

Web Services: A Strategic Analysis

by

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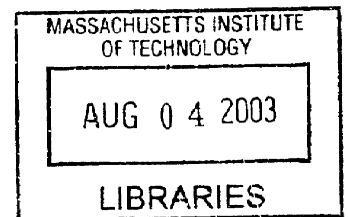
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Abstract

This thesis is an investigation of the strategic impact of Web Services on the firm. A literature review was conducted to gain a broad understanding of the research previously done on various related subjects. The core of this thesis is focused on looking at Web Services using time-tested, generally-accepted strategic management frameworks in order to better understand the true potential impact of Web Services.

Utilizing in-depth interviews with industry leaders, comprehensive knowledge of Web Services technology, and seminal academic research where appropriate, the author has attempted to derive the strategic implications of Web Services over a three- to five-year horizon.

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I would like to acknowledge and thank all individuals in the MIT community who have provided support during my tenure in Cambridge. My colleagues in the MOT program have enabled an excellent shared learning experience which has significantly shaped me professionally and personally. My thesis has been a very positive experience and has led to significant discovery thanks to the guidance offered by Dr. Michael Cusumano.

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Chapter 1: Introduction

Introduction

Web Services is an exciting new technology standard that enables communication between heterogeneous computer systems. Web Services emerged as a standard, commonly supported by Microsoft and IBM, only in the last 2 years. At its core, the technology is simply XML moving from one computer to another in a form that each computer can reliably process. The technology is not advanced in comparison to other, more sophisticated initiatives in information technology—such as artificial intelligence and encryption—but it is a significant improvement to traditional systems integration, and it does have significant implications for the firm. These implications affect the decisions relating to the boundaries of the firm, and the strategic position of the firm relative to others.

Web Services fundamentally alters the definition of the edge of the firm. Transactions that were previously more cost-effectively carried out within the boundaries of the firm may now be more appropriately executed outside of the firm. Proprietary integration among business partners is not new, but the types of businesses that have access to such integration will change with Web Services' adoption. The rapid growth of Cisco and Dell during the 1990s was partially attributed to tightly integrated supplier networks held together by integrated information systems. To integrate an entire supply chain onto one information technology infrastructure is a significant capital investment that can cost over \$100 million. Web Services lowers those costs of entry for such supply chain integrations by standardizing interconnectivity. For example, the Amazon Web Services developer kit can be downloaded at no cost and used to integrate a small online retailer with the power and sophistication of Amazon's technology platform in only a few hours. This thesis studies such effects of Web Services' on the firm's boundaries in light of established transaction cost theory. Using Ronald Coase's groundbreaking work on how transaction costs dictate the "Nature of the Firm," this study explores how Web Services may impact firm strategy due to changes in transaction costs.

Jobs

This thesis proposes that Web Services is such a significant enabling technology that its effects will be felt across verticals, markets, and firms. Web Services, like all enabling technologies, is no more important than the most important application enabled by it. Thus, communication of the exact potential and the exact strategic implications of the technology to specific firm contexts are difficult. The applications that leverage the enabling technology will be industry- or, potentially, firm-specific, and will not be obvious to the business manager simply by learning about Web Services, the technology. For example, Amazon.com has implemented a Web Services interface to its very rich content. The result is that Amazon.com is not only an e-retailer but also an e-retailing platform on which thousands of new e-retailers have started building complementary e-retailing solutions.¹ The strategic implications of this highly creative use of Web Services are profound. As demonstrated by the rapid growth in partners using Amazon.com Web Services developer kit, Web Services can and will continue to create modular products and services supported by an underlying platform. This thesis will thoroughly examine the relevant strategic issues associated with such modularity.

Due to its effects on firm boundaries, transaction costs, and the resulting strategic implications, Web Services will enable potentially disruptive business models and products in established industries, making it potentially disruptive to established industry leaders. To fully understand Web Services' role as a disruptive force, this thesis will also leverage seminal research in the area of disruptive technologies.

Beyond its role in changing the nature of the firm, Web Services is also a significant step towards larger and more collaborative inter-firm networks. By definition, a network is an interconnected or interrelated chain, group, or system.² The strategic implications of networks are numerous: networks fundamentally change technology diffusion patterns, economic rents of the first entrants into a market, and a customer's ability to change products. This thesis addresses the topic of network economics and how Web Services affects these economics.

Web Services provides common communication standards that allow the replacement of many, very small, proprietary networks with fewer, much larger standardized networks. The opportunities for communication on the Internet infrastructure are fundamentally changed by Web Services because a new class of

communication is possible on a large scale: application to application. Currently, the predominant types of communications on the Internet are person-to-computer and person-to-person. A person browsing web sites would be an example of person-to-computer communication. Two people exchanging e-mail would be an example of a person-to-person communication. Web Services facilitates, yet does not fully implement, the ability to expand computer-to-computer communication.

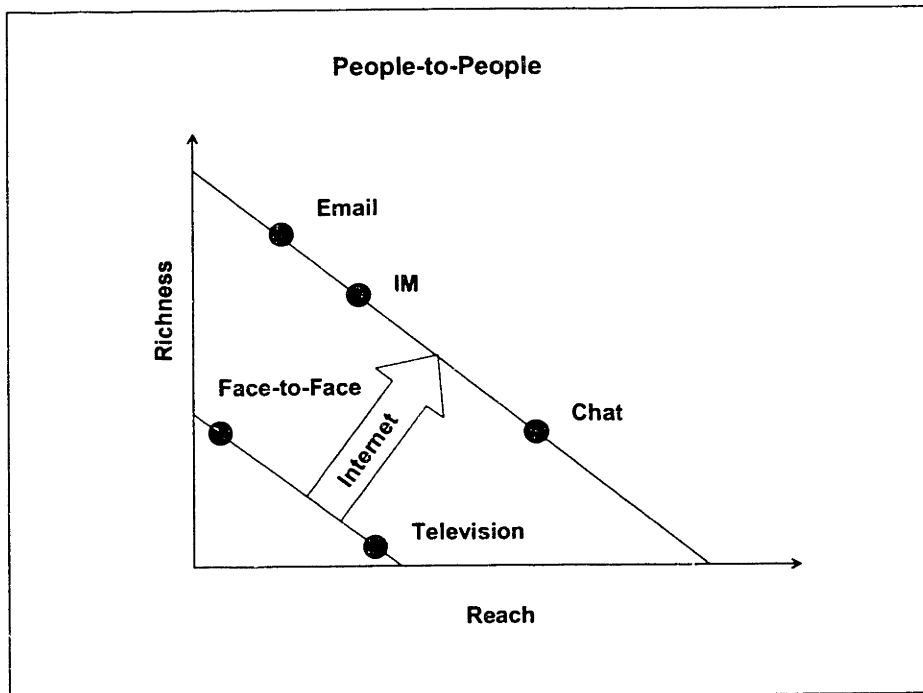


Figure 1.1 People-to-People Communications Range³

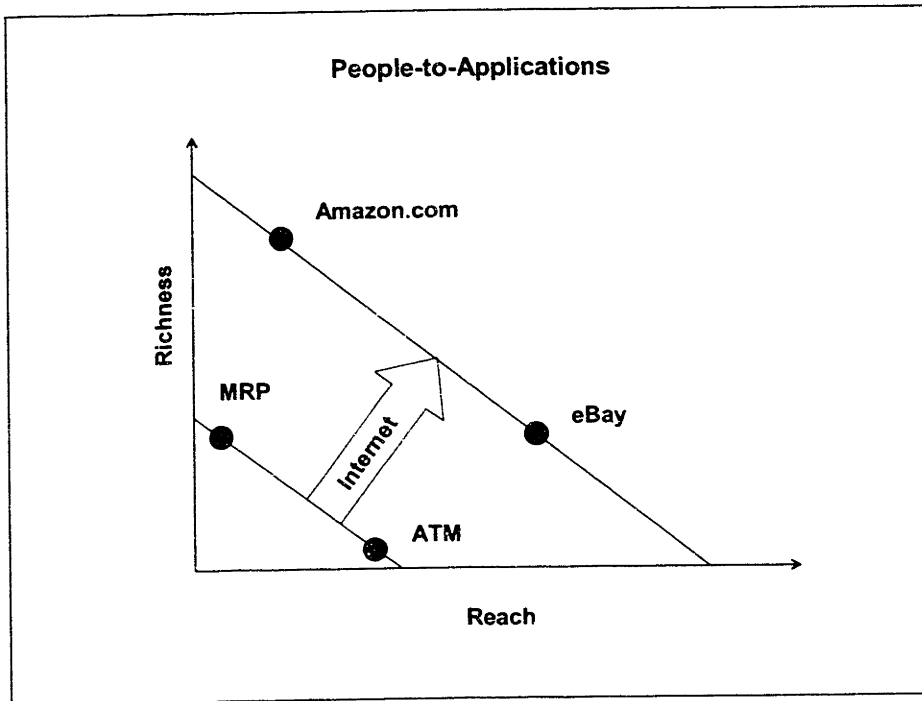


Figure 1.3 People-to-Applications Reach and Range⁴

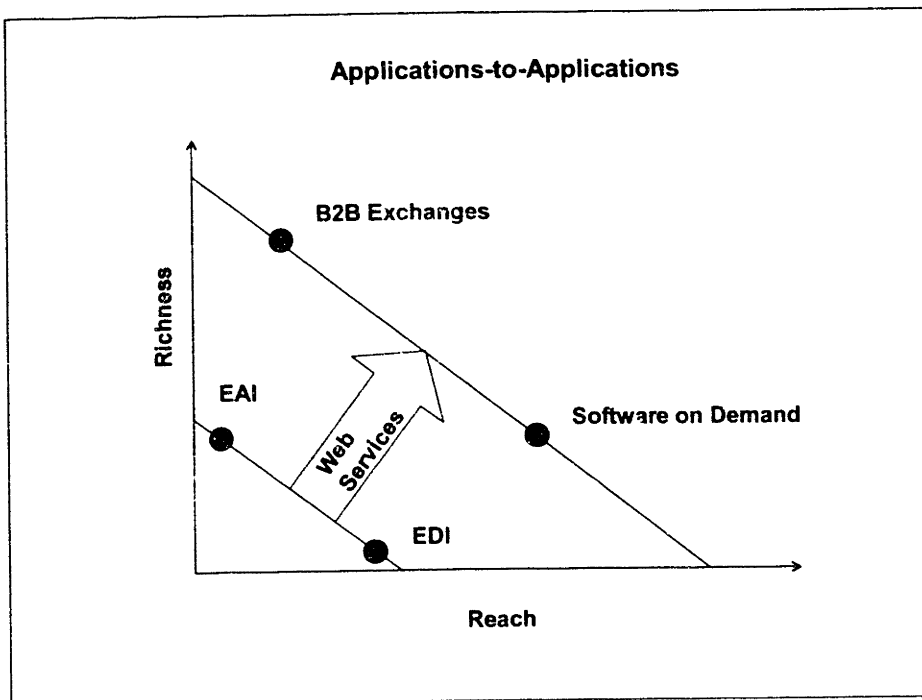


Figure 1.5 Computer to Computer Reach Range⁵

As denoted in the figures above, Web Services is a rare instance of a technology that achieves greater reach and range at the same time.

Motivation

This thesis was motivated by two shortcomings in the current, abundant material published on the strategy implications of Web Services: the tendency of that material to focus on outcomes, rather than on the forces that drive them, and the tendency to take a binary approach to the adoption of Web Services technology. This author believes that these shortcomings limit the business manager's ability to make relevant strategic choices in the face of Web Services because they advance more scripted strategic outcomes. The author intends to approach this review of Web Services in a way that highlights the forces Web Services can impact, and how Web Services can be incorporated into existing businesses in a gradual, non-disruptive, and strategic way.

Regarding focus on outcomes, there are quite a few Web Services strategy books that make specific and absolute claims about the exact implications of Web Services.⁶ One example of such far-reaching assertions, made by Mr. John Hagel in *Out of the Box*, is that of "unbundling and rebundling" the corporation. This theory argues that all firms will consolidate into a product innovation/commercialization, infrastructure management, or customer relationship focus.⁷ It is this author's belief that such predictions of exact results of Web Services do not serve the business decision-maker well; the chances of that exact prophecy playing out are relatively small. In contrast, this author argues that there is less uncertainty about the industry forces that Web Services amplifies, and that those forces are abstract enough that they exist across industries, even though these forces' impacts may, in fact, be different in specific industry settings. These forces are central to understanding the impact of Web Services, and they are driven by transaction costs, modularity, disruption, standardization, and network economics. This thesis will provide the business decision-maker with a review of the basics in the established body of knowledge regarding these amplified forces, thus enabling the business decision-maker to be better prepared to navigate his or her own business domain, given the entry of Web Services.

Regarding the current literature's apparent all-or-nothing approach to the adoption of this technology, this paper looks at Web Services as a continuous, enabling technology advancement that enhances current information technology assets, and can be implemented incrementally in a systematic way. One explanation for the more typical black-or-white perspective on adoption is that, in the desperation of the technology recession of the late 1990s and early 2000s, individuals claimed that Web Services was the next must-have in order to stimulate demand. This thesis will demonstrate that Web Services is, indeed, an essential part of a firm's technology and strategy portfolio, but it can be introduced in a systematic and non-disruptive way.

Assumptions

This thesis examines the strategic implications of Web Services. To accomplish this in a way that is thorough but still accessible, the author has defined the following assumptions as background to the overall story:

1. Web Services, when properly implemented, lowers transaction costs.
2. Web Services is a modular replacement for previously integrative data exchanges.
3. Web Services represents a potentially disruptive alternative to the established Enterprise Application Integration (EAI) industry.
4. Web Services is a standardization of what was previously a proprietary technology solution.
5. Web Services will increase the prevalence of network effects in the marketplace.

Web Services Affects Transaction Costs

The author has made the general assumption that, given critical mass of adoption, Web Services will have the net effect of reducing transaction costs. This assumption is not based on empirical data, but on the examination of the net effect of other, similar technology advancements, such as the World Wide Web (WWW) and its subsequent reduction in transaction costs.

Web Services Increases Modularity

The Web Services standards make great progress toward creating a standard interface between heterogeneous information stores. This standardization transforms what were previously integrative links in the value chain to modular links in the chain.

Web Services is a Potentially Disruptive Technology

Web Services is not assumed to be a disruptive technology. Instead, it is assumed to have the potential to be a disruptive technology, and is studied as such. An entire section (Chapter 4) is dedicated to deeper analysis of this topic.

Web Services Increases Standardization

Web Services is assumed to be a standardization of what was previously proprietary. The Web Services standards stack is not yet complete, and there are various significant holes in the overall technology which have yet to be standardized. The author assumes that yet-to-be-completed standards are due to the product's lack of maturity, and do not reflect the future of Web Services as a standards-based replacement to proprietary solutions. This assumption is based on historical patterns of standards adoption and advice from industry leaders regarding the future of Web Services.^{8,9}

Web Services Affect Value Chain Structure

The structure of the value chain within an industry has a significant impact on the structure of that industry. The most common and simple example would be an entirely integrated value chain versus an entirely disintegrated value chain: the difference in value chains feeds back to drive the industry structure. For example, a vertically integrated industry would have higher barriers to entry than a disintegrated industry that made greater use of suppliers.

