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An Exploratory Study on Adoption of Complex Networked Technologies: The Case of the eXtensible Markup Language(XML) Specifications

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Abstract

This paper provides insight into the forces shaping the adoption of XML technologies by organizations. Unstructured interviews were conducted with four global organizations and, despite the small number of study participants, some interesting cross-industry patterns worthy of further study emerge. Among them are indications that a lack of recognized industry standards slows market adoption of XML technologies, and that organizations are building internal expertise in anticipation of future standards-based work. Balance of power in customer/supplier relationships also emerges as a significant element. Further study is necessary in order to ascertain the presence of these effects and their extent across industries.

Keywords: XML, Standards, Adoption of Innovations, Power

1. Introduction

The rise of the eXtensible Markup Language(XML) and supporting technologies has been well documented in industry

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(Lim and Wen 2002, CIO 2002). The XML has been gaining a lot of attention and popularity from practitioners as well as academia as a solution technology to conduct "frictionless" electronic transactions among organizations and thus as an alternative to replace traditional EDI(Electronic Data Interchange) technology. XML has the ability to establish common, flexible, and robust industry standards to describe products and services. The purpose of the XML specification is to establish a uniform syntax for the development of markup language elements(also known as *tags*) that describe products or services in machine-readable format(Harold 1999). XML has been declared by industry publications as the future "linchpin of successful enterprise information management in an e-business environment"(CIO 2002), and called the "Esperanto format" (DeJesus 2001) and the "Holy Grail" of e-business(Hyle 2002).

However, the unfortunate downside of all this attention is that its real capabilities are not well understood by a majority of decision makers in organizations. From an academic perspective, research on XML has been almost exclusively focused on syntax specifications, and the proposal, design, and testing of formal applications to solve specific industry needs. Despite these effort and its popularity, the study of XML adoption by organizations has not been addressed(Chen et al. 2003a, b), and very little is known about the ways in which such an important technology is deployed. Recognizing the importance of(but the lack of) the research on this issue, this study attempted to explore the forces shaping the adoption of XML technologies among organizations, providing some insights into adoption phenomenon of such a complex technology. Considering the XML technology to be complex technological innovation, this study draws on diffusion of innovation theory as theoretical base. This research is expected to contribute to both practitioners and academicians by discussing XML adoption patterns emerged from this exploratory study and suggesting important factors to adoption of complex network technologies such as the XML technology.

This paper is organized as follows: The following section provides an overview of XML tyechnologies and the specifications. This is followed by a review of literature on the Diffusion of Innovations(DoI) theory. The next two sections

describe the research method and research findings, respectively. Then, discussion of research findings and conclusion of the study follow.

2. The eXtensible Markup Language(XML) and The Specifications

XML is a set of World Wide Web Consortium syntax recommendations that facilitate the seamless, cross-platform exchange of data via the development of formal industry-wide applications(Glushko et al. 1999). Unlike the HyperText Markup Language(HTML), XML goes beyond merely defining data format on a browser window. User-defined tag sets provide transaction-specific meaning to data, whose display format may be customized to meet any need. This capability provides data with uniform meaning for buyers and sellers in any specific transaction for which a formal XML application is created. Using XML, a standardized tag set(or application) may be developed to ensure consistent meaning and uniform machine-processing of this data. This application may be enforced within a single company or extended to an entire industry. Since XML is simply a set of syntax rules, any number of code implementations may exist. This flexibility to generate transaction-specific definitions creates problems in the development and adoption of industry-standard specifications.

Multiple proposals for formal XML applications are currently sponsored by various industry-specific alliances. In some cases, these consortia act simply as repositories for multiple industries (Dogac and Cingil 2001) or for multiple applications for a single industry(see http://www.XML.org). However, as of late 2002, no official, internationally-recognized standards for XML applications exist. This potentially confusing situation highlights the complexity of XML technologies. Three distinct types of XML specifications could be considered: Proprietary, Sponsored, and Public specifications, respectively. Of the three types of XML specification, however, only two currently exist. Proprietary and Sponsored specifications abound, while Public specifications have not yet been developed. We now turn our attention to the properties of each type of specification.

