An Empirical Study of Standards Development for E-Businesses: A Social Network Perspective

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Abstract

Research on the nature of e-business standards and the organizational context in which they are developed has received little attention in the literature of IT standards and standardization. This study investigates communication patterns in online standards groups to provide insights into the nature of group dynamics among standards decision makers and its relation to the standards context. Email data is used from the ebXML standards initiative. Findings suggest that standards groups operating on the Internet appear to form a cohesive structure, despite the fact that they tend to consist of large group of participants coming from various backgrounds and industries, while their communication patterns are influenced by standards orientation. Policy implications for managers in online standards groups are presented.

KEYWORDS: E-business Standards, Online Standards Groups, Social Network Analysis

1. Introduction

Standards are essential in e-businesses as they enable interoperability among information systems within and across the industry. As the Internet economy becomes mature, the context in which standards are made has become complex and covers core business processes, as well as the realm of infrastructure technology. To fulfill the market need for timely and effective development of diverse standards for e-businesses, an alternative form of an organization has emerged in the private sector which mainly operates on the Internet through a voluntary, consensus based approach [9; 11; 22]. Participants utilize computer-mediated communication technologies to partake in the process. While it is important to effectively and efficiently manage the increasingly prevalent activities, there has been relatively little interest in understanding how the organization operates to perform its tasks.

Using a social network analysis approach [27; 45], this study examines group dynamics of the process, in relation to the e-business standards characteristics. A social network consists of both a set of actors, who may be arbitrary entities like persons or organizations, and one or more types of relations between them, such as information exchange or economic relationship [30; 31]. Social network analysis (SNA) is a set of research procedures for identifying structures in systems based on the relations among actors [32]. This approach has been used for the last twenty years in different areas, including communication studies in an organizational context [1; 27; 30; 31; 32].

Drawing on this approach, this study specifically focuses on understanding the nature of group dynamics through the analysis of the communication network structure being formed and how it is related to the characteristics of e-business standards. The use of SNA is particularly important to understand group dynamics in a situation where the quality of the final outcome of a group activity is hard to measure [48]. One of the advantages of using social network analysis is that it allows us to deal with multiple units of analysis [28]. Both the network and individual level analysis are performed which helps us to

examine various dimensions of standards development in online standards groups.

Data for this study comes from email archives from the ebXML standards initiative. Findings from this study suggest that interestingly enough, standards groups operating on the Internet appear to form a cohesive structure, despite the fact that it tends to consist of large group of participants coming from various backgrounds and industries, and that the underlying communication network structure of those standards groups is influenced by standards orientation.

The rest of the paper is organized as follows. In the next section, the research context is provided, followed by a brief description of social network analysis methods. Hypotheses are then presented. The research method and research results are presented in subsequent sections. Finally the conclusion is presented.

2. E-business standards development

The roles of information technology standards have evolved to meet needs of diverse business requirements [33; 38]. The Internet enables an interconnected information infrastructure to provide higher-level services for business activities. While standards efforts related to information technology have largely taken an infrastructure orientation (e.g., development of network interfaces, communication protocols and data formats), more recent efforts have extended into the development of high-level, business process-oriented standards over compatible infrastructures. In addition to the relatively well understood task of interconnecting disparate computer systems through standards for network interfaces, data formats, and storage devices, the task of defining business process-oriented standards is becoming equally important to facilitate business activities over the Internet. Recent efforts, such as the ebXML standards initiative for e-commerce, FSTC for financial and banking sector, or adXML in the advertising sector, are examples of such cases that would require input from the general business community. It is noted that standards groups that deal with business process-oriented standards appear to reveal coordination-intensive or iterative processes, whereas others dealing with infrastructure-oriented standards shows rather sequence-intensive or waterfall processes [9]. It implies that the characteristics of e-business standards orientation influence the patterns of communicative interactions among participants in the group.