The structure of a value chain is driven by the architecture of the industry's product, among other things. More modular product architectures lend themselves to a more modular value chain, while an integrated architecture will result in a more integrated value chain.

Web Services Affect Industry Structure

A firm's competitive strategy is rooted in the environment or industry in which that firm operates. The structure of the industry dictates the potential profits that can be earned by the firms in a particular industry and, subsequently, explains many of the motivations of the competing firms in an industry.¹⁰

Web Services Increase Network Effects

When widely adopted, Web Services will increase the network effects commonly seen in other information technology markets.

Resulting Key Strategy Questions

This thesis will use a well-established base of research to build on the above assumptions and to synthesize the current strategy literature in order to address some key strategy questions that Web Services forces modern-day management to consider. Specifically, this paper can help managers address the following strategic questions:

- How will value chains be structurally changed by Web Services?
- Will there be a change in the value captured in particular links of the chain?
- What does standardization mean to me, the business decision-maker?
- Could Web Services disrupt my firm's business model and associated revenues?
- What effects does Web Services have beyond cost reduction?

Structure and Methodology

Audience

This thesis is intended for a managerial audience in industries that have information exchange as a key value-add activity in its value chain. The author intends to discuss any technology-related material in a simple, straightforward language that does not assume previous programming experience or exposure to the Web Services standards.

Structure of Thesis

- **Introduction.** Introduces the thesis, the assumptions underlying the thesis, and the strategic questions that will be addressed.
- **Structure and Methodology.** Describes audience, structure, and methodology.
- **Transaction Costs.** Reviews the basics of transaction cost theory and how Web Services relates.
- **Modularity.** Reviews the previous research on modularity in product architecture and how this relates to Web Services.
- **Discontinuity and Disruption.** Reviews some of the seminal research in the field of disruptive technologies, and analyzes Web Services as a disruptive technology.
- **Standards.** Reviews some of the more recent research into standards and their effects on technology adoption and diffusion. Analyzes Web Services' strategic impact as a standard.
- **Network Economics.** Reviews the special economic forces at play in systems or markets that have high interconnectivity. Assuming that Web Services increases the prevalence of networked markets, the potential resulting impact is discussed.
- **Recommendations and Conclusions**
- **Bibliography**
- **Appendices**

Methodology

Secondary Research

The majority of the data used in this thesis is in the form of secondary research. The primary sources for this secondary research are journal articles and books for the business management audience.

Primary Research

In-depth interviews were conducted with three industry leaders. The interviews lasted between 30 and 90 minutes and covered different scenarios for Web Service

diffusion and the resulting effects on value chain and industry structure. Interview respondents were chosen for their depth of knowledge of the Web Services standards and their experience. IBM Corporation and Microsoft Corporation were targeted due to their position as leaders in the technology industry, and Amazon.com was chosen due to its recently introduced Web Services integration solution.

Date	Respondent	Company	Title
2/18/2003	Mr. Colin Bryar	Amazon.com	Dir. Associates Program
2/28/2003	Mr. Cliff Reeves	Microsoft Corporation	Director .NET Strategy
2/28/2003	Mr. Bob Sutor	IBM Corporation	Director of Web Services
4/1/2003	Mr. John O'Donnell	Cisco Systems, INC.	Manager, Business Development

Table 1.1 In-Depth Interview

Chapter 2: The Nature of the Firm

Introduction

As a technology standard, Web Services is a very useful aide to the execution of transactions that have an informational component. Take, for example, the role of Web Services in a typical supply chain: Web Services may be used to update a retailer's current inventory of a product supplied by a given distributor, thus spawning a delivery by that distributor. Alternatively, that same transaction could be addressed manually, with someone contacting the distributor either by phone or facsimile. On the surface, the difference between the methods for completing this transaction would simply be a cost optimization. However, the economic research behind transaction cost theory leads us to a much more leveraged proposition: the difference in the costs associated with the two different transaction methods actually determines the size of the firm and what the firm does internally versus externally.

In order to cut through the hype surrounding Web Services and to better understand the underlying, real meaning of Web Services' impact on commerce, this chapter will look at Web Services using the perspective of transaction cost theory. In particular, *The Nature of the Firm*, by Nobel Prize winning economist Ronald Coase, provides an excellent lens through which to examine Web Services at the most fundamental of levels.

Types of Transaction Costs

Transaction costs are of six general types: search, information, bargaining, decision, policing, and enforcement.¹¹ Below is a brief description of each type of cost, along with the highly relevant elements of Web Services which could significantly change it:

- **Search costs.** Costs incurred by buyers and sellers finding each other inside the increasingly broad and disorganized open market. The Universal Discovery, Description, and Integration (UDDI) part of the Web Services architecture would, if widely adopted, fundamentally change those costs associated with searching.
- **Information costs.** For buyers, costs incurred learning about the products and services of sellers and the basis for their cost, profit margins, and quality; for

sellers, costs incurred learning about the legitimacy, financial condition, and need (which may lead to a higher or lower price) of the buyer. Expanded versions of UDDI currently under standards review would provide the capacity for Web Services to provide significant, meaningful information about a given product or service, thus reducing its informational costs.

- **Bargaining costs.** Costs incurred by buyers and sellers setting the terms of a sale or contract for services, which might include meetings, phone calls, letters, faxes, e-mails, exchanges of technical data, brochures, entertainment, and the legal costs of contract negotiations.
- **Decision costs.** For buyers, costs incurred evaluating the terms of the seller compared with other potential sellers, and the internal processes, such as purchasing approval, designed to ensure that purchases meet the policies of the organization. For sellers, costs incurred evaluating whether to sell to one buyer instead of another buyer, or not at all.

Regarding bargaining and decision costs mentioned above, the Rule Markup Language (RML) currently under development by the W3C is focused on providing the contractual negotiations among electronic agents, and would affect bargaining and decision costs if adopted. This is not part of the Web Services standard, but could potentially be used in a Web Services architecture.¹²

- **Policing costs.** Costs incurred by buyers and sellers taking steps to ensure that the goods or services and the terms under which the sale was made—which have been ambiguous or even unstated—are, in fact, translated into the actual goods and services exchanged.
- **Enforcement costs.** Costs incurred by buyers and sellers in ensuring that unsatisfied terms are remedied. This could range from mutual agreement on a discount or other penalties, to the often high cost of litigation.

Please note, currently there is only discussion of the need for standards and associated technology implementations to address the policing and enforcement costs.

Web Service Networks

Simply because current Web Services standards do not directly address a particular transaction cost does not mean that that cost can not be reduced via Web Services in combination with a Web Services Network (WSN). A Web Services Network provides additional services that are not currently standard. Over time, the proprietary aspects of WSNs that supplement Web Services standards will likely yield to network effects of larger networks that are driven exclusively by open standards.

To illustrate that evolution, a parallel can be drawn between Web Services today and the proprietary online communities that predated the universal acceptance of the World Wide Web. Prior to the standardization of the content (HTML) and transmission (HTTP), there were several proprietary online offerings, such as CompuServe®, AOL® and Prodigy®. Each of these proprietary online content services mitigated the lack of functionality available in a widely-adopted standard by providing proprietary extensions. Once the functionality required by the user has been met by a standards-based technology, the market migrates to that standard technology, assuming switching costs are not prohibitive.

As shown in the figure below, a market for Web Service Networks (WSNs) will exist until the general requirements for Web Services exceeds what is available in the Web Services standards. The WSN will supplement the existing standards with proprietary add-ons in order to fill the gap between the current standards and the requirements of the market. However, as soon as the Web Services standards have met or exceeded the general requirements of the market, the opportunity for WSNs will be greatly diminished.

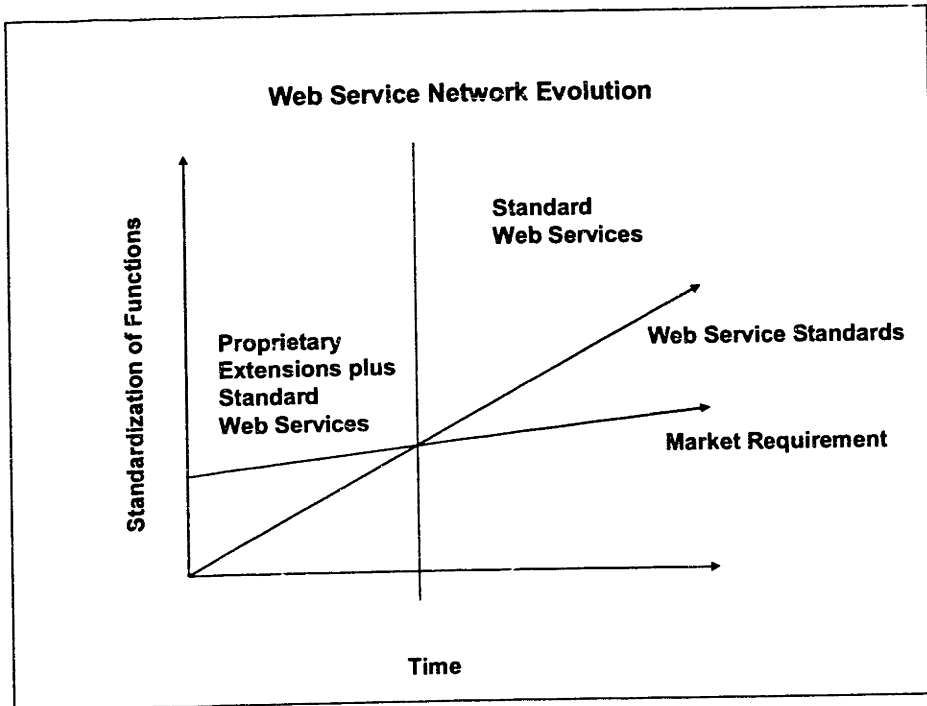


Figure 3.1 Web Service Network Evolution

If this framework is applied to Web Services, it is apparent that the proprietary WSNs will be replaced by standard Web Services at some point in the future.

Strategic Implications

Transaction costs are integrated into a firm when the internal cost of exchange is less than the external cost of exchange.¹³ Figure 3.2 shows two different firms, one with automated transactions, the other with the same transactions performed manually.

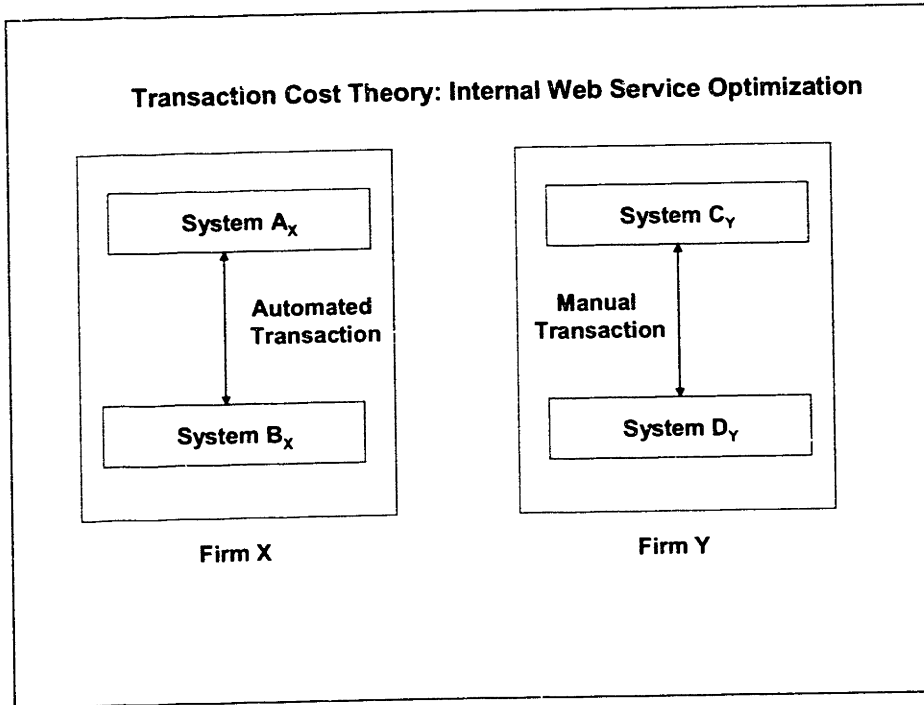


Figure 3.3 Transaction Cost Theory: Two Firm Example

Looking at two firms where all else is equal except for the efficiency of transactions between two business critical systems, some assumptions can be made regarding firm size. As reflected in Figure 3.2, Firm X would, on average, find more transactions that are cheaper to execute internally than would Firm Y. The result would be that Firm X would be a larger firm than Firm Y. However, as a firm grows, there is a limiting negative feedback: bureaucracy.¹⁴ At some point, the additional bureaucracy of Firm X's larger size would outweigh the transaction cost benefits of internalizing given transactions.

A majority of the transaction costs are associated with open-market transactions or transactions that cross the firm boundary. Web Services is a technology that focuses not only on internal systems integration, but also on inter-firm integration, thus lowering

the transaction costs associated with inter-firm transactions. Using the basics of transaction cost theory allows us to project the potential impact on firm size assuming that Web Services is a transaction cost reducing force for inter-firm transactions. If all else were equal, firms would shrink in size because reduced transaction costs associated with inter-firm transactions would increase the relative attractiveness of external options relative to internal options.

However, all things are not equal: the current state of the Web Services standard lacks universal meaning for the data exchanged. Firms are better positioned to provide such universal meaning within firm boundaries than outside of firm boundaries. Therefore, the resulting effect of Web Services on transactions costs prior to standardization of the semantics of data exchanged is that it lowers transactions costs more internally than it does externally. Transaction cost theory leads us to believe that the initial impact of Web Services may be to increase the size of large firms, rather than to reduce their size, as has been widely speculated in the popular business press.¹⁵

Example Case – Cisco Systems, INC.

The explosive growth and unique organizational structure of Cisco Systems highlight the profound strategic impact transaction cost changes can have on the nature of the firm. Cisco is the world's largest supplier of network infrastructure equipment and for a brief time was also the world's largest firm by market capitalization. The term used in Cisco to describe their structure is Networked Virtual Organization.¹⁶ At the heart of the networked virtual organization is use of inter-firm data communications in order to lower transaction costs. For example, visibility of the status of orders exists all the way from Cisco through tier one, tier two and tier three suppliers. With the lower transaction costs Cisco has been able to use partners for various core manufacturing and distribution functions.

The case of Cisco provides a valuable lesson regarding web services, transaction costs and the nature of the firm. Cisco doesn't limit their strategic use of lower transaction costs via inter-firm integration to only cost savings. Instead, Cisco uses the reduced transaction costs relative to competitors to radically change the nature of the firm. Cisco is a large manufacturing firm with the balance sheet of a much smaller, more agile

firm due to the ecosystem of partners which are pulled together in order to bring product to market. This ecosystem the firms which make up the networked virtual organization would not be possible without the integration between the different players.¹⁷

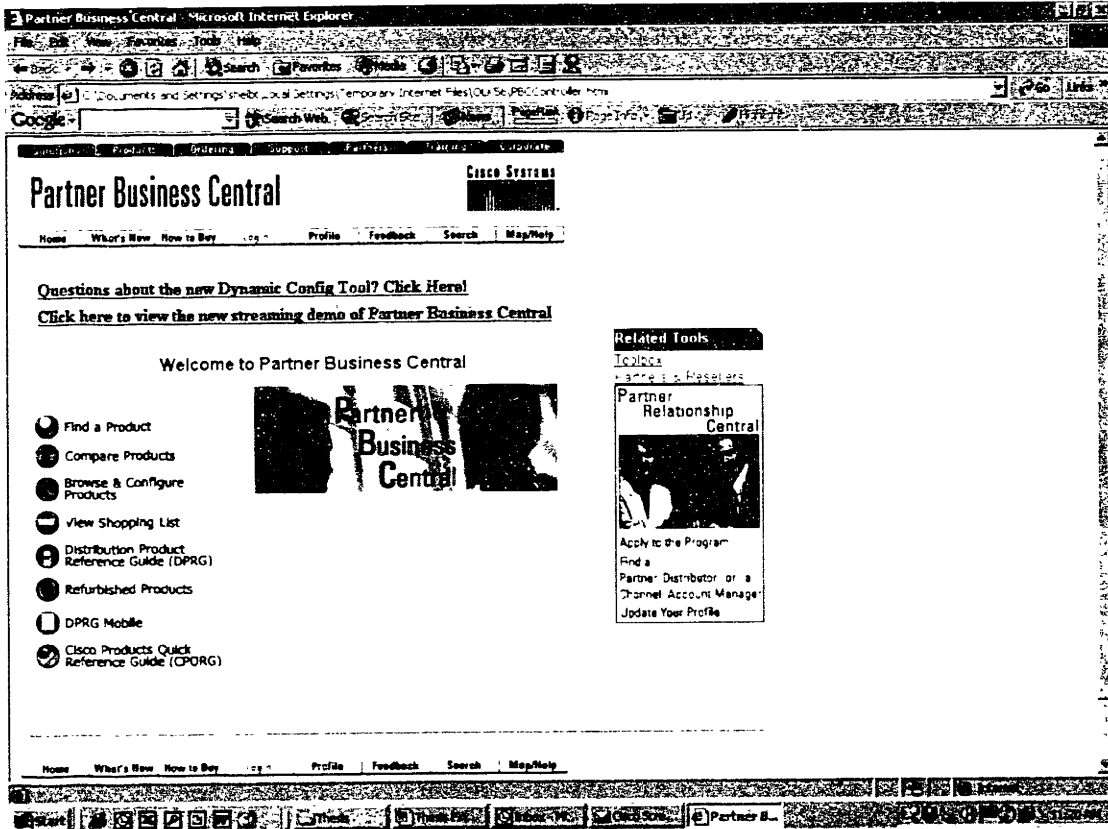


Figure 3.5 Cisco Partner Business Extranet

Chapter 3: Modularity

Introduction

Web Services is a step down the path toward modularized business relationships. As such, it is important to utilize the established research on modularity and its effects on value chains and industry structure. The business leader must understand one key point about modularity: all else equal, a modular product will be easier to maintain and upgrade at less cost than an integrated product. **Web Services is modular software.** Web Services is poised to deliver where its predecessors, Object-oriented and Component software, failed. As a testament to Web Services' strength in modularity, some systems that have no need to interact with external systems are being modified to make use of Web Services simply to take advantage of this greater modularity.¹⁸

Modularity Defined

For the purposes of this thesis, modularity is defined as the building of a complex product or process from smaller subsystems that can be designed independently yet function together as a whole. A modular system is based on two different design rules: visible or public, and hidden or private. Visible design rules fall into the following three categories: architecture, interfaces, and standards.¹⁹

1. **Architecture.** High-level blue print that defines what modules are part of the more complex system, and what role each module will play. The architecture of a personal computer defines that a hard drive, CPU, motherboard, display device, and keyboard are all brought together as modules.
2. **Interfaces.** Detailed definition of the public elements of the module which will be connected to other modules. Modules interact with each other only at each module's interface. The most obvious example of an interface standard is that of electrical power. Manufacturers of electronics meet the standard for the electric plug and the product can then interface with an outlet and get power.
3. **Standards.** For testing a module's conformity. The automobile industry has standards for testing of a vehicle against such metrics as miles per gallon and time from start to 60mph (miles per hour).

As a design principle, modularity is equally significant to physical products, software products, and information flows. The increasing complexity of software finally forced across-the-board adoption of modular software design, or object-oriented software. Object-oriented software is the default software architecture for all new software written. Prior to object-oriented software, programmers would have the choice of writing a program that was either modular or integrative. Object-oriented software enforces a modular architecture. The most popular object-oriented software languages are Java[®], C++, C#[®] (C sharp), and Smalltalk. A modular architecture flow would define the data that needs to be handed to other modules in the system.

Web Services as Software Modularity

If nothing else, Web Services is one of the most significant advancements in the modularization of software that has ever taken place. As reflected in figure 4.1, software has been progressing towards greater and greater modularity over the past 15 years. Web Services represents a large leap forward on the path toward highly modularized software, in that it is the first successful effort to move the proprietary interfaces and coupled integrated architectures behind a standard modular interface.

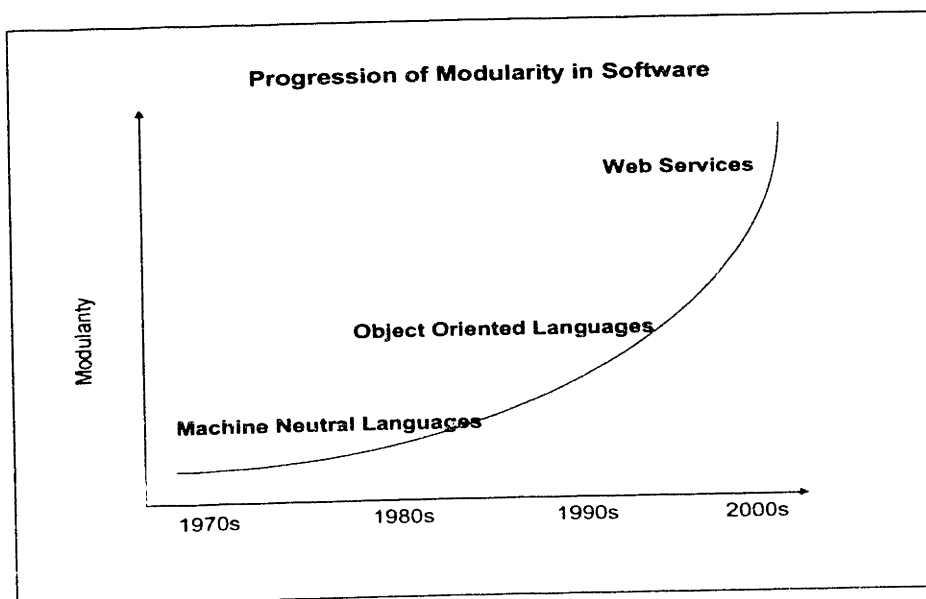


Figure 4.1 Progression of Modularity in Software 1970s - Present

To date, software has remained more integrated, rather than modular, as a product solution, and for good reason: modularity is not free; it can only exist in situations where the technology performance exceeds the general performance requirements of the market against vital performance metrics. Modular architectures are not as efficient as integrated architectures against these performance metrics. A common criticism of the Web Services architecture is based on the overhead inherent in parsing the XML on either side of a transaction and the bloated size of XML messages. An alternative integrated architecture that moved proprietary binary messages between applications across the wire would perform much faster than a modular architecture. In general, access to the implementation details of each component allows for optimizations and shortcuts among integrated components. The net result of such an integrated architecture is that it is harder and more expensive to maintain, more rigid and less robust when changed, and, finally, more expensive to manufacture. As long as the market demand for speed exceeds the technology's capacity, there will be no acceptance in the marketplace for the slower-performing modular Web Services architecture.

Understanding the strategic implications of this relationship and its ramifications is essential. The winner of various high-stakes, competitive commercial battles will be the firm that times its switch from the integrated to the modular architecture to occur while their competition sticks with the integrated architecture. For technology products, if the technology capacity is well in excess of the market requirements, the firm with the modular architecture is going to be able to produce the product with greater flexibility in manufacturing and with less cost.

These same principals hold true when this framework is applied to Web Services and information flows: if two competing firms both have information flows between systems, partners, and customers, the firm with the more modular architecture for that information flow will be at a competitive advantage over the firm with an integrated information and data flow.

Rate of Innovation

Modularity increases innovation.²⁰ The increased innovation is enabled by a reduction in the interdependencies in the overall system, limited to the interfaces of the components. Therefore, change and, subsequently, innovation is free to continue within each individual module as long as the visible interface of that component is not changed. Another force contributing to an increased rate of innovation is that companies are able to more easily focus on select modules. For example, a start-up with a deep, yet narrow, core competency can focus on innovation in a particular module of the overall system. The disk drive industry reflects how an entire industry has focused on one module of a larger system.²¹

Value Chain

Modularity significantly changes the role of suppliers;²² the opportunity to add value is increased across all links of the supply chain. In general, suppliers need to move from the mindset of supplying low value-adding supplies to higher value-add modules. As in the case of airplane engines—modules in the airplane system—the value capture can be equal to or greater than the system in which the module exists. Modularity changes the traditional supply chain, in which materials are brought to a central location for an integrated product build process, to a less integrative, assembly-based supply chain in which modular components are supplied to a central location for assembly. By delegating the manufacturing process to many separate suppliers, each supplier has the opportunity to add greater value by innovating on their particular module. At the same time, the assembler gains significant flexibility and cost reduction by not having to take on the fixed costs required to support each module.

Industry Structure

Examining what invention exactly is will be useful to discussing and understanding the effect of a modular product architecture on industry structure. This thesis assumes the following definition of invention: inventions combine components—whether simple objects, particular practices, or steps in a process—in new and useful ways.²³ Inventions or new products can, therefore, be a new assembly of previously

existing components or modules, or invention can require whole new modules. The latter example would be a more complex integrative invention.

Products based on highly modular innovation make it difficult to maintain competitive advantage because the ease of copying the component technologies lowers the barriers to entry. In general terms, modular design tends to result in incremental product improvements rather than important advances. In contrast, products that have a more integrated or coupled design have a higher risk for failure, but create a higher barrier to entry if successful.²⁴

Strategic Implications

The strategic implication of Web Services is not simply that software is now more modular. If information is a significant part of a firm's assets, then that firm is now more modular. Web Services makes the entire business modular. The basic "pros and cons" of modularity are described below:

Architecture Type	Barrier to Entry	Benefits	Drawbacks	Implications
Modular	High	Components can be mixed and matched easily. Design costs can be minimized through reuse. Distributed development is safer. Stability and reliability.	Easier to copy. High risk of IP appropriation. Tougher to differentiate. Competitive business landscape is more complex. Lower performance.	Provide adequate IP protection and/or complementary capabilities. Compete as system architect.
Coupled	Low	Difficult for competitors to imitate.	Higher risk in success.	Require more centralized manufacturing

Table 4.1 Benefits and Drawbacks of Modular Architecture²⁵

Modularity can change the entire competitive landscape by de-integrating the industry. Early in an industry's evolution, few firms control all or a majority of the components of which a product is comprised. As the industry matures, the product designs become more modular and, subsequently, the industry de-integrates into a larger number of firms, each of which contributes one or more components to the final product.²⁶

The competitive landscape of modular products often falls into two distinct camps: the platform, and complementary products that leverage the platform. It is the goal of more and more firms to control the platform.²⁷ However, managing a platform and providing the leadership necessary to enable that platform's user base to grow while orchestrating the innovation of complementary products is a very different strategic landscape from that of non-platform based, integrative products. Annabelle Gawer and Michael Cusumano present a case-based examination of the different levers involved in effective platform leadership, and how several high-profile platform leaders compare. The four levers in the framework used to analyze a firm's platform strategy are: Scope of the Firm, Product Technology, Relationships with External Complementary Product Firms, and Internal Organization.²⁸

Example Case – Amazon.com

To further understand how Web Services leads to such strategic considerations I have chosen to examine Amazon.com's Web Services initiative using the platform leadership framework. Amazon presents us with an excellent of this modularity applied. Amazon, through the use of Web Services, has modularized their product so that it can be fit into multiple stages of the electronic retailing value chain. Amazon sits as a front end for the products of other retailers, most notably Target. Amazon is the customer-facing and fulfillment engine for other products purchased at Amazon.com. And, finally, Amazon is a fulfillment service for many smaller, specialized electronic retailers with the emergence of their Web Services developers' kit.

- **Scope of the Firm.** Amazon has not yet considered how the conflict between Amazon acting as a complimentary products competitor and platform leader may affect the trust placed in Amazon as a platform leader. The current agreement that a complementary product company signs leaves Amazon in control. Time will tell, but at this point Amazon is not looking to limit the scope of the firm in order to stimulate the network.²⁹
- **Product Technology.** Amazon has done an excellent job managing the technical aspects of the platform. It has made the most complex aspects of the platform

visible and accessible to the complementary platform providers. The value-add information regarding a customer's purchasing history and cross-sell opportunities are all made available on the platform via an easy to access Web Services interface.

- **Relationships with External Complementary Product Firms.** Amazon is managing its relationships with the complementary product companies through a contract that all complementary product companies must sign on to. Additionally, there is effort being exerted by Amazon to create a better development environment for the complementary product firms. Amazon is making a sincere effort to partner with and encourage innovation in the complementary product market.³⁰
- **Internal Organization.** Amazon is managing its Web Services from its partner business unit. This business unit has traditionally managed relationships with all partners that brought business to Amazon.com. No clear "Chinese Wall" is in the firm to communicate a separation of the platform management issues from the elements of Amazon that compete in the complementary products market.

In summary, Amazon has not entirely committed to the role of platform leader. The initial data regarding "Scope of the Firm" and "Internal Organization:" leads this author to believe that Amazon is not really committed to growing the platform if doing so implies any real sacrifice to their complementary product, Amazon.com. However, at the same time, the amount and quality of the information exposed from the platform to the complementary product firms is impressive and enough to build high-quality online retail sites.

Chapter 4: Discontinuity and Disruption

Technology S-Curves

Introduction

The technology S-curve theory is the most cited theory for a graduate student of technology management at MIT. At the same time, Web Services is often referred to as a disruptive technology. The author has chosen to examine Web Services through the very sharp lens provided by the established body of knowledge on disruptive technologies in order to explore any potential strategic implications.

Technology S-Curve Defined

The technology S-curve theory postulates that all technologies evolve in a similar way. By plotting a dimension of performance against the cumulative effort expended to achieve that performance, the resulting graph appears in the form of an “S”, as shown below in Figure 5.1. Effort is the preferred and appropriate dimension against which to measure performance, and is not equivalent to time. Effort can be managed and is, therefore, more powerful to the business decision maker.³¹

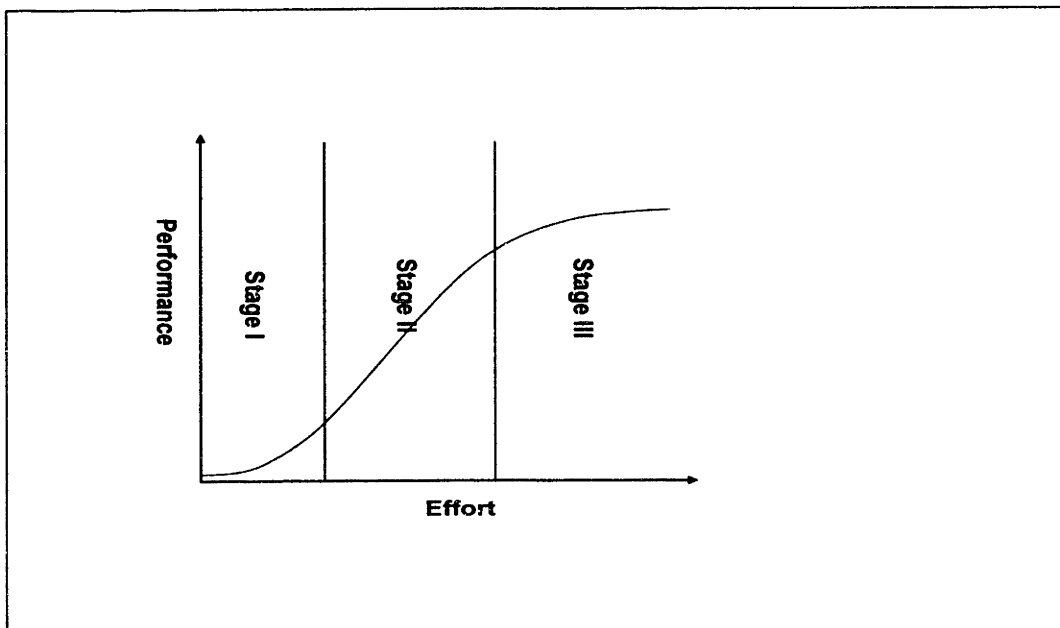


Figure 5.1 Stages of Technology S-Curve³²

System Dynamics is a method for studying the world around us which was pioneered by Jay Forester at MIT. The central concept to system dynamics is to understand how all the objects in a system interact with one another. Viewed through a System Dynamics lens, S-shaped growth behavior is the result of a system that is initially dominated by positive feedback and then makes a non-linear shift to a being dominated by negative feedback.³³ The technology S-curve is composed of three stages:

- **Stage I.** Stage I of the technology development has a relatively high level of effort per unit of performance improvement. The low slope of the line at this stage is assumed to be the result of inexperience. In addition, materials might be used in a different way, or, possibly, the architecture of the underlying technology is new. It is intuitive that the early stages of any new technology require relatively high effort to result in incremental increases in performance.
- **Stage II.** In Stage II of technology development, the system demonstrates improved performance per unit of effort. The slope of the line is now above 1. Again, this change in behavior is intuitive. The experience of those developing the technology has probably grown. In addition, the economies of scale in the production process could also explain a shift in the slope of the technology S-curve.
- **Stage III.** Finally, in Stage III, there is an assumed point where there are diminishing returns, as shown by the decreasing slope of the line. The marginal effort required for each increase in marginal performance becomes greater and greater. The behavior of the system at this point is assumed to be hitting the physical limits of the technology. In the case of some technologies, such as fiber optics, it is accepted that the speed of light is a physical limitation which no amount of effort is going to accelerate. However, in the case of various other technologies, limitation resulting from the laws of nature is not as prevalent.

Firm Level Analysis

Some of the earliest contributions to S-curve analysis came from the corporate research and development community. Early literature was intended to simply assist in

optimizing research and development investment. That literature put forth an essential lesson: anyone managing technology investment must understand that not all effort (investment) is equal. Depending on where a technology is on its S-curve, marginal effort will yield very different performance returns. At the firm level, plotting the S-curves of different technology initiatives is an excellent way to focus limited resources where they can have the largest impact.³⁴

An typical example of how the S-curve is applied in modern-day software development would be its use in understanding when the returns start to diminish for optimization effort. Once all the “low hanging fruit” has been harvested, additional man hours of effort invested in optimizing the software for performance will yield less and less performance improvement. At this point of diminishing returns, it is logical to look to other performance-improving alternatives, such as additional hardware.

Strategic Implication—Discontinuities and Disruption

The strategic implication of a technology S-curve discontinuity is enormous. In 1986, Richard Foster brought the analysis of S-curves from simple optimizations to the strategic realm by discussing discontinuities between S-curves. The gap between two or more S-curves is called discontinuity, illustrated in Figure 5.2. Post Foster, the strategic literature of S-curves moved from the analysis of one S-curve to that of multiple S-curves. The fact that multiple technologies compete for the same market, each with a different S-curve, makes for a very uncertain strategic environment.³⁵

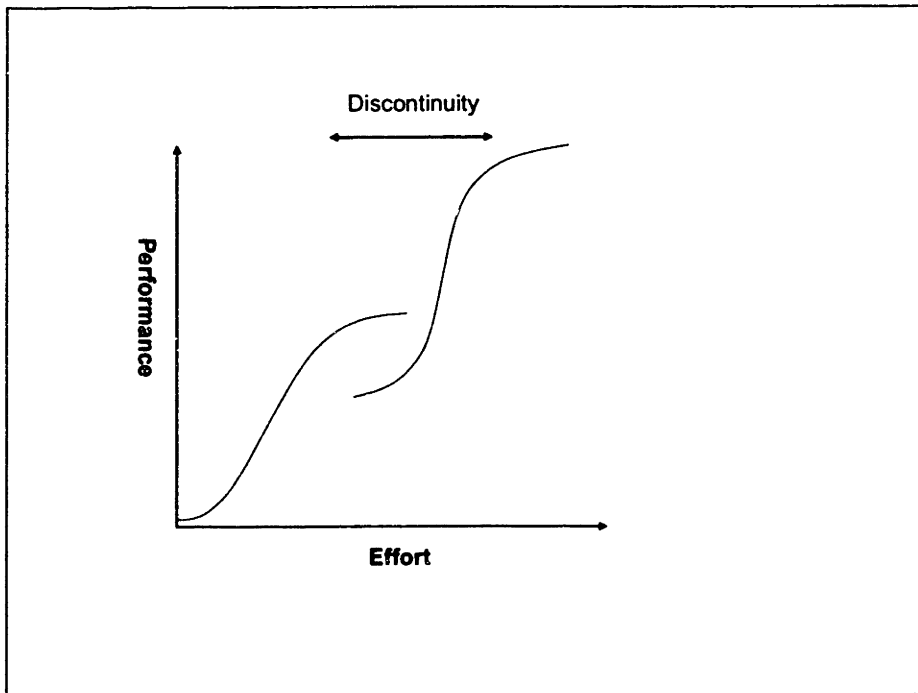


Figure 5.3 Technology S-Curve Discontinuity³⁶

The strategic implications of which S-curve a company ties its future revenue can explain a great deal about the successes and failures of corporations over the last century.³⁷ Analogue versus digital, vinyl albums versus compact discs, and luxury liners versus airplanes are all examples of the effect that a discontinuous technology can have on an industry. The impact can be immediate. Most recently, Polaroid Corporation entered bankruptcy, most likely due to a discontinuity of technology S-curves underlying its core product line. A greater understanding of S-curve technology discontinuities and their potentially terminal effects has brought greater strategic focus to the technology aspects of a firm.

Efficient vs. Effective Emphasis

Discontinuous technology S-curves split the field of technology management into two camps: efficient and effective.³⁸

Efficient technology management limits the scope of available technologies to one. Its purpose is to maximize efficiency in order to quickly move up the S-curve of a given technology ahead of the competition. Efficiency-based innovation is also called

“sustaining” or “incremental.” In an industry where technology is not a competitive differentiator, an efficient technology management scope is entirely satisfactory and may even be appropriate.

Effective technology management emphasizes in **which** technology S-curve the company is investing. As demonstrated by Figure 5.3, if a firm chooses a technology that reaches a stage of diminishing returns prior to a competing technology, the difference in performance may be substantial. Effective technology management can mean that a portfolio of technologies is supported in order to reduce the risk of choosing the incorrect technology.

Core Competence or Core Rigidity

Technology S-curve discontinuities, and the fatal end to those firms that cannot effectively transition to the new technology S-curve, shed a more critical light on a firm's core competence. A firm whose core competence is coupled with a particular technology would have the most difficulty transitioning to a new technology.³⁹ Kodak is an excellent example of a core competence quickly becoming a core rigidity in the face of a technology S-curve discontinuity. The Kodak company culture and core expertise has been based squarely on chemical-based technologies. In the face of digital photography technology, they have struggled to make the transition to the new technology S-curve, the digital photography technology S-curve.

Disruptive vs. Non-Disruptive Patterns

The most recent literature on technology S-curve discontinuity focuses on patterns that emerge among the nature of a technology, the market it services, and the resulting impact on the value chain. A new technology is deemed to be disruptive if the current industry leaders are unable to migrate to the new technology S-curve, subsequently losing their position as market leaders.

Components vs. Architectural

The work of Rebecca Henderson and Clayton Christensen provides valuable guidance in different types of technology discontinuities, and how they relate to a disruption of the current industry leaders. When viewing new technologies along the dimensions of new component technology or new architectural technology, a pattern

emerges regarding the current industry leaders' ability to migrate to the new technology S-curve. The industry leaders are able to migrate to the new component technology, thus missing any major disruption.⁴⁰ (See Figure 5.3)

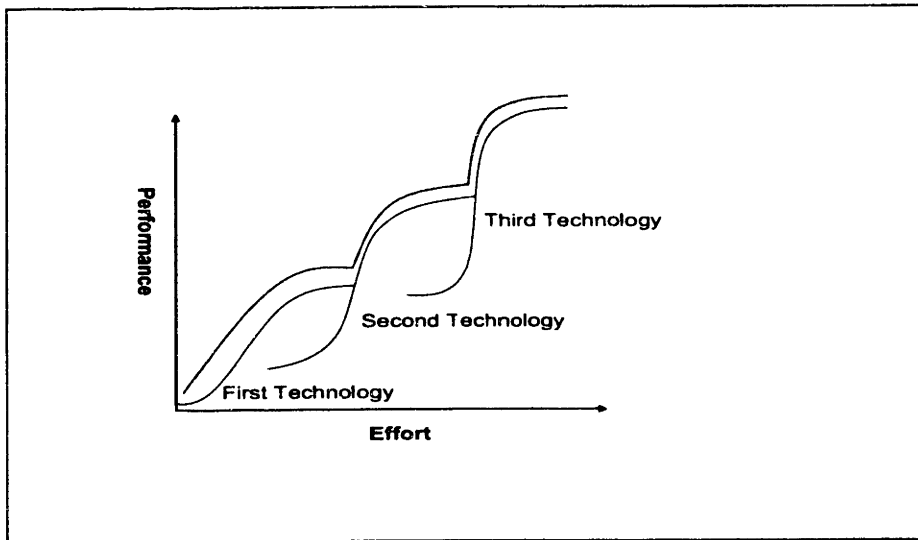


Figure 5.5 Multiple Technology S-Curve Disruptions⁴¹

The leading firms' lack of success in migrating to new architectural innovations does cause a disruption in the industry leadership.⁴² The explanation for this failure is compelling: the nature of the game has shifted, or, in the language of technology S-curves, the Y-axis has changed to a new dimension of performance. Where speed may have been the performance measure by which competition had been focused, a new architecture may shift the performance attribute of competition to size (See Figure 5.4). This shift in the nature of competition may likely go unnoticed to the industry leaders because, initially, the new technology architecture may appear to be in a different product category altogether. Eventually, the requirements of the original market converge with the new market, causing the disruption. The classic example is that of the personal computer first entering the market as a low-cost, low-performance tool for non-business activities. Later, new performance metrics that were exclusive to the personal computer, such as size and graphics ability, became the new dominant performance measures. The rules had changed, the architecture had changed, and the disruption of industry leaders followed.

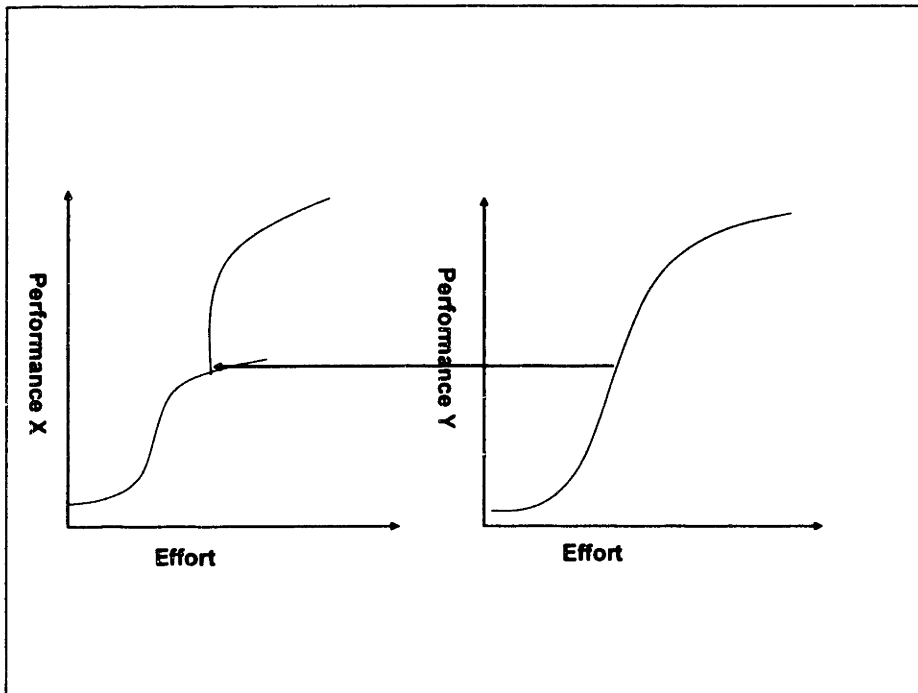


Figure 5.7 Point of Disruption Between Technologies

Disruption as it Relates to Value Chain

In Christensen's oft-cited *The Innovator's Dilemma*, the literature regarding patterns of disruptions is extended to include consideration of where the disruptive technology is introduced to the market, at what price, and at what level of performance relative to the standard technology. The model for disruption offered is a case in which an architectural discontinuity occurs and initially arrives to the marketplace with inferior performance and a lower price point. Eventually, this "inferior" technology's S-curve intersects with the technology requirements of the majority of the market, and there is a discontinuity as the new technology overtakes the old.⁴³ The arguments put forth by Christensen do extend the body of knowledge of S-curves, discontinuities, and patterns of disruption, but make a one-size-fits-all assumption; even though the attack-from-below disruption does take place, it doesn't account for all stories of industries being disrupted by technology S-curve discontinuities.

Unknown S-Curve Shape

The obvious weakness of S-curve theory to date is that there is no accurate way to predict the shape of a technology S-curve. To forecast the shape of a technology's S-curve, one would have to correctly predict all third-party enabling technologies, the true limit of the laws of nature, and the effort that would need to be invested across an entire set of industries. In the best case scenario, someone could identify a technology as being in Stage I with an estimate regarding when it would move to Stage II. To predict effort alone would be sufficiently difficult, since it will be highly correlated to the financial returns derived from the technology.

Foster's original work on technology S-curve analysis provided a framework for breaking down discontinuities into easily-predicted managerial exercises. However, those exercises were no more or no less correct than a present value calculation. Unfortunately, it depends on a manager's accurate knowledge of uncertain future events, such as potential alternatives to the firm's technology, future technical drivers of customer value, and true limits to the firm's existing technologies. Understandably, an analysis based on such uncertain information is not of great value. Foster proposes a simple 10-step guide to infer whether the competition may be operating on a superior technology S-curve. This paper uses this guide when looking at the strategic relevance of Web Services as a potential disruptive technology.

Organizational Architecture

Given the difficulties in defining the future of technologies, it is fair to assume industry leaders would be interested in optimizing their current firm structure to quickly migrate from one technology S-curve to another, thus avoiding a potential disruption of profits. The literature does not offer a consistent organizational structure to provide such agility. A case is made that only separate, autonomous business units sized to the market they serve are appropriate.⁴⁴

Web Services, Discontinuity, and Disruption

Web Services is an enabling technology that will affect every industry and market within those industries differently. Web Services will be implemented in distinct stages, the first as an internal systems integration solution, and, at some point in the future, on

the edge of the firm in order to integrate one or more firms into more decoupled business networks. The examples of large-scale implementation at the edge of the firm are too new and too untested to determine the disruptive forces. On the other hand, Web Services as an alternative to traditional EAI providers is well underway, and some of those strategic implications are known.

Below is a review of the key aspects of a disruptive technology and how Web Services aligns. The analysis is limited to the Enterprise Application Integration (EAI) industry.

- **Change in Performance Metric.** A common situation when a new technology disrupts the established industry state is when the performance metric by which the competition judges itself changes. Currently, the performance metric in the EAI industry that drives purchase is the richness and depth of the integration between systems, as illustrated by that fact that over 60% of all information technology spend is dedicated to just such integration activity.⁴⁵ Web Services operates along a different performance dimension: size of network. Web Services offers far greater reach because it is standardized and, therefore, generates positive feedback from network effects. This change in performance metric is common to disruptive technologies and should be duly noted.
- **Entry from Lower End.** Disruptive technologies most often enter from a lower cost and margin price point with less functionality initially.⁴⁶ Web Services is significantly less expensive than the established EAI offerings and, correspondingly, offers less functionality.
- **Challenge to Industry Core Competence.** The core competence of the large EAI solutions providers is a large, well-trained staff that can program custom integration interfaces to various proprietary systems. Web Services threatens this asset and, potentially, makes it a liability. Web Services is being supported across the board by the different application vendors, including IBM Corporation, Oracle Corporation, BEA Corporation, and Microsoft

Corporation. The result will be integration between different systems all with the same Web Services interface.

When viewed through the lens of the established literature on discontinuity and disruption, Web Services appears, on the surface, to be potentially threatening to the EAI established leaders.

Chapter 5: Standards

Introduction

This chapter is dedicated to a close examination of standards for the following reasons because: Web Services is a standard—not an actual technology, Web Services standards could affect everyone, and standards are not well understood by those outside of the technology industry.

The crux of Web Services' value-add is that it is a standard that, so far, has been supported by all major technology suppliers. Web Services enables applications on heterogeneous systems in different locations to communicate with each other. Those familiar with the technology industry are well-versed in the critical role that standards play in determining the future of technology markets. Few, if any, technology products stand alone in complete isolation. For example, an application that runs on a personal computer must adhere to the standards of the operating system for applications. The operating system must adhere to the standards of the underlying bus architecture. A web site must send its data to the user's browser using a particular standard for HTTP communications in order to ensure correct display on the user's browser.

Open-Loop vs. Closed-Loop Systems

Technology products are often described as open-loop, implying that the end user solution from the product is intertwined and, therefore, dependent on auxiliary products. The interface between these auxiliary products is normally defined by a standard. On the contrary, non-technology products are more likely to be closed-loop systems and, thus, have no dependencies on auxiliary products. For example, a garment, publication, or food item is generally a complete solution for the consumer, creating no need for any interaction with subsequent products. Even when other products are required, there is little dependence on tight integration and, therefore, the interface does not need to be standardized. For example, a food producer does not need to meet a form factor specification that is part of a standard in order to ensure that the product can be properly consumed with a fork and knife. A human supplies the resource, in this case special

reasoning, to fill the gap between two products which are closed-loop and not integrated by a standard interface.

The equivalent in information flows across firm boundaries is called “swivel seat integration”. Human resources are brought to bear to integrate the information from one closed-loop system (Firm A) and a second closed-loop system (Firm B).

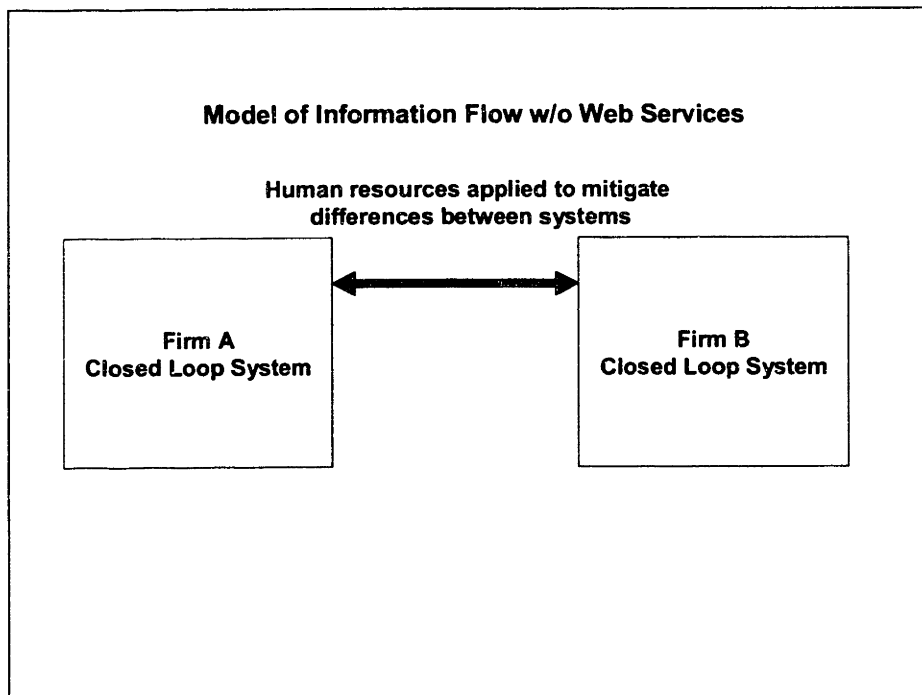


Figure 6.1 Information Flow Between Systems

So, why does the non-technology manager care about standards and why does Web Services accelerate his or her need to understand? The answer is that an industry that adopts Web Services transitions from being a collection of closed-loop firms to being a business web of open-loop systems that are all interconnected. The contract which dictates the interfaces of information flow are standards.

Standards Defined

Since Web Services represents a form of standardization that did not previously exist in information technology, and since a key goal of this thesis is to explore how this standardization may affect the firm, the author has looked to the following two economic definitions of standards to build a definitional foundation:

“A standard can be defined generally as a construct that results from reasoned, collective choice and enables agreement on solutions of recurrent problems. Looked upon this way, a standard can be viewed as striking a balance between the requirements of users, the technological possibilities and associated costs of producers, and constraints imposed by government for the benefit of society in general”⁴⁷

“An industry standard is a set of specifications to which all elements of products, processes, formats, or procedures under its jurisdiction must conform. The process of standardization is the pursuit of this continuity, with the objective of increasing the efficiency of economic activity”⁴⁸

Web Services fits these definitions of standards from the economic literature very well. Based on these definitions and on the current state of the technology, it is safe to assert that Web Services are, in fact, a form of standardization. Given that, the general literature and research on standardization and its impact on industry will be used as a mechanism to better understand the impact of Web Services on the industries that adopt it as an information technology standard.

Functions of Standards

“Standards” is such a large concept with so many applications that it is helpful to divide standards into some finer-grained sub-categories before looking at Web Services specifically. Gregory Tassej breaks standards down into four functions in order to create a categorization through which to analyze the economic impact of each:⁴⁹

- **Quality/Reliability.** Standards that address quality and reliability are normally set by a governmental or industry policy entity. The standard sets a minimum performance attribute from which industry competition builds. Examples of such quality or reliability standards include the government setting the minimum miles per gallon for the automotive industry, or the minimum insulating capabilities of new windows in the home construction industry.

- **Information Standards.** Information standards create a commonly understood and accepted set of evaluated scientific and engineering information. The information is made available via multiple channels, such as databases, web sites, or publications. The net effect is increased efficiency due to each party not having to re-test a product in order to acquire the same information. For example, the automotive industry is required to adhere to the information standard of making the mileage of a vehicle very clear to the potential buyer. If this information was not standardized, each manufacturer might have its own scale for presenting the mileage characteristics of its vehicles. The result of such a non-standard system would be the expenditure of a great deal of time and effort by the buyers to validate the mileage of each car.
- **Compatibility/Interoperability.** Compatibility or interoperability standards specify the required properties of a product that enable that product to work with other products within a larger system. This type of standard has the largest effect on overall system-level innovation because firms can focus on innovating on either side of the interface between the two components with an assurance of operability with components on the other side of the interface. Compatibility/Interoperability standards are commonly used in the information technology industry and are the type of standard that Web Services brings to any industry. By definition, Web Services is an interoperability standard that creates an interface that multiple components can use in order to interact with other components.
- **Variety Reduction.** Finally, variety reduction standards reduce either the number of different properties or the range of properties of a product. The effect of such standards is to facilitate achievement of economies of scale. Commonly, the variety reduction is initiated by industry consensus.

Types of Standards

The two major types of standards, product and non-product, provide an additional perspective from which to view standards, and to better understand where Web Services fits in.⁵⁰

- **Product.** A standard that defines some fraction of how a product actually operates is referred to as a product standard. Historically in the U.S. economy, these standards are *de facto* standards controlled by either a large firm or by a group of large firms. A common pattern is for a dominant design to emerge in an industry and become the *de facto* standard.⁵¹
- **Non-product Standards.** Standards that address not the product itself, but some surrounding, facilitating standards, such as measurement or test methods. These standards are normally established by governmental or industry policy entities because the non-product standards yield most of their positive effects at the industry- or economy-level through increased efficiency.

Tassey provides a further categorization of non-product standards in the form of a hierarchy.

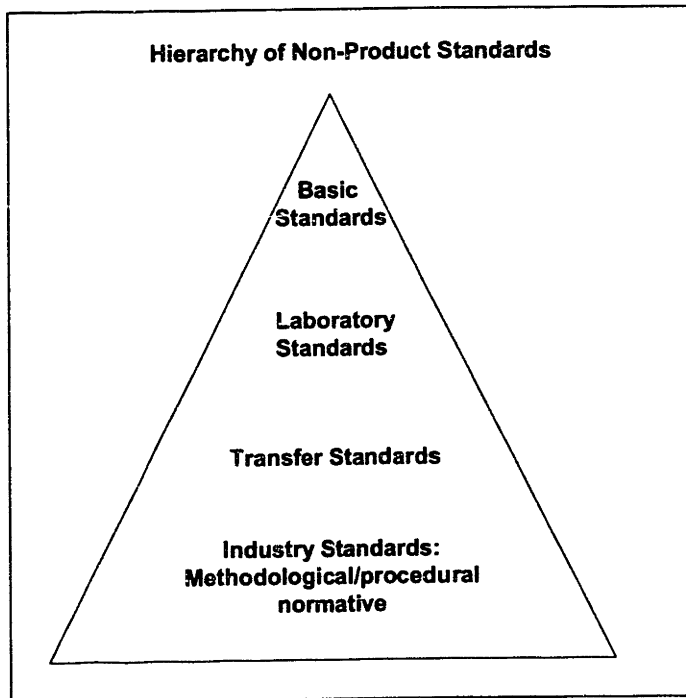


Figure 6.3 Hierarchy of Non-Product Standards⁵²

Effects of Standards on Technology

Standards have both positive and negative effects on economic efficiency. Economic efficiency is enhanced within a technology life cycle by providing a commonly understood interface between modules that enables specialization at the module level. However, standards can also have a negative effect on economic efficiency by retarding investment in future generations of technologies which would replace the current standard.⁵³

Standards' Effects on Industry Structure

Standards do affect different industries in different ways. As has been mentioned, standards can even affect the same industry in two different ways, depending on when the standards are implemented. However, there are patterns across industries in response to standards. To better understand the most common effects of standards on industries in

general, this section examines standards using Michael Porter's model of industry structure.

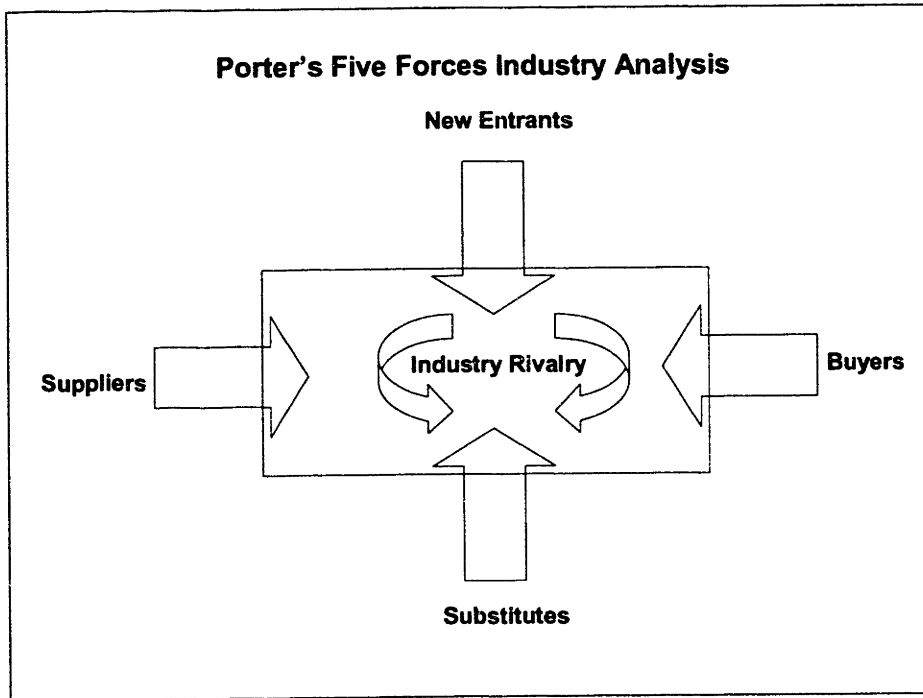


Figure 6.5 Porter's Five Forces Industry Analysis

- **New Entrants.** Increased standardization lowers the barriers to entry, resulting in new entrants exerting more power in the industry. Proprietary systems and products require a new entrant to bring the entire solution to market in order to vie in the industry. The result of standards is that small- and medium-sized businesses can enter the industry by focusing on just a few smaller components or modules within the overall industry.
- **Suppliers.** Suppliers gain power due to their ability to supply multiple parties with one design. Suppliers that are selling products that meet a standard are able to supply multiple firms and are, therefore, not as dependent on any given firm. For example, since car tires abide by interoperability standards, a tire manufacturer is able to supply a wide range of auto manufacturers from the same

production assets without exclusive dependence on one buyer. The net result is increased power for the suppliers.

- **Substitutes.** The industry's receptiveness to substitutes is diminished by standards. History is filled with standards that have persisted in the face of seemingly superior alternatives. The reason is that standards increase lock-in. When a standard exists, a whole network of suppliers, complementary product firms, and competing firms make significant investment in meeting the standard. This investment may take the form of physical machine tool infrastructure or the training of employees. This investment creates a large disincentive for the established players to migrate off of the standard, thus depressing the opportunity for substitutes.
- **Internal Industry Rivalry.** Internally, industry rivalry is fundamentally altered in an industry that has standards. Standards push the overall market toward commodity goods. Customer lock-in is reduced because proprietary systems are replaced with standard systems. Firms compete at the module level, and not at the overall product level. The net result of these effects of standards on internal industry rivalry creates a great deal more rivalry and price competition among players in the industry.
- **Buyers.** There is no direct effect on the role of buyers in a market that has adopted standards. Buyers do enjoy a greater selection of product offerings and greater pressure on prices, but that is attributed more to the dynamics at play in the internal industry rivalry.

Strategic Implications of Standards

Assuming that Web Services does create an environment in which standards could move from the domain of technology to that of business processes, it is critical to examine the strategic ramifications of standards on business strategy.⁵⁴

- **Increased Network Externalities.** Network effects and positive feedbacks are so central to the Web Services story that this subject is discussed separately in

Chapter 6. Briefly, though, standardization increases the size of the network due to increased ease for complementary products and services to enter the network.⁵⁵

- **Reduced Uncertainty.** In the early stages of a new technology, multiple proprietary technologies may be competing for market dominance. If this is a durable product, the consumer is going to be very concerned about choosing the product that will be compatible with complementary products in the future. A broadly supported standard reduces this consumer uncertainty and unleashes greater demand.⁵⁶
- **Reduced Customer Lock-in.** If the standard is open, competitive forces will be greater and, by virtue of the technology being standardized, the costs of migrating to a different implementation of that standard will be lower. Historically, standards have reduced customer lock-in, but have not eliminated it.⁵⁷
- **Competition in Proprietary Extensions.** Rarely does a standard cover 100% of the functionality provided to the user. The difference between the standard and the complete solution is the new locus of competition for suppliers to a standard platform.⁵⁸
- **Competition for the Market vs. Competition in the Market.** The locus of competition changes from an early battle for dominance in the market to a later battle for market share. One must be wary of an “open” standard that captures dominant market share only to later find out the standard is not, in fact, open.⁵⁹
- **Competition on Price vs. Features.** Standards shift the locus of competition away from features to price. The reason is that the standard ensures that most alternatives have a relatively similar feature set. When the entire product is finally standardized, the product is essentially commoditized, and the market within which it exists behaves like a commodity market.⁶⁰
- **Component vs. System Competition.** Standards create two very distinct realms for competition. Either your product is a system or platform, or a component or complement to a platform. In general, standards reduce the number of competing systems and, thus, focus competition on the components that are part of that system. This point is very important when looking at the specific case of Web Services. Extending the previous discussion about the impact of Web Services,

the firm will either be an orchestrator, or a platform leader of a larger business web, or a component within that web. For those that are the components, competitive forces will increase through standardization of the product offerings of the different components.⁶¹

- **Increased Granularity of Products.** Standards between components allow a greater precision in putting together the final product. Instead of a larger, integrated, proprietary system, the standards allow for more customized and, therefore, more granular products to emerge. The standards in the personal computer industry have spawned markets for very specialized personal computers.⁶²

Chapter 6: Network Economics

Introduction

Web Services potentially brings to the business manager an entirely new set of economic principles that should be understood, and that were previously applicable to only complex, high-technology products. This chapter offers an examination of the new economic principles that are specific to networked products. Web Services, by definition, is about networking. Web Services is a standard for two or more heterogeneous computers sharing information in a form that can be easily processed. Therefore, a firm that moves certain edge-of-the-firm services to Web Services will be moving those services into a much larger network. The final value provided to the end customer will, to some degree, be determined not only by the service in isolation, but also by the value-add of the network of which that service is a part.

A quick examination of well-understood and studied networked markets provides insight into the seriousness of the ramifications for adopters of Web Services. Personal computers and the Internet are examples of buyers selecting the best network, and not necessarily the best stand-alone product relative to comparables. The IBM clone personal computer running Microsoft Windows® is considered, by many, to be an inferior personal computer when compared to the Apple Macintosh®. However, the market has demanded the IBM clone running Windows because it is part of a far superior network of complementary products and goods. The original web sites on the Internet were visually and functionally inferior to their comparables on AOL, yet the larger network of content available on the Internet eventually prevailed over the AOL content offerings.

The business decision-maker must understand that these new economic effects of networks are coupled with Web Services. The easy decision is to implement a Web Services architecture and expose processes and services on the edge of the firm. The far more important questions, with a far less certain answers, are in which network to participate, and under what terms. The answers to these questions are not always apparent. For example, a major shipping company was dismayed to find that an aggregator was using its Web Service to populate a least-cost shipping web site. With a couple of clicks on the aggregator's web site, the user was displayed all the major

shipper's rates to a particular destination for a given size and weight parcel. The shipper was fearful of being exposed to the commodity price pressures that such side-by-side price comparisons would create. The hasty response of the shipper was to disable the Web Service that enabled the information access to the shipping rates. This resulted in declining sales and profits.⁶³ That initial response of the shipping company demonstrated a lack of understanding of the value of the network. In this case, the value of the network exceeded the opportunity lost in increased competition.

Finally, the networked economy operates at a much higher clock speed than did the traditional industrial economy, and it is driven by economies of demand rather than economies of scale.⁶⁴ This increased speed raises the stakes for decision-makers. Market dominance can be dismantled in a matter of a year or two, while start-ups may achieve market leadership positions in new markets in only months.

Switching Costs and Lock-In

The most fundamental drivers of network economics is that of switching costs and the subsequent customer lock-in. Switching costs are the costs incurred by the consumer in replacing one product or service with a competitive product or service.

It may seem odd that switching costs are a topic for discussion in the context of Web Services, as there is a fair amount of hype about the WWW, Web Services, and frictionless commerce. It has been asserted by some, when discussing Web Services, that switching costs would decrease greatly and that economic rents would fall with them.⁶⁵ To date, this has not played out in the WWW (person-to-computer) domain, nor is it a near-term possibility for Web Services (application-to-application). In the case of Web Services, as long as there is a lack of a truly universally-accepted meaning for the XML passed between applications, there will be some customized programming necessary to incorporate new or additional Web Services. Web Services optimizes the integration of the heterogeneous systems, but switching costs will persist until there is shared meaning.

When the costs of switching from one product to another product are substantial, the customer has been locked-in.⁶⁶ Due to the switching costs associated with training and learning a new, alternative system, the relative level of complexity of information technology systems produces very high customer lock-in. As a point of reference, for a

large Fortune 1000 firm to replace a core information technology system, the switching costs alone can easily exceed \$100 million.⁶⁷

Type of Lock-In	Switching Costs
Contractual commitments	Compensatory or liquidated damages
Durable purchases	Replacement of equipment; tends to decline as the durable ages
Brand-specific training	Learning a new system, direct and opportunity costs; tends to rise over time
Information and databases	Converting data to new format; tends to rise over time as data store grows
Specialized suppliers	Funding of new suppliers; may rise over time if capabilities are hard to find
Search costs	Combined buyer and seller search costs; includes learning about quality of alternatives
Loyalty programs	Any lost benefits from incumbent supplier, plus possible need to rebuild cumulative use

Table 7.1 Types of Lock-In and Corresponding Switching Costs⁶⁸

The switching costs associated with Web Services are specialized versions of the information and database categories. The software code that will parse the XML when it arrives to the Web Service and the code that will construct the XML when sent from the Web Service will potentially be locked into the current network due to the undesirable switching costs of updating this code for other networks.

Network Effects

To understand network effects, the value of a network is first examined. Network effects are driven by the value of a network exceeding the value offered by alternative products or even alternative networks. Robert Metcalfe, founder of 3Com Corporation and the inventor of the network protocol Ethernet, is credited with first articulating the concept of network value in the form of an equation:⁶⁹

$$\text{Utility} = \text{Users}^2$$

Equation 7.1 Metcalfe's Law of Network Utility⁷⁰

The utility of a network is equal to the square of the number of users who are also using that network.⁷¹ The simplicity of this equation easily communicates the exponential

returns as the network grows. The utility or value of the network and how that network value can drive product value is best understood with a simple example:

- If you own a telephone and no one else owns a telephone, the network is non-existent and the product is worthless.
- If you own and one of your friends owns a telephone, then the network has some limited value and the phone has some limited value.
- If you and all 10 of your friends own telephones, then the network has a value that is greater than the cumulative value of 10 separate networks.

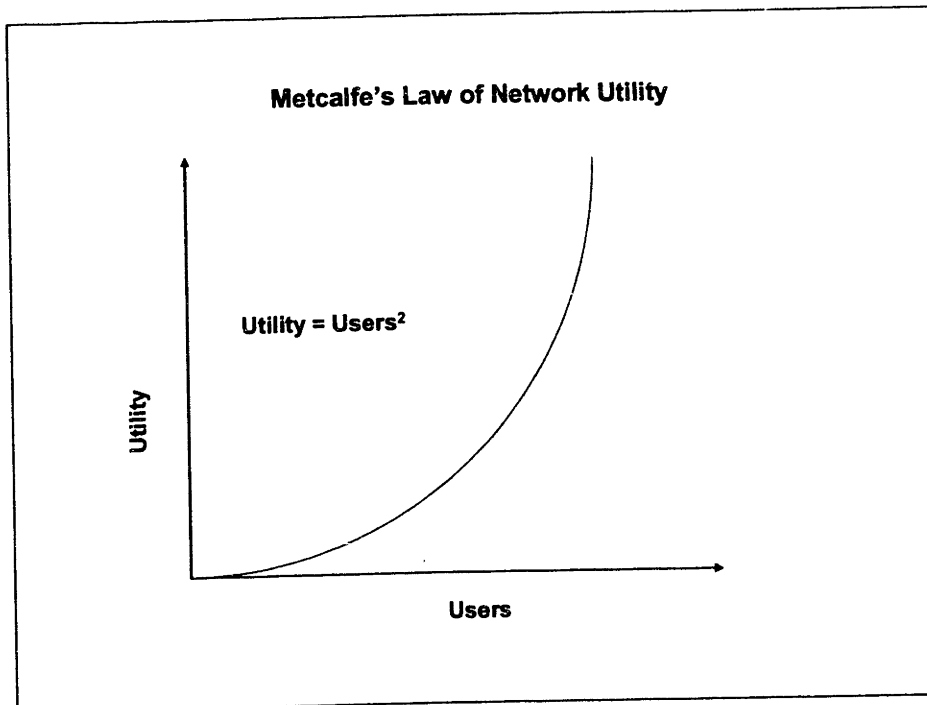


Figure 7.1 Metcalfe's Law of Network Utility

The principals underlying Metcalfe's Law are not new. History is full of examples of networks demonstrating similar exponentially growth in utility as the number of users in the network grow. The world's telecommunications and transportation networks are excellent examples of Metcalfe's Law playing out. What is new is the prevalence of network effects in defining the winners and losers in markets, particularly in the

information technology markets, and the speed at which society moves up the curve.⁷²

The following characteristics of the information technology sector contribute to the higher prevalence of network effects and increased clock speed:

- **Switching Costs.** Information technology's very high, inherent switching costs commit buyers to their product choice and its subsequent network for an extended period.
- **Lack of Standardization.** A specific contributor to the high switching costs is the immaturity of the information technology industry. The relative newness of information technology has created a fragmented, overly proprietary product environment with less interoperability than would be expected from a more mature industry.
- **Ease of Network Entry.** The digital nature of the information technology-based networks enables very quick and easy addition of new users to the network. This should not be confused with switching networks which, as discussed above, is gated by switching costs. A user who has no investment in a specific product or network can add himself or herself to a digitally based network, potentially in hours, with no capital investment.

Date	# of Web Sites on Internet
06/93	130
12/93	623
06/94	2,738
12/94	10,022
06/95	23,500
01/96	100,000
06/96	230,000 (est)
01/97	650,000 (est)

Table 7.2 Internet Growth as Represented by Hosts⁷³

The growth in the number of web sites illustrates the ease of entry into a digitally-based network. A physically capital-intensive network, such as a traditional transportation network, could not grow with such speed.

Positive Feedback and Path Dependence

The engine of the network economy is positive feedback. To get a better understanding of some of the resulting behaviors of a system (market), this section looks to the field of Systems Dynamics. The most complex behaviors in systems are not attributable to the complexity of the individual components in the system, but to the interplay of feedback between the components.⁷⁴ The feedback between two components in a system is always only one of two types: positive or negative.

Positive feedback is self-reinforcing and, thus, the instigator of rapid change in a system or market. The stock of the system is increased due to the positive feedback. The greater the stock in the system is to start with, the greater the resultant positive is to that same stock. This is the core principal in networked markets, making the strong stronger and the weak weaker.

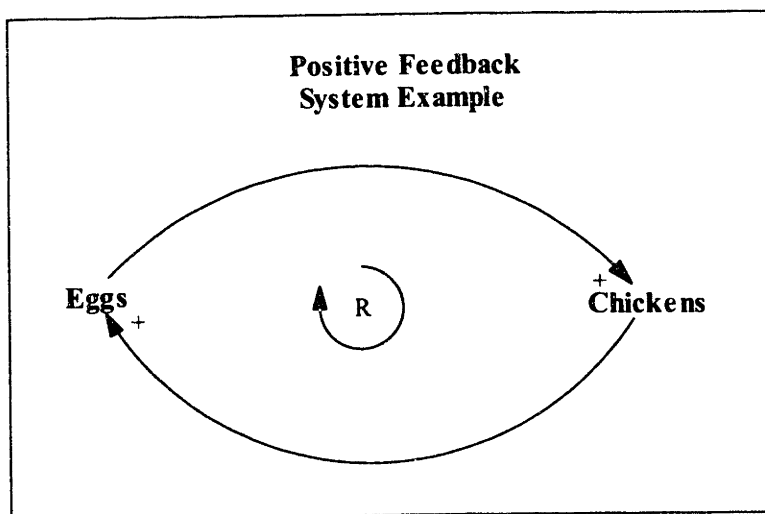


Figure 7.3 Positive Feedback Example

From the diagram in Figure 7.2, it is possible to track the most basic behavior at the core of positive feedback. A given number of chickens lays some eggs, some fraction of these eggs will result in more chickens being hatched, and thus the stock of chickens

will have been increased. All else equal, the next iteration of eggs being laid will result in more eggs and, thus, more hatched chickens. As expected, the stock of chickens is not only growing, but growing exponentially, as shown in Figure 7.3, below.

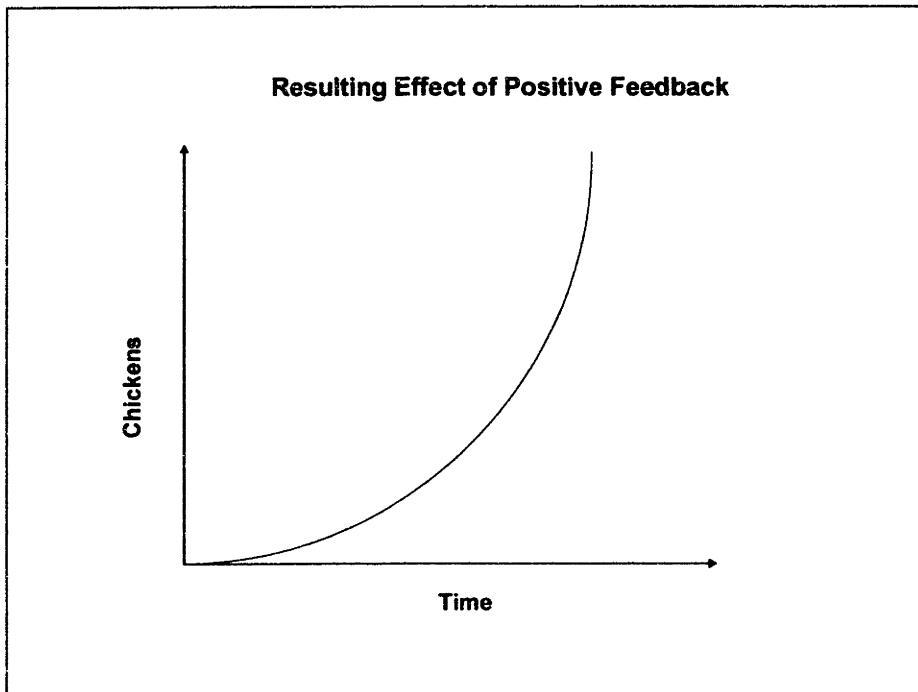


Figure 7.5 Resulting Effect of Positive Feedback

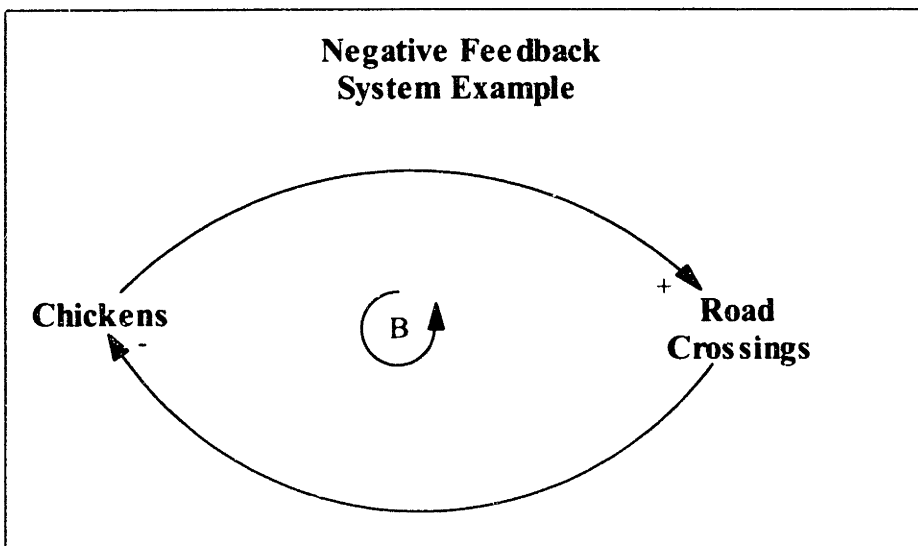


Figure 7.7 Example of Negative Feedback

Using the diagram in Figure 7.4 (above), it is possible to envision a contrived system in which the number of chickens is balanced by negative feedback from road crossings. The more chickens, the greater the number of chickens that will attempt to attempt to cross the road. All else equal, the greater the number of chickens crossing the road, the greater number that will be killed, thus reducing the total number of chickens and balancing the overall system. The resulting behavior of a negative feedback loop, as shown in Figure 7.5 (below), is not as intuitive as the positive feedback.

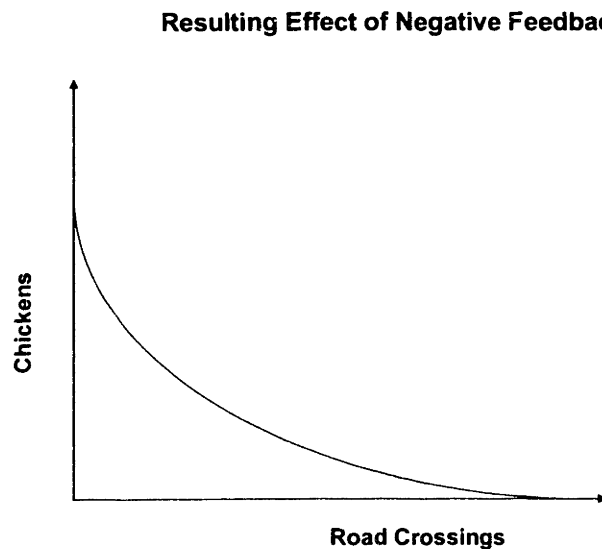


Figure 7.9 Resulting Effect of Negative Feedback

Negative feedback loops in systems are self-correcting and balancing in their resulting forces on the system within which they operate. For this reason, negative feedback is not as important to the business decision-maker, and, therefore, its strategic implications are not explored in detail here.

The result of strong positive feedback in a market is a market that is referred to as “tippy”.⁷⁵ This “tippy-ness” is due to path dependence. Path dependence is a behavior in which small or random events at the very start of a system’s life determine the ultimate end state of the system, even when all potential end states have equal probability.⁷⁶ Due

to strong positive feedback, the market can easily tip toward an extreme with a corresponding negative feedback to bring it back into equilibrium. The positive feedback can drive either a virtuous cycle or vicious cycle for a particular product. The event which kicks the positive feedback into action in technical markets is normally the point of a dominant design emerging from a normally fragmented market of alternative designs.

“A dominant design in a product class is, by definition, the one that wins the allegiance of the marketplace, the one that competitors and innovators must adhere to if they hope to command significant market following.”⁷⁷

The dominant design in technology markets is a common event that would shock a “tippy” market that is in some form of equilibrium toward its strong-get-stronger-and-weak-get-weaker reinforcing positive feedback loop until, finally, there is one product with dominant market share. The dominant design is not inherently the best design, product, technology, or solution available to the consumers at that given point and time. Instead, it is simply the design that customer design coalesces around, creating the critical mass for the engine of positive feedback to start. The dominant design may be determined very early in a technology’s life cycle, when only the crudest of designs are available. The dominant design could be established, thus tipping the market purely by serendipity.⁷⁸ The result of these dynamics at play is that the superior technology design often is not the design which is dominant, and is even less often the design which captures the dominant market share.

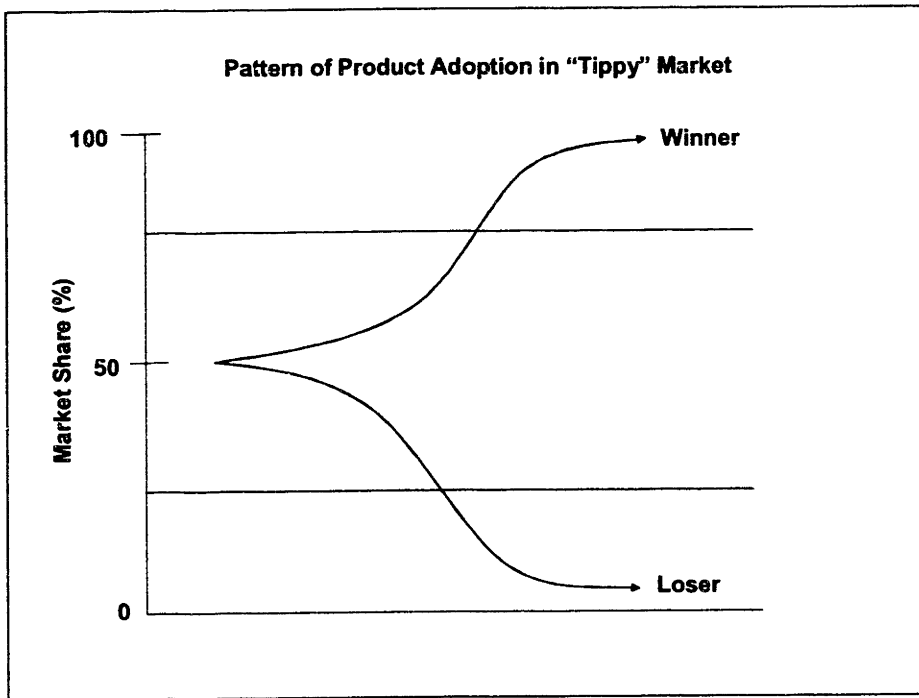


Figure 7.11 Pattern of Product Adoption in "Tippy" Market⁷⁹

The classic example of products either rising with the tide of a virtuous positive feedback, or being driven almost to extinction in the case of a vicious positive feedback, is the case of the personal computer.

Demand vs. Supply Side Economies of Scale

Positive feedback's role determining the winner of a market is not new, but its role has shifted greatly, from affecting only the supply side in the past to now affecting the demand side as well. The shift in the underlying economics is demonstrated by changes in industry structure. Industries used to be oligopolies (that is, dominated by a few large firms) in which the members of the oligopoly changed infrequently. The key economic driver of the "old economy" was that of economies of scale. At the core of the old economy exists positive feedback: the more units produced, the lower the cost per unit, thus allowing lower prices, larger market share, and, subsequently, even more units being produced. However, the resulting behavior of the system only affects the cost of product and does not affect the market outside of potentially lower prices due to associated lower production costs.⁸⁰

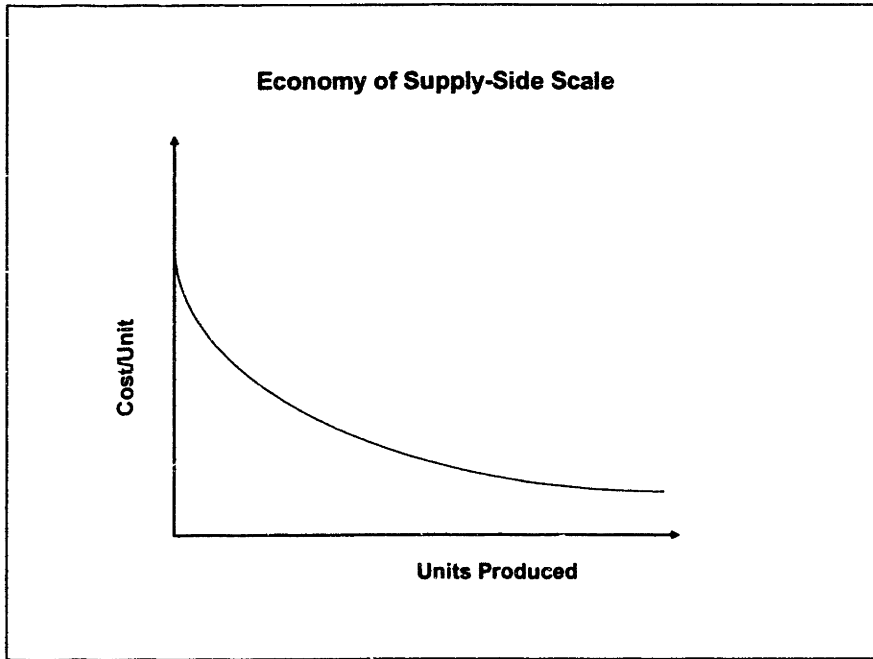


Figure 7.13 Economy of Supply-Side Scale

The industry structure of the information-based economy is marked by temporary monopolies. Instead of multiple technology firms sharing the market, firms are taking turns enjoying extreme market dominance. The reasons for this new industry structure are the network effects specific to demand-side economies of scale.⁸¹ A major player in the operating system market, Microsoft, does enjoy some economies of scale that enable it to produce more copies of software at a lower per unit cost, but the real driver of its success is the demand-side economy of scale. Microsoft's customers choose the Windows operating system not because of the price point driven from lower production costs, but because of the value derived from the scale of the installed base of customers who are also using the product.

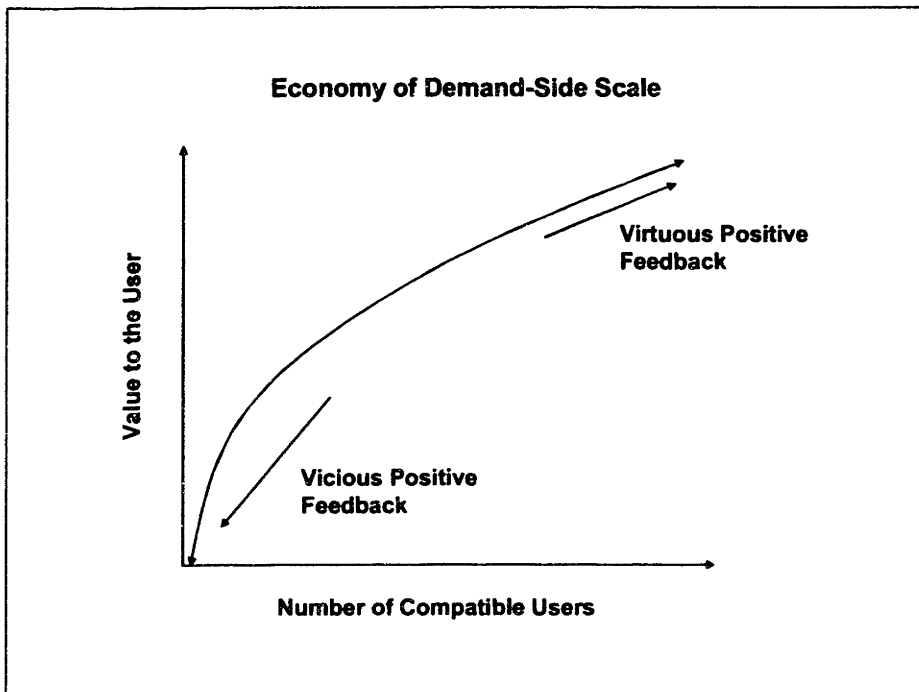


Figure 7.15 Economy of Demand-Side Scale⁸²

Network Externalities

Information technology-based networks are slightly different than standard physical networks, such as a transportation grid or a telecommunications network. An information technology network is often referred to as a “virtual network.” A virtual network includes all of the characteristics of a physical network and, therefore, adheres to the behaviors of networks, such as Metcalfe’s Law, but it also has a larger network of entities that provide positive feedback called network externalities.⁸³ Externalities in a network arise when one network component affects another entity without compensation being paid. When a customer is choosing a product in a market dominated by network economics, he or she will most likely be choosing between networks that include the positive value provided by network externalities. The most common network externalities in the information technology field are complementary products.

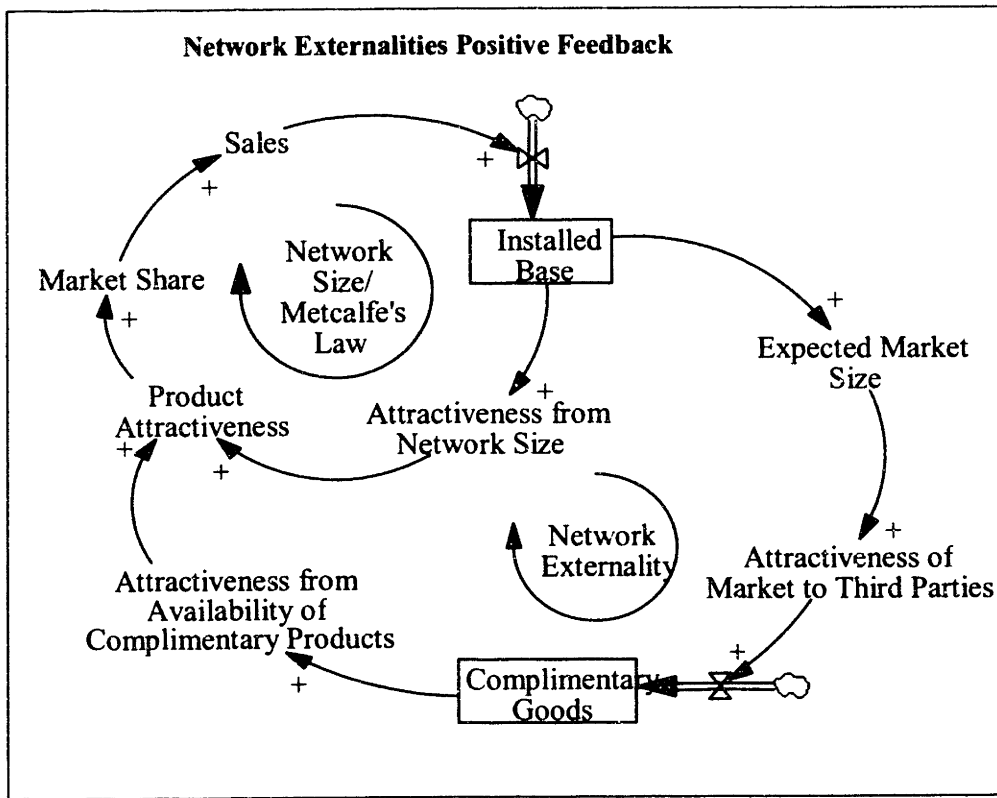


Figure 7.17 Network Externalities Positive Feedback⁸⁴

Using of the System Dynamics syntax shown in Figure 7.9, the specifics of how network externalities positively reinforce the sales and rate of entry of additional users to the stock of the installed base is apparent. The feedback is initiated by the complementary goods market expecting a large network; this increases the attractiveness of that network, which, in turn, increases the amount of investment and innovation put into the complementary goods stock. The larger base of complementary products then increases the attractiveness created by the availability of these complementary products. Finally, the network externality loop positively feeds back into the product attractiveness which, of course, contributes to greater revenue and installed base. At this point, the entire process starts again, stronger and more virtuous.

Strategic Implications

Universal Meaning

Web Services is a standard for moving data between heterogeneous systems; it is not a standard for moving information between heterogeneous systems. The difference between data and information is the ability to understand and, therefore, more intelligently act. For example, a simple piece of data sent between systems may look like the following:

```
<ORDER NUMBER="23569">  
  <PART ID="DE34933" QUANTITY="5">  
</ORDER>
```

The recipient of this piece of data would have to have some previous relationship with the source of this data in order to understand what each of these fields actually represents and what to do with each. Building agreement among all parties as to which data will be exchanged and in what form, along with the programming the rules operate on the data, are switching costs.

Universal meaning is a core element of switching costs and deserves special attention. With universal meaning of the XML passed between Web Services, the switching costs, theoretically, go to zero. Examination of the technology stack for Web Services reveals three categories of technologies: standardized, in the process of standardization, and not expected to be standardized.

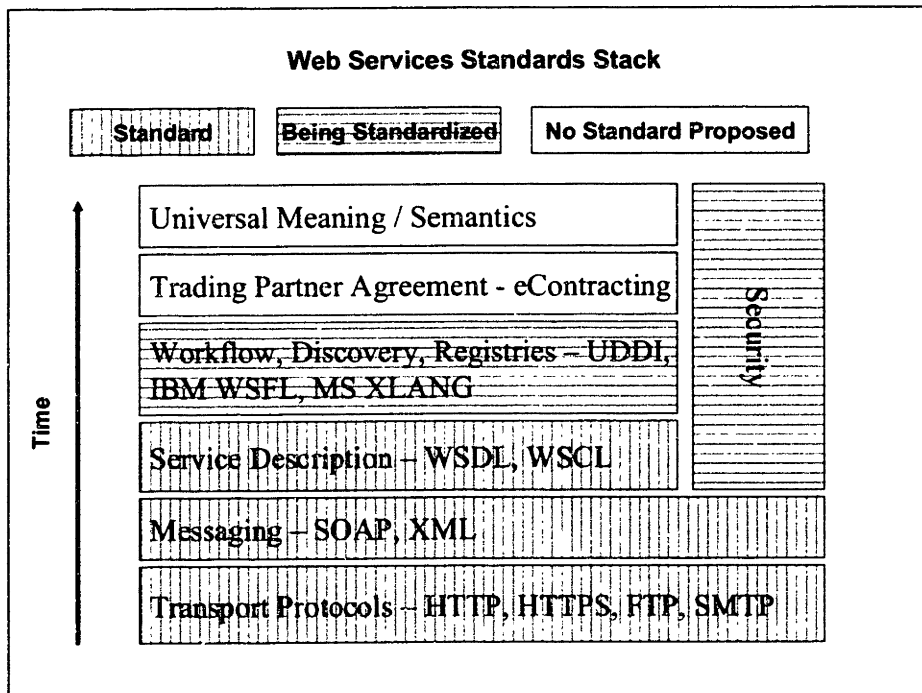


Figure 7.19 Web Services Standards Stack⁸⁵

There are standards either in place from vendor-neutral standards bodies, or standards under discussion for all aspects of the “frictionless” Web Services, except the universal understanding of the XML exchanged. Assuming that, over time, this layer will also move toward standardization, it is helpful to frame whence these standards may be driven. *De facto* standards are normally introduced either by dominant industry players or by a coalition of like-minded industry players in the same vertical.

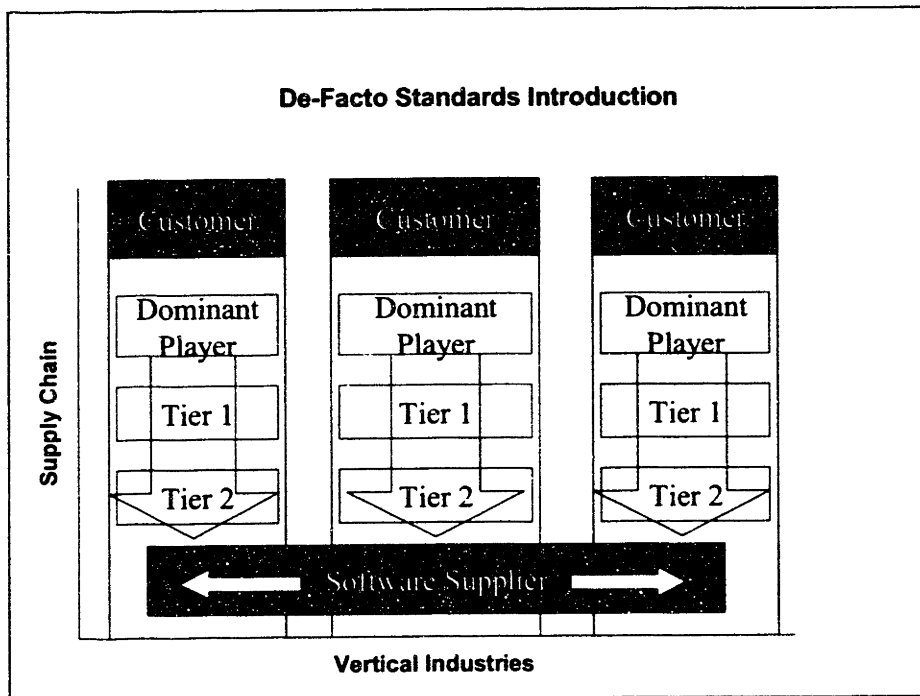


Figure 7.21 De-Facto Standards Introduction

The dominant software suppliers, such as Microsoft and IBM, have access across verticals and are, therefore, very well positioned to introduce standards that are vertical-independent.⁸⁶ Standards that are specific to the verticals, such as the meaning of XML that is part of common transactions in that vertical, will be best introduced by the dominant industry player.⁸⁷

Firms that own and dictate the standards for the meaning and semantics layer are better positioned to align those standards with their unique service offerings. For example, if Amazon.com is driving the semantics for the online e-tailing industry, it could ensure that the semantics support meaning for data that is core to Amazon.com's unique benefits. A case in point, Amazon has competitive advantage due to its ability to compare a shopper's activity to other similar shoppers' activities and make valuable recommendations to the shoppers. If Amazon is controlling the potential industry standard semantics for e-tailing, it can ensure the standard supports that functionality.

Networks vs. Products Focus

Firms may need to change their entire focus from product differentiation to network differentiation. Consumer demand and, subsequently, market share may go to the best network, not to the best product. If the company culture is currently very product focused with little regard for the network externalities that add value to that product, the company culture may be a liability in a more networked market.

Example Case – The Gallup Organization

The Gallup Organization is the world leader in public opinion polling and has been in existence since 1936. The business model of Gallup is very traditional and vertically integrated. Gallup sales professionals sell Gallup's survey research and consulting services directly to customers and each study is customized to some extent to the customer purchasing the service. No parts of Gallup's services were sold through non-direct channels and other than 'word-of-mouth' recommendations there were no network economics which drove Gallup's business. The leadership of Gallup never viewed Gallup's products or services as a potential subcomponent of a larger complex product or platform which would yield positive feedback due to network externalities.

In 1999 this all changed with the launch of Gallup University, Gallup's web based learning system. Gallup University was a pre-packaged set of courses which captured Gallup's most advanced intellectual capital for customer loyalty management, employee management and employee selection in highly modular web service enabled components. The courses were made accessible via a web service using the standard Web Services specification. The resulting potential network effects and subsequent different business models available was profound. First, network externalities were triggered by e-learning solution vendors adding Gallup's content to their bundled solutions. Due to Web Services Gallup courses could easily be added to their bundled solution thus providing a new inexpensive channel Gallup. Second, positive feedback was generated by using the Web Services interface to build integration adapters with the major enterprise software solutions such as Siebel and PeopleSoft. The larger the installed base for these systems the larger the potential market for Gallup's content. The larger the potential market, the

more resources available for adding more courses. Gallup may continue down this course to become a pure content provider.

The case of Gallup offers an interesting lesson regarding the strategic impact of wrapping a product or service in a Web Service interface. A business model which has been in existence for over 50 years can become revitalized over night. The operational leverage offered by implementation of Web Services has increased the potential market for Gallup's goods and services.

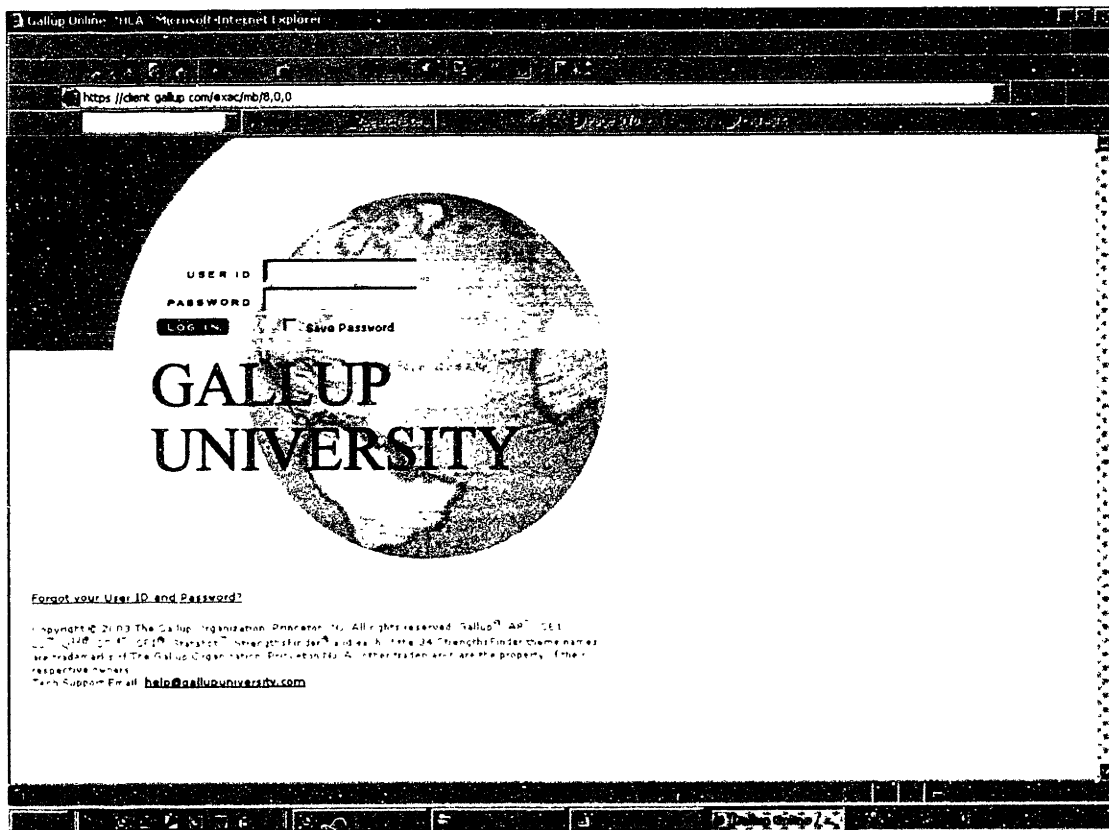


Figure 7.23 Gallup University

Chapter 7: Conclusions

Given any significant changes in the transaction costs, modularity, potential disruption, standardization, and network effects in a market or industry, it can be concluded that significant strategic imperatives arise. Of course, it is unknown at this early stage in the diffusion of Web Services the exact extent to which each of these drivers will be amplified, which industry settings will be most impacted, or which new markets may arise. However, it is the author's opinion that to understand Web Services is to understand the strategic impact of transaction costs, modularity, disruption, standardization, and network economics.

Web Services will, to some extent, change each of these drivers in every market, and it is, therefore, not too early to challenge business decision-makers to consider some of the implications of Web Services for their businesses, given established knowledge. Each market will react differently to the changes in these forces brought on by Web Services. The intent of this thesis has been to help the reader to better and more accurately appreciate the strategic impact of Web Services by providing an overview of the drivers that underlie Web Services to complement the reader's own expertise in the subtleties of his or her industry.

Recommended Considerations

Nature of the Firm

Transaction cost theory underlies the most fundamental aspects of industry, as presented by Ronald Coase's Nobel Prize-winning work. It is too early to pinpoint exact changes in transaction costs due to Web Services, but the alignment between the stated goals of Web Services standards and the types of transaction costs requires the business decision-maker to use transaction cost theory as a lens to consider the strategic impact of Web Services. The reader should appreciate that incremental changes in transaction costs may have very leveraged strategic effects. As Mr. