. Because EDI-like systems appear to be adequate in this regard, we shall not focus on the operational level.

At the managerial level, computerized support is aimed at facilitating the coordination process. Issues such as performance evaluation, subcontractor selection, and task allocation are particularly important. A coordination support system can facilitate the decision making at managerial level. At the strategic level, attention is drawn to how to enable organizational learning so as to improve the effectiveness of coordination and sustain the network organization’s adaptability. A knowledge system that can be drawn upon like an organizational memory repository to analyze feedback, provide information for review, and facilitate organizational experiments can help a network organization to achieve these goals.
4.1 Computerized Support at the Managerial Level

We use a structured bidding mechanism to model the coordination process within a network organization. By extending the functionality of an EDI system to include features such as standard bid format, standard message template (See Table 1), and bid evaluation functions, a coordination support system can facilitate decision making at the managerial level.

Table 1 A Generic Message Template Used in a Bidding System

<table>
<thead>
<tr>
<th>Message := [To: recipient-list ] [From: sender-id ] [Type: message-type ] [Content: content-block]</th>
</tr>
</thead>
<tbody>
<tr>
<td>recipient-list := [f1 i=1 to n, f1 ∈ M_a ]</td>
</tr>
<tr>
<td>sender-id := firm-id</td>
</tr>
<tr>
<td>message-type := Task Announcement ! Bid Contract ! Information ! Request for Information ! Acknowledgement</td>
</tr>
<tr>
<td>content-block := Task specification ! Bid content ! Terms ! Request content ! Information ! Conclusion of bidding process</td>
</tr>
</tbody>
</table>

To keep itself open for alternatives and a secured supply, a core firm tends to maintain relationships with multiple firms with the same specialties. When faced with a task to be subcontracted, the core firm selects one or more firms to carry out the task. Before making the decision as to whom it subcontract the task, the core firm may solicit bids from its qualified firms in its network. Even when the core firm has predetermined a firm for subcontracting, it still needs to check with the firm about its availability and a time frame for task completion. In this case, the information interchange between the firm and the subcontractor can be facilitated by EDI technology.

A bidding process begins when the core firm sends out a task announcement to its IOPs. The interested firms submit bids, which then are evaluated by the core firm. The core firm negotiates with the prospective bidder(s) until a contract agreement is reached. The core firm informs the other bidders about the bidding outcome to conclude the underlying bidding process. The complete bidding process is depicted in Figure 3. The information processing and decision making involved in the bidding process are potentially computerizable as follows.

![Figure 3. A Complete Bidding Process](image)

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Core firm determines who to receive a task announcement

For each task to be carried out by its IOPs, the core firm can electronically send out a task announcement to initiate a bidding process. However, the core firm must first determine the set of IOPs that are qualified for this task. The set of IOPs selected by the core firm with respect to the announced task may be as small as only one firm, which is more likely to take place in a stable network. At the other extreme, it may include all the other participating firms in the network. Recall the functions we introduced in Section 3 to model network organizations. The functions for determining membership (M), role scheme (R), labor Division and specialization (D and S) are amenable to computer implementation so as to generate the candidate set.

Interested firms respond to the task announcement with bids

The interested firms submit bids, if they are available and the time frame required by the core firm is achievable. At any given time, a core firm's IOP may be faced with multiple announcements from firms of other networks in which it is participating simultaneously. With limited resources, the firm needs to decide to which announcements to respond and consider the possibility of subcontracting the task to its own IOPs, if applicable. Here, again, we have the opportunity for computerized support, to help IOPs in analyzing their response options and in generating bids. Bids are collected by the core firm before the deadline.

The core firm evaluates the bids

To computerize the evaluation process, we introduce the notion of reputation. This is a quantified measure of a firm's value/performance to date. In our model, each firm has a reputation for each role it plays. Each firm also possesses a generic reputation which is an aggregation of the reputations built up across all roles it plays. The function:

\[ REP(f_i, NO_{\alpha}) = (r_{f1, REP_1}, r_{f2, REP_2}, ..., r_{fn, REP_n}) \]

represents the reputation information about firm \( f_i \) in a network organization \( NO_{\alpha} \), where \( REP_1 \) is \( f_i \)'s generic reputation, an index of \( f_i \)'s overall performance in the network as perceived by the core firm \( \alpha \).

While the core firm of a network organization chooses a market over a hierarchy to conduct its business, it can have a more sophisticated use of the market. Price is an important factor, but not the only consideration by the core firm when selecting an competent IOP. The selection of a supplier from the set of bidders depends on not only what they offer in the bids, but also on their reputations.