2.1. Public specifications

Free market forces are responsible for making XML the *de facto* technology for developing data-exchange applications within and across industries(CIO 2002). This does not mean, however, that a single, universally-accepted standard for specific industries, or even individual transactions, exists. Since the object of XML-based transactions is to enable end-to-end computing without human intervention, XML-based product descriptions used by organization members have to be identical. This example illustrates the fact that, while XML is the *de facto* technology for data-exchange application development, there is still a great need for the development of uniform product descriptions within industries. For true public specifications to take root, they must be championed by an internationally-accepted standards-setting body, or imposed by governmental decree. There are no proposed XML specifications currently being championed by any international standards-setting body, and in the United States, government involvement has been limited to exploratory and coordination efforts by federal agencies(Kane 2002). These efforts are strictly internal, i.e., they are limited to establishing uniform XML specifications for use by government agencies, and not to the regulation of XML specifications within or across industries. Government agencies currently investigating or adopting XML include the General Services Administration(Kane 2002), the U.S. Navy, Air Force, Army, the Department of Energy(XML.CoverPages.org), and the General Accounting Office(GAO.gov). Outside the United States, government involvement has been similarly limited (Microsoft.com 2002). The result of these initiatives, or the lack thereof, is that no open specifications currently exist for any industry, despite joint efforts between industry alliances(such as OASIS) and international standards-setting bodies(like the ISO).

2.2. Proprietary specifications

The lack of universally-accepted transaction or industry-specific standards has forced organizations using XML technologies to develop applications specifically suited to their

needs. These idiosyncratic, proprietary XML applications cannot be adopted by other organizations without major modifications, and sometimes not at all. The investment made between two organizations in developing these applications is very specific to the nature of their relationship and cannot be easily redeployed. Classical transaction cost economic theory identifies these investments as being relationship-specific(Clemons et al. 1993) between organizations. Such relationship-specific investments in XML applications increase the risk to organizations by negating fundamental economic characteristics of software, such as replicability, transferability, and the reduction of sunk and switching costs(Clemons and Row 1992).

2.3. Sponsored specifications

Sponsored specifications are created by alliances of organizations in a single industry, or in related industries. The aim of these alliances is to establish technologically-integrated business communities offering complementary services to their memberships, and to establish a position of dominance over their target markets(Hill 1997). Thus, applications are developed in a collaborative manner and made available, typically free of charge, to firms participating in the alliance's target industries. While the IP rights for these applications remain with the alliances themselves, they are distributed freely in order to establish the communities and dominant positions sought by the alliance(Updegrove 1994). There are nearly as many of these alliances promoting their own niche XML specification as there are industries in need of consistent specifications. Organizations such as XML.org, ebXML, XBRL, xCBL.org, cXML.org, and XML.gov maintain websites to disseminate information about their individual efforts and constituencies.

3. Theory Base: Diffusion of Innovation Theory

Since its introduction diffusion of innovations(DoI) theory has been used, and extended, by researchers to explore the adoption and diffusion of contemporary information technologies, including interorganizational systems(IOS). Classical DoI theory

attempts to explain how a technology, a product, or a service moves from its introduction to a market to its adoption and dispersal throughout the same(Rogers 1995). Rogers first suggested that an innovation goes through several stages, from the initial exposure to a potential adopter(knowledge), through stages of persuasion and decision, until it is implemented by the adopter. Lastly, the innovation provides confirmation of its benefits through positive outcomes resulting from its use. Further, DoI theory posited that innovations are generally characterized by five principal qualities that contribute to the adoption decision: the relative advantage afforded by the innovation, its compatibility with the potential adopter's values and environment, the degree of complexity of the innovation, the innovation's inherent ease of experimentation(trialability), and the observability of its results. Classical DoI theory assumes individual potential adopters making binary, voluntary decisions to either accept or reject an innovation based on the expected benefits of their use of the innovation. Diffusion of innovations theory has been criticized on this account(Tornatzky & Klein 1982), and extensions have been made to include various innovation/potential adopter scenarios.

One such extension is the comparison of pre- and post-adoption attitudes of potential adopters versus actual individual users of a technology(Karahanna et al. 1999). The study found that pre-adoption attitudes towards a specific innovation are based on a richer set of characteristics describing the innovation than post-adoption attitudes are. The issue of mandated innovation adoptions(versus the classical voluntary decision) has also been called out as an area that requires further analysis (Bayer & Melone 1989). The influence of the competitive environment of both innovation suppliers and potential adopters has been empirically confirmed(Robertson & Gatignon 1986, Gatignon & Robertson 1989) and industry resource symmetry, the significance of entry barriers, and timing considerations (Clemons 1990) have also been explored within the context of DoI theory. For small businesses, research has found that the characteristics of an organization(e.g., business size, IS expertise) are the principal determinants of IS adoption(Thong 1999). The enabling and limiting roles that social networks play in the diffusion of innovations has been explored via social

exchange theory(Abrahamson & Rosenkopf 1997).