Standards are typically classified as *de jure standards*, *de facto standards*, and *voluntary standards* [34]. They are however not necessarily exclusive. A de facto standard, for example, can be adopted as a voluntary standard, which then can be adopted as a de jure standard by formal standards development organizations (SDOs). Voluntary standards are generally established by private sector bodies such as industry consortia through voluntary consensus standards creation process. Two broad categories emerge as leading contenders in the context of e-business standards: business process oriented standards and infrastructure oriented standards. A brief comparison between these two types of e-business standards is presented in Table 1.

Table 1. An Overview of e-Business Standards Orientation

	Business process oriented standards	Infrastructure oriented Standards	Note
Definition	The specifications that define procedures for horizontal or vertical business transactions performed over the Internet	The specifications for a group of technologies to form a technical framework that provides an infrastructure on which organizations can perform business transactions	[8; 20]
Focus	• Process focused • Business collaboration across organizations • Analyzing business activities and developing business process meta-models, business rules, naming conventions and forms of business collaboration and agreement • Application or higher level of system architecture • Context sensitive • Predominantly qualitative criteria • Establishment of basic principles and models	• Product focused • Compatibility for hardware, software, and communication integration • Developing specifications for hardware, software, and communication protocols • Lower level of system architecture • Domain independent • Predominantly objective criteria • Establishment of actual specifications and system interfaces for products or outputs	[7; 17; 41]

In recent years, an increasing number of information technology standards have been developed by private sponsors through industry consortia. These consortia have increasingly been playing an important role in standards development [11; 18; 23; 47]. To facilitate collaboration among participants geographically dispersed around the world, such standards groups have relied on communication technologies, creating 'online standards groups' [49]. 'Online standards groups' can be defined as "a group of people to perform a task associated with standards development, who interact across space, time, and organizational boundaries, are guided by common purpose, and are linked through communications technologies such as the Internet."
In the IT area, examples include World Wide Web Consortium (W3C), Internet Engineering Task Force (IETF), and Organization for the Advancement of Structured Information Standards (OASIS). Participants in online standards groups often use emails to communicate and coordinate their task and to provide, receive, or exchange ideas and information. The context of and the way in which standards are developed in traditional standards development organizations may be compared against those in industry consortia in many aspects. A brief comparison between traditional standards development in formal standards development organizations and an alternative way of standards development occurring in industry consortia is provided in Table 2.

When a computer network connects people or organizations, it is a social network mediated by communication technologies [48]. Communication patterns emerge through social interactions to perform certain tasks or to respond to particular events [13]. The communicative activities exhibit a structural pattern of the communication network in the long run. As standards development processes can be viewed as evolutionary negotiation and collaborative decision-making processes, the communicative patterns may be examined and used as a surrogate to determine an organization's information processing capacity [3; 10; 19]. Social capital theory posits that social networks retain social capital that is embedded in social relations among individuals, which encourages compromise to accomplish a collective action, helps reduce transaction costs, and channels the flow of information [29; 35]. Social capital refers to connections among individuals, or social networks, and the norms of reciprocity and trustworthiness that arise from them [29]. Social capital carried by the social ties may be viewed as a manifestation of an internal quality of social networks, which eventually affect knowledge transfer and group decision-making within the system.

We argue that the characteristics of task to be performed should be carefully considered to fully understand performance of online standards groups as tasks need to fit with certain emergent communication network structure to produce a quality outcome [1; 35]. The characteristics of a task also may affect the role of actors and the nature of interactions within the group, thus contributing to the emergence of an emergent communication network structure [49]. Tasks in general have been categorized into either *routine* or *non-routine* tasks, based on task analyzability [1] and variability [48], or either *intellective* or *maximizing* tasks, with respect to how group output is measured [24]. While standards development tasks can be categorized as *non-routine* or *intellective*, much like software development tasks [23], standards development tasks don't cleanly follow the task categorization in the management literature. It is noted that the performance of the standards group cannot be measured by the cleanly-defined outcome. As such, the dynamics of the emergent processes of e-business standards development, with regards to the characteristics of e-business standards, should be carefully analyzed.[48].