The core firm maintains an evaluation profile for each of its IOP firms. There are two factors considered in this profile. One is an IOP's reputation with respect to a certain role, and the other is its frequency of filling this role. The former serves to avoid the false decisions when selecting a qualified firm for a certain task, and to enhance cooperation (Ching, Holsapple and Whinston 1990). The latter reflects an IOP's history in performing a certain role. It provides the core firm with an additional dimension for evaluating a firm. Such profile are readily amenable to computerization.

The core firm negotiates with the prospective subcontractor

After evaluating each bidder, the core firm selects the prospective candidate(s) and negotiates with it. The coordination support system in our architecture can facilitate the negotiation process by incorporating the functionalities of a negotiation support system (Holsapple, Lil, and Whinston 1990). If the negotiation leads to a contract between the core firm and the prospect, the core firm informs other bidders to conclude the bidding process. If the negotiation is fruitless, the core firm can approach other prospects. In the case where no contract is awarded and the prospect list is exhausted, the core firm may send out another (i.e., modified) task announcement.
4.2 Computerized Support at the Strategic Level

Organizations learn from experience. An organization may learn about a new way to handle a certain task or how to avoid repeating the same mistakes from the experience. Experiential learning is enhanced by the availability and analysis of feedback, which may be a result of intentional, systematic efforts, or may be acquired unintentionally or systematically [Ching 1988; Hsuer 1991]. At the strategic level of our proposed architecture, the computerized support emphasis is on how to enhance organizational learning in a systematic way.

There are two approaches discussed in the literature to facilitating intentional organizational learning: (1) to ensure the collection and analysis of such feedback, (2) to increase the accuracy of feedback about cause-effect relationships between organizational actions and outcomes [Straw 1977; Warner 1984]. Ching, Holopainen, and Whinston [1990] in their model of distributed decision making quantify an organization member's reputation as a way to represent its observed performance. In a network organization, the same notion can be used to keep track of a participating firm's performance in filling various roles for the core firm. It can be used as feedback for decisions made in subsequent bidding processes. Thus, we generalize that approach to reputation adjustment as a basis for facilitating intentional organizational learning in a network organization.

The various role reputations associated with an IOP are first instantiated when it joins a network organization. As each firm is initially recognized by the core firm with several qualifications fulfilled, a start-up reputation can be initialized for each role it is qualified to perform. All the reputation measures associated with a firm are adjusted over time based on its participation in various tasks.

The adjustment of an IOP's reputation by core firm a in network NO is can happen at several distinct junctures. First, a positive "credit" may be given to firms submitting bids. This is the juncture where a firm can increase the recognition of its capability of playing the role or roles required by this announcement task, acquiring the core firm via its submission of a bid. This adjustment allows a new firm in the network to gradually exhibit itself.

Secondly, a firm's reputation may be positively impacted at the time a contract is reached with the core firm. We use rep to represent the portion of role reputation that a firm commits and puts on the line when submitting a bid. The firms that do not get the task contracts are not bound to the amounts of reputation they have committed by submitting bids. This adjustment is referred to as recovery, (1/k), which indicates the amount of reputation, rep, that firm f has committed to the announced task k at the time of bidding, to be recovered when f is informed at time t about losing the competition. The third juncture is upon the winning IOP's completion of a certain task as it is released from that task to complete. When a firm completes a task, its reputation(s) with respect to the role(s) required by that announced task is increased to reflect its increased availability.

Lastly, an IOP firm is evaluated on its performance upon completing a task, which may be a result of further subcontracting. There is post-completion feedback that would impact on a firm's reputation positively or negatively. This performance refers to the way an IOP handles the task assigned to it, which may consist of executing part of it and subcontracting the rest of it. In turn, one IOP firm's performance as a supplier to the core firm (a consumer) may depend on its IOPs' performances in other networks. Recall the ripple effect mentioned earlier. Over time, such reputation adjustments can influence which firms will accept work in various networks concurrently. It follows that performance of a supplier can influence the reputation imputed to its immediate consumer (the core firm), as well as consumers many levels away. In Figure 4, we use a directed graph to appor tion credits to firms of various network involved in a distributed task process that originates from the network NO. Recall that the G function yields a set of decompositions for a given task j that is available to the core firm a, and is used for determining the pattern of credit attribution or imputation. As a subtask is decomposed from a certain task, a weight coefficient, w, is assigned to this corresponding edge. This w is given by the core a according to the importance of the subtask when compared with other subtasks that are decomposed from the same task j. The sum of these weights that are assigned to the set of subtasks of the same task is:}

\[ W(D) = \sum_{k=1}^{\infty} w_k \]

where \( D \in \mathcal{G}(a) \), and \( \sum (w_k) = 1 \)

Each node in this graph is associated with a pair of identifications, (j,k,j), indicating the fact that firm f is in charge of task j. The straight or dashed edges leaving node (j,k,j) represent the decomposition of j by firm f, and each of the edges is attached a weight coefficient, w. The two dark edges in the graph are the precedence edges indicating the constraint that task j must be performed before j can be done, and task j can only proceed after j is completed.

In Figure 4, task j is decomposed by firm f into j, which is assigned to f. Tasks j and j are awarded to f and f as a result of the preceding bidding processes. As j, j, and j are all decomposed from j, their weight coefficients sum to 1. For each entity corresponding to a terminal nodes in the graph, when it completes the assigned task, its reputation is first increased to free up the amount of reputation it has offered in the bid for the completed task. Then N is adjusted to conform with the evaluation of its performance. The amount of reputation adjustment, according to the mechanism, can be increased or decreased by as much as it has committed.

![Figure 4. Representing Task Decomposition by Using a Directed Graph](image)

In addition to reputation adjustments enforced at the above four junctures, an IOP's reputation is depreciated over time. Depreciation reflects the rate of "unlearning" due to lack of participation in carrying out some tasks which require the underlying role. In summary, firms' reputations embody what the core firm has learned about coordination and, provide a way to learn about assessing possible interaction patterns, thereby characterizing an organization's coordination options and preferences. These nontrivial reputation adjustment mechanisms, together with performance profile, are candidates for computerization.
Over time, a firm's reputation across all the roles it plays can form a profile of performance. According to this profile, the core firm can evaluate its utilization of resources available in the network and make necessary adjustments. For example, a firm with a high reputation for some roles and low ones for the rest indicates the firm's demonstrated expertise, or its inclination towards certain roles. This performance profile can also be referenced when evaluating a firm's performance for the purpose of switching or replacement. A low reputation with respect to a certain role may only cost the firm some related task bids, but a low generic reputation can force the firm to exit from the network organization.

There are two kinds of changes that can take place in a network organization as a result of learning. In terms of the entry and exit of the IOP firms, they are: instantiation and role changes. An instantiation change refers to a core firm switching from one supplier to another from time to time within the network as a result of individual learning. An instantiation change causes the pattern of coordination conducted by the core firm to vary, but it does not affect the boundary of the network. For example, a toy company XYZ that has been switching among several contracted manufacturers to produce various kinds of cloth does not cause new entry or exit of its IOP firms in the network.

The role change, on the other hand, causes entries and exits of firms into or from the network, and consequently changes the boundary of the network (recall Figure 1). A role change takes place when the core firm’s demand for products/services has changed. That is, the current role scheme (R) of the network can no longer accommodate the core firm’s needs. To cope with new demand, new firms are introduced to the network. Some firms are forced to exit the network when their services are no longer needed. As a result, the role scheme is changed, as is the division of labor within the network. For example, if the XYZ company in the above example has given up its dolls niche on the market and shifts to electronic toys due to the change of consumer tastes, those doll manufacturers will soon be replaced by some companies that specialize in manufacturing electronic toys.

5. Conclusion

The trend towards more use of markets and network organizations indicates an increasing need for more flexibility and sustained adaptability. The development of network organizations leads to inter-organizational cooperation and collaboration, in an effort to ease the turbulence of the business environment [Trost 83]. We have characterized the various features of network organization, such as its membership, role scheme, division of labor, tasks, and coordination community in a formal model so as to suggest computer-based support possibilities for enhancing the network organization's effectiveness and maintaining its adaptability.

We considered information support requirements at various levels: the operational level, the managerial level, and the strategic level. At operational level, we exploit the functionality of an EDI-like system to ensure the ease and efficiency of communication between members of a network. In this context, standardization is an important issue. At the managerial level, information support facilitates the coordination process, which is represented by a structured bidding process in our model. Decisions as to the selection of candidates for the task, evaluation of bids, negotiation, and contract awarding are well susceptible to being supported by a coordination support system. At the strategic level, we facilitate intentional organizational learning through collection and analysis of feedback that reflects the cause-effect relationships between organizational actions and outcomes.

In a stable environment, a network organization can benefit from the core firm's intentional learning to acquire long-term stability while maintaining adaptivity. In a dynamic environment, a network organization can better cope with the environmental changes, if there is a well conceived mechanism to systematically enhance the core firm's intentional learning. As the network organization continues to develop, it is not unusual for a certain firm to simultaneously participate in several networks. Our information support architecture is applicable to each firm in a network, as one IOP firm in a network may well be the core firm of another network. We believe that the return for a core firm in a network organization is a function of its effectiveness of learning with which it can moderate the turbulence in the environment by forming a network with the "best" inter-organizational partners (IOPs).

In sum, we have introduced a formal model of network organizations in the interest of making the concept of networking more effective, especially by suggesting computerization possibilities for supporting intra-organizational specialization, cooperation, and coordination.

References