Innovations have been characterized as focused either on process and administration, or on technology products and services and a number of efforts exist that study their particular adoption patterns(Bayer & Melone 1989, Swanson 1994, Ravichandran 2000). A different research classification framework introduced by Fichman in 1992 categorizes innovations based on the type of technology being studied and on its locus of adoption. The framework divided technologies into those that conform to the assumptions of the classical model of diffusion of innovations and those that do not, and labeled them Type I and Type II, respectively. Empirical research points to the importance of organizational learning and knowledge barriers (Attewell 1992) to the adoption of technological innovations (Fichman & Kemerer 1997), and that these barriers tend to reduce over time. Fichman's(1992) framework also recognizes that the decision adoption for different technologies may be made at the individual level or at the organizational level. Using this framework as a reference, research on the adoption of IOS technologies falls under the category of organizational adoption of Type II technologies, i.e., those with high knowledge burden and/or user interdependencies.

The adoption of technological innovations has been frequently studied using the Technology-Organization-Environment framework(Tornatzky & Fleischer 1990). The framework identifies technology factors as those from all available technologies, internal or external, that are of relevance to the firm(Zhu et al. 2002) and may influence the process of adoption. The grouping of Organizational contextual variables include firm descriptors such as size and available resources, as well as management structure(centralization, process formality, etc.). The Environmental context is represented by the variables that describe the firm's competitive landscape, and includes a description of its home industry, competitors, suppliers, and customers. While adoption processes have been found to be heavily contextual(Premkumar et al. 1997), the Technology-Organization-Environment framework has proven quite useful at guiding the exploration of adoption factors for technological innovations across industries.

While adoption is discussed using general concepts from

diffusion of innovations theory(Rogers 1983), extensions to the original theory are necessary to get a more complete picture of the processes at work and issues faced by the organizations in this study. Classical diffusion theory describes voluntary choices made by individual adopters to accept or reject an innovation whose expected benefits are independent of the adoption of the innovation by others(Fichman 1992). As previously discussed, XML is a complicated technology generally not subject to adoption by individuals but by organizations, and it is subject to the effects of network externalities(Katz and Shapiro, 1985, 1994). In Fichman's(1992) framework of classification of diffusion research, XML is a Type 2 technology: it presents a high knowledge barrier to potential adopters, it is subject to significant user interdependencies, and has an organizational locus of adoption. As such, the classical assumptions of diffusion theory are not sufficient for the analysis of XML adoption, and additional variables such as competitive effects (Robertson and Gatignon 1986) and power effects in the competitive environment(Emerson 1962, Cook and Yamagishi 1992, Lucas et al. 2001) must be incorporated into the present analysis.

4. Research Method

The validity of the case study approach as an exploratory tool has been recognized by leading researchers in the MIS field (Benbasat et al. 1987, Lee 1989, Walsham 1995), and is employed in this study to provide a starting point for hypothesis generation and further empirical study. In order to explore the forces shaping XML adoption by organizations in various industries, a series of unstructured interviews were conducted with IT leaders from four global organizations currently using or planning for XML deployment. In all cases, the names of the participating organizations have been changed to protect their confidentiality. The companies participating in this effort are major players in the financial services, pharmaceutical, and aviation industries. The small number of participating organizations and the exploratory nature of the interviews make a strict quantitative methodology impractical at this stage.

However, the information gathered during the interviewing process offers clues to emerging cross-industry adoption patterns. Naturally, more extensive empirical work is needed in order to confirm any of the observed phenomena.

5. Research Findings: Some Patterns of XML Adoption

This section summarizes the experience of four global organizations currently using XML technologies. All of the participating organizations make use of sponsored XML applications to meet some of their business needs. Some of these companies use sponsored applications to exchange data with business partners. Others use them simply to convert incoming data to internally-acceptable formats. At the same time, all of these companies are busy developing in-house XML applications either to meet internal business needs, or to develop expertise with the use of XML technologies. The organizations included in this study have only deployed Proprietary and Sponsored specifications, since public specifications do not yet exist.

The data collected indicate that a lack of recognized industry standards slows market adoption of XML technologies. Also, the relative balance of power in customer/supplier relationships across these industries appears to be a significant factor in XML adoption. We have also learned that, while waiting for accredited industry-wide standards to emerge, organizations are developing in-house expertise by deploying XML applications specifically tailored to their needs. These events have combined to slow the deployment and adoption of consistent XML applications across these industries and to greatly reduce the impact of XML technologies in the electronic business landscape.

5.1. Standards Development

The Finseco Corporation, a major player in the financial services area, has adopted the Open Financial Exchange specification(OFX.net) to download and use Quicken data from publicly-available sources. OFX was developed by CheckFree, Intuit and Microsoft in 1997, and became XML-compliant in the Fall of 2001. Company representatives indicate Finseco's use of

this sponsored specification is currently limited to the download of public financial information for internal consumption, i.e., Finseco does not yet exchange structured documents via this specification with its business partners. The current lack of industry-wide standards is of great concern to the company, as is the fact that no movement towards convergence is evident. Lastly, Finseco IT leaders are keenly aware of the importance of installed base as a determinant of success for standards in their industry. They believe that XML specifications adopted by the company's major customers will lead to increasing returns (Arthur 1989, 1996) in the financial services industry, which will provide the impetus for other firms to adopt those specifications, leading to an industry-wide standard.

Interviews with Icaria, a large multinational organization in the avionics industry, and with Global Pharmaceuticals Incorporated(GPI) reveal concerns similar to those of Finseco IT leaders. There are no industry-wide standards for the submission of clinical trial and product development data to regulatory agencies. Similarly, the avionics industry lacks a recognized set of XML industry specifications. Various consortia, such as the International Conference on Harmonization (ICH.org) in pharmaceuticals and Cordiem in the aerospace industry, are leading efforts towards the creation of such standards. While the promise of these sponsored efforts is great, usable specifications are still several years away.

5.2. Customer/Supplier Power

All of the organizations participating in this study acknowledge the importance of positive network externalities(Katz and Shapiro 1985, 1994) on the acceptance of XML specifications. The larger the number of organizations supporting any given specification, the more attractive the specification becomes. More important, however, is the influence major business partners exert over the choice of specifications these companies adopt. IT leaders at Icaria state they will support any specification, be it proprietary or sponsored, their major customers support. In fact, they add, Icaria will support as many specifications as necessary in order to exchange vital business information with these customers. They further added

that adopting XML-based specifications, even multiple ones, will be simpler and cheaper than continuing to provide development and support for the bevy of inconsistent EDI specifications they currently support.

Regulatory agencies such as the FDA and the FAA in the United States, are in a unique position to determine the dominant XML specification for their respective industries. Industry players need to implement virtually any sponsored specification adopted by either agency in order to remain competitive. GPI and Icaria recognize this situation and, as a result, actively participate in the development work of both consortia and government agencies. They see this participation as a way of protecting their investment in XML technologies by attempting to influence the development of industry specifications. It is widely recognized, however, that while government participation is critical in the establishment of a specification as dominant in an industry, it is not sufficient by itself. This is certainly the case in industries in which the federal government does not play a major role as regulator. Thus, participation in government efforts towards standards convergence is prized by both Icaria and GPI management.

5.3. Internal Expertise Development

Previous diffusion literature has identified the role of organizational learning in reducing knowledge barriers in technology adoption strategies(Attewell 1992). Companies participating in this effort use a combination of internal resources and consultants for XML application development, and justify the costs as a way of building internal expertise in preparation for future standards-based work. As stated by diffusion researchers Fichman and Kemerer(1999), they are choosing to "create the option of... [using] the technology when the appropriate time has arrived."

GPI is one of the organizations that actively collaborate with industry standards-setting consortia to develop internal expertise. GPI receives electronic customer data from various sources(email, FAX, or by surface mail on CD-ROM), and a Java application converts it into XML templates developed internally. This process, known as "reskinning" in XML parlance,

homogenizes data for use by internal database, Knowledge Management, Enterprise Application Integration, and Enterprise Resource Planning systems. Once integrated into these corporate systems, the data is reskinned once again in formats best suited to the consumption needs of internal customers. The company's data acquisition, analysis, and dissemination processes are all reflected in the components of this proprietary application, making the actual code sensitive competitive information. This situation would not occur as readily with the use of sponsored or public specifications. The longer it takes for industry-standard specifications to emerge, the more difficult it will be for organizations to simply abandon their proprietary applications in favor of a new standard. Proprietary XML specifications become highly specific investments(Williamson 1984, Clemons et al. 1993) and increase risk to an organization (Clemons and Row 1992) since they cannot be easily deployed to other uses in different contexts.

Worldwide Insurance, the fourth participant in the study, is one of the largest and most influential members in the financial services and insurance industry. Worldwide has developed an XML-based data exchange application capable of providing real-time commercial insurance quotes to business partners. The application has been created in-house by a Worldwide wholly-owned subsidiary. The role and strategic positioning for the proprietary application and its capabilities are the subject of much debate at the company. Worldwide IT leaders are currently exploring the ramifications of maintaining tight control over the application versus becoming an open-source service center for the industry. The final strategic deployment of this proprietary specification will determine its specificity level (Williamson 1984) and the benefits to Worldwide Insurance of its internal expertise development efforts.

6. Discussion of Research Findings

Several important themes were easily observable despite the small sample of organizations participating in this study. The first is that a large amount of effort is being spent by organizations in building internal expertise with XML

technologies. The primary mechanism for acquiring this expertise is the development of proprietary XML applications. This investment may play a significant role in the adoption of industry standards later on, as companies attempt to protect their investments on systems that have been custom-made to handle their business processes. Software development, business process changes and disruptions, and organizational retraining all contribute to the costs of migrating from these proprietary specifications. Thus, organizations may be slow to embrace emerging industry specifications, delaying their adoption and the onset of positive network externalities.

Second, a lack of official industry-wide, or even transaction-specific, standards forces organizations to develop proprietary specifications to meet their particular needs. As noted before, protecting large investments in these proprietary systems, along with migration and business process change issues, may lead to slower market convergence on a single sponsored(or public) XML specification. Not surprisingly, sponsored specifications lead the way in the exchange of information between organizations. All four of the organizations interviewed for this study declared their preference for the simplification of development and support activities associated with standards. However, they view the confusing landscape of multiple sponsored specifications as promising, despite the current slow pace of adoption.

Lastly, it has become clear through the interviews that the balance of power between organizations is a factor worthy of deeper study. All of the companies mentioned in this paper cite an influential business partner's or their industry's collective decision to adopt a particular specification as critical in their own choice of applications. Influence of trading partners has been shown to be a significant factor in the adoption of technologies similar to XML, such as EDI(Bouchard 1991). Government influence is seen as important in regulated industries, but not as the decisive factor for adoption of any particular specification. Though the United States federal government is a major customer for two of these companies, IT leaders interviewed believe that free market forces will have the most influence in the determination of the dominant XML specification for their industries.

The research findings suggest further extension of classical

diffusion of innovation theory. As proposed by Fichman(1992), adoption factors and processes vary depending on technology(or innovation) type and the locus of innovation adoption and thus should be explained in each context where a particular innovation is adopted. This study indicates important factors in the case of organizational adoption of Type II technologies. The study implies that organizations attempt to lower knowledge barriers(by developing internal expertise) in expectation of their future adoption of industry-dominant XML specifications possibly forced by competitive environments. Also, the study suggests that organizations have intention to adopt major XML specifications used by major business partners or majority of their competitors. This discussion is in line with the characteristics(e.g., network externality) of Type II technologies with an organizational locus of adoption.

7. Conclusions

This study attempted to identify some important XML adoption patterns common to organizations in various industries through unstructured interviews with IT leaders of those organizations. Three meaningful patterns emerged from this exploratory type of study: standard development, customers/suppliers power, and internal expertise development. These findings may explain forces influencing the adoption of complex networked technology-based organizational innovation. The study shows the importance of competitive organizational environments as a driver of such type of innovation.

It must be noted that all of the participating organizations in this study are large corporations with sizable IT resources and budgets. Initial conversations were also held with a medium-sized company in the data networks and telecommunications industry regarding its use of XML technologies. The initial interview offered clues that companies with fewer resources prefer a wait-and-see approach to this problem. Data from this interview was not included in the main body of findings because of its preliminary nature, and due to the very different size of this organization with respect to the four companies highlighted in this article.

The results of this study suggest that additional empirical research would be fruitful. The interviews, while useful, do not adequately identify which variables play the most important roles in determining the success of XML specifications. For example, companies that distribute physical products may have different reasons for adopting specifications than companies that distribute information-based products. Suppliers of homogeneous(commodity) products, such as salt, stock quotes and, increasingly, personal computers, may have different motivation to adopt uniform specifications than suppliers of products that are more easily differentiable. Perhaps more importantly, a much larger sample of both industries and products is necessary to rigorously isolate these and any other individual variables affecting adoption of XML specifications.

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