3. Social network analysis

Before we proceed further, social network analysis method and some basic concepts are briefly introduced to facilitate understanding of the rest of this paper. SNA facilitates in organization, and representation of interactions between actors of any organization, focusing on relationships rather than attributes of actors. The underlying assumption is that structure affects substantive outcomes and that structures are emergent. SNA is an instrumental technique to analyze the structural properties of social structure and has been applied in areas such as sociology, organizational psychology, and anthropology [45].

Table 2. A Comparison between Different Standards Processes

Feature	Traditional standards process	Community-based standards process
Standards type	De jure	De facto
Membership	Closed (open to members only)	Closed or open to the public
Organizational type	International SDOs, Governmental SDOs	Industry consortium
Governance structure	Formal, bureaucratic, Hierarchical or centralized	Informal, autonomous, decentralized
Representatives	International SDOs, national standards bodies, technology providers, service providers, vendors	Technology providers, service providers, vendors, user organizations
Communication tools	Face-to-face meetings, email, news group, phone conferences	Email or mailing list or archives (most important), phone conferences, face-to-face meetings (optional)
Strength	Emphasis on openness and transparency, Consistent, higher quality	Relatively quick, fast and efficient
Weakness	Slow and take long period of time	Varied quality

The relationships between actors can be represented as a network or graph [21] where the nodes represent people and a link (or edge) is drawn between nodes if the relationship exists. The strength of the relationship is converted to a score ranging from 0 (weakest relationship) to 1 (strongest relationship). The relationships can be analyzed in many different ways. Two important network concepts are *centrality* and *cohesion*. The *centrality* measure is used to identify hubs or connectors in a network, referring to the connectedness of an actor to others in the network [14]. An individual with a large number of messages exchanged will not only change his or her own position in the network, but others' relative position as well [1]. The centrality is measured by "degree centrality," "closeness centrality," and "betweenness centrality."

The number of direct connections to an entity is the number of degrees, which refers to degree centrality in network terms. Degree centrality is used to identify hubs or connectors. It refers to the extent to which an actor is linked to others in the network [14]. The degree centrality measures the influence (out-degree centrality) or prestige (in-degree centrality) of an actor. In a directed network, the sum of the ties from an actor to others is called the out-degree. The out-degree centrality usually indicates how influential the actor may be. On the other hand, if an actor receives many ties or has higher in-degree centrality, he or she is often said to be prominent, or to have high prestige. For instance, the participants who possess formal positions (e.g., members including leaders and editors) in online standards groups are believed to have a higher centrality, both out-degree and in-degree. For example, in a mathematical term, the count of the degree is measured for a point, p_k,

$$C_D = \sum_{i=1}^{N} a(p_i, p_k)$$

where

$a(p_i, p_k)$ =1 if and only if p_i and p_k are connected by a line,
0 otherwise

The magnitude of $C_D(p_k)$ is a function of the size of the network on which it is calculated. So, the normalized magnitude is calculated by dividing it by the size of the network. A given point, p_k, can at most be adjacent to N-1 other points in a network. The maximum of $C_D(p_k)$ is N-1. Then,

$$C'_D = \frac{\sum_{i=1}^{N} a(p_i, p_k)}{N - 1}$$

is the proportion of other points that are adjacent to p_k [14].

A node that exists between distinct sub-groups is one that displays betweenness. Betweenness is a critical concept because it shows the linkages between sub-groups, often being an indicator of influence. Betweenness centrality captures the role of bridges or boundary spanners as they often connect groups or sub-groups in the network with outside or potentially unrelated groups [45]. Nodes with high betweenness centrality often connect groups or sub-groups in the network with outside or potentially unrelated groups. Betweenness centrality is referred to as the frequency with which a node falls between pairs of other nodes in the network.

Another important concept to indicate the connections of the social network is the density. The notion of density is related to the context of adjacencies of the network. The constraints and opportunities for an actor in a network can be determined by the distance between actors within the same network. For instance, where distances are great, it may take a long time for information to diffuse across the network. If the geodesic path distances are small, a network tends to be dense, thus having information travel quickly in the network. The density of a group is the proportion of ties that are present among a subset of the actors in the group. The measure of network density or distance-based cohesion may be used for evaluating cohesion.

4. Hypotheses development

Standards groups function differently according to the standards orientation. For example, in developing the business process-oriented standards, participants often experience frequent iterations among different thematic context of discussions. Task handling by participants in the online standards group dealing with the business process-oriented standards requires more resources to be devoted to coordination. Such coordination pattern may be viewed as 'reciprocal coupling' [48], indicating a high degree of task interdependence [26]. Group dynamics in this group is much more likely to be affected by the rationale of participants and rapport with end-users, as developing business process-oriented standards requires a significant amount of coordination to align the requirements and needs of various stakeholders. On the other hand, the process of developing infrastructure-oriented standards is largely design-centric and sequence-intensive with reduced need for coordination. This classification is consistent with Mintzberg's (1983) notion of classifying decision making tasks in terms of task complexity and task uncertainty; the task of developing the business process-oriented standard is viewed as an unstructured task, while the task of developing the infrastructure-oriented standards is viewed as a structured task.

To support a high level of coordination, groups usually require high level of social processes [48], resulting in a more cohesive and dense network structure. Communications between two actors will be 'reciprocated' if the relationship is bi-directional or balanced among actors. A network that has predominance of reciprocated ties may be more 'stable' than the one with predominance of asymmetric connections, indicating that the network is more cohesive than otherwise. Cohesive groups, which rest on the pattern of multiple connections within the network, are usually robust enough to resist disruption [15; 16]. The discussions above form the basis for the first hypothesis.

Hypothesis 1 (Task characteristics and group cohesiveness): A communication network structure of online standards groups associated with the development of business process-oriented standards will be more cohesive than those associated with the development of infrastructure-oriented standards.

CMC studies have shown that informational influence can be just as effective and in some cases more important than normative influence with respect to group decision making processes. Informational influence or 'persuasive arguments' refers to the conformity which results from accepting evidence about reality provided by others. This occurs when one tries to persuade others through valid arguments with the use of logic or verifiable facts and, as a result, the views are believed to be valid and reliable [4; 12]. Innovative ideas or information for standards development may come from those who have external ties with large firms or government institutions, as well as from those who possess formal positions within standards bodies. Considering the fact that an investment on standards development usually requires significant resources[1] and efforts by participating organizations, it is not surprising that standards bodies often consist of participants from large firms across industries. It is, therefore, expected that the informational influence exerted by members in online standards groups plays an important role in affecting the perception of other participants in the process of standards development.

In network terms, 'weak ties' tend to build 'bridges' between clusters or different groups [2; 46]. From a network point of view, these 'bridges,' or 'brokers' are most crucial in introducing and distributing information or innovations into the system, as they can control the flow of information. The theory of the 'strength of weak ties' posits that individuals with whom an actor has weak ties are

[1] Hawkins (1999) showed that costs directly attributable to standards-setting would appear to be in the average range of US$5-7 million per firm in the information and communications technology industry, per year and rising. The full costs are probably much higher.

likely to be embedded in a 'structural hole' [6], as the information obtained from these weak ties is less likely to be redundant and therefore more valuable. In standards discussions, information or knowledge that is new to the system is very likely to be delivered through these brokers who have access from external resources. Therefore, we propose the following hypothesis on the role of brokers in online standards groups.

Hypothesis 2 (Role of brokers in online standards groups): In online standards groups, the participants who possess formal positions (e.g., members including liaisons, leaders and editors) have a higher betweenness centrality than others (e.g., non-members) within the group.

5. Research method

While the relationships can be analyzed in many different ways, we primarily rely on two network concepts: *centrality* and *cohesion*. As indicated in Section 3, the *centrality* measure is used to identify hubs or connectors in a network, referring to the connectedness of an actor to others in the network [14]. 'Degree centrality' measures the influence (out-degree centrality) or prestige (in-degree centrality) of an actor. 'Betweenness centrality' captures the role of bridges or boundary spanners. *Cohesion* may be measured using network density or distance.

5. 1. Data gathering and network creation

We used the data collected from the email archives of the ebXML standard initiative during the period of November 1999 to May 2001. Detailed information on these work groups can be found in the web site (www.ebxml.org). To create a social network for the online standards group, we used the message exchanged among participants as the basic unit of observation of communication. When a message is sent from a participant or a node to another, a link or an edge is established between the two participants. The basic network data set is an N x N matrix S, where N equals the number of nodes or participants in the network, and each cell, S_{ij}, was measured in terms of the number of email exchanges, rather than dichotomous values. Some rules were applied when constructing the adjacency matrix: (1) The group distribution email id for the current group was deleted, as it applies equally to everybody, while other, external group email ids were treated as a separate entity; (2) Carbon copy of email exchange were considered as being analogous to the receiver of the email.

A separate social network was created respectively for Transport, Routing and Packaging (TRP) for the infrastructure-oriented standard development, and Business Process Methodology (BPM) group for the development of business process-oriented standards. A 241 by 241 one-mode, directional and weighed adjacency matrix was developed for the BPM group, while a 381 by 381 one-mode, directional and valued adjacency matrix was created for the TRP group. The networks were then fed into UCINET 6 Network Analysis Software [5]. To compare the two networks, normalized measures were calculated by dividing original values by the size of the network [48]. One of disadvantages of using email archives from listserv is that network measures may contain spurious effects through inclusion of individuals, who make very little contribution to the standards discussion. To test the reliability of the analysis results, centrality analysis was performed on social networks that were separately created for only threaded discussions, instead of the entire network. The results from both data sets turned out to be consistent.

6. Research results

6.1. Hypothesis 1

Hypothesis 1 tests the relationship between task characteristics and group cohesiveness. The average distance between reachable pairs for the BPM group was 1.313[2], and the distance-based cohesion index was 0.843 (range 0 to 1; larger values indicate greater cohesiveness), with network-based density of 0.0482 (s.d.=0.7826). The average distance among reachable pairs for the TRP group was 1.439 and the distance-based cohesion index was 0.812, with network-based density of 0.0329 (s.d.=0.6992). This is a support for hypothesis 1 that the network structure of online standards groups associated with business process-oriented standards development will be more cohesive than those associated with infrastructure-oriented processes.

The research results are summarized as follows. First, while online standards groups may largely be cohesive, specific process patterns may reveal

[2] To our knowledge, the outcome of the SNA analysis using UCINET 6 does not provide the information on standard deviation for the average distance measure.

varying degrees of core-periphery structure in their communication network. It implies that it is the process pattern that influences the network structure of online standards group, yet the process pattern is closely related with It implies that the nature of the task to be performed in the online standards group influences the patterns of interaction among participants as shown in the communication network structure. This result provides an important implication regarding an emerging open standardization, as it suggests that allowing for a wider business community to access the process of standards development may cause for some process gains or losses to occur as far as standards discussion is concerned. This finding means that the relationship between the characteristics of the task being performed and the emergent process pattern in the context of online standards groups should be more carefully examined.

6.2. Hypotheses 2

Hypothesis 2 investigated the ego network of the online standards groups. Two-tailed heteroscedastic t-tests were performed on centrality indexes between members and non-members within each network (Table 3).

Table 3. Two-tailed heteroscedastic t-test results

Centrality indexes	BPM group	TRP group
Number of member	92 out of 241	74 out of 381
Out-degree centrality	Significant (P=0.005)	Non-significant (P=0.498)
In-degree centrality	Significant (P=0.043)	Significant (P=0.003)
Betweenness centrality	Significant (P=0.015)	Non-significant (P=0.067)

All the centrality measures for the BPM group were significantly different between members and non-members, thus supporting hypothesis 2. In the BPM group, the participants who served as members demonstrated a higher level of all centrality indices than non-members. Only in-degree centrality was significantly different in the TRP group, thus providing limited support for only hypothesis 2.

Participants in formal positions appear to have normative and informational influence on others in standards development. However, we found it interesting that out-degree and betweenness centrality for members in the TRP group were not significantly different from those for non-members. It implies that while the participants in the TRP group had received a lot of information (i.e., high in-degree centrality), non-members were as much active as members in bringing in new information and knowledge into standards discussion (i.e., out-degree centrality) and sharing them (i.e., betweenness centrality) to affect the development of the infrastructure standards. Obviously this was not the case for the BPM group.

As for the group dynamics in the TRP group, we conjecture that there is an extant, large base of rather homogeneous technical experts with strong interest in the development of the standards. The rationale for the participation of technical experts in the process of standards development is partially explained from a perspective of social exchange theory [9]. It should be noted, though, that while there was active participation both from members and non-members, participants with high status seemed to control the process in terms of information receiving and decision-making. As for the BPM group, it is reasonable to conjecture that there could be 'information overload' on participants. It is noted that the development of business process-oriented standards usually entails the coordination-intensive process where multiple tasks are strongly interdependent over time, thus creating a sizable cognitive load, which serves as a barrier for most non-member participants. The finding also seems to produce mixed expectations on the potential effects of non-member user participation in the process of standards development. It may be interpreted as being partially supportive of the idea that non-member user participation may not have much impact on standards development processes. Better process and coordination mechanisms may be necessary to take advantage of open standardization.

This research also allows us to assume that the group dynamics of standards development in online standards groups may not be inherently different from those in the traditional standards development environment. A small group of participants may exert powerful social influence, enabling them to persuade others even in the presence of an open standardization policy. Strategic planning must be in place for managers to be able to truly exploit the advantages of open standardization policy. For instance, the TRP group dynamics indicated the potential for groupthink or group polarization. Greater attention should be paid to the aspects of standards group composition and user participation.

As for the BPM group, on the other hand, the focus should be on improving coordination activities, especially when the number of participants increases. The input from diverse groups should be well managed to maximize the effectiveness of the process of standards development within online standards groups. In summary, by diversifying the attributes of participants, process losses may be reduced for developing infrastructure standards in online standards groups, while process gains could be achieved through better coordination mechanisms for management of inputs from users with diverse organizational backgrounds.

The context of the study should be carefully considered so that the findings can be interpreted in a meaningful manner. Email data were aggregated for the entire period of the standards initiative. This may present a biased view on the realities of the standards activities that usually occur over a long period of time. However, communication patterns inevitably are studied over a time span. The aggregated view may represent the realities better than arbitrarily imposing time spans. We believe that this limitation may be addressed in the future when we perform a longitudinal study to gain a deeper understanding of the standards development process. Furthermore, this paper relied on a single case to explore the phenomenon. Follow-up studies in other contexts would be necessary to generalize the findings from this research.

7. Conclusion

Standards development processes are inherently unwieldy because of the complex nature of the task and its organizational environment. By perfoming an empirical analysis of the communication patterns in online standards groups, this paper contributes to an understanding of the process of e-business standards development. Using two ebXML standards groups, this paper demonstrated that the characteristics of e-business standards lead to varying degrees of core-periphery structure in online standards groups and that the role of social influence, namely normative and informational influence, may manifest differently depending on the nature of the task performed. The findings provide managers with implications on the importance of strategic planning on standards development occurring in the context of online standards groups.

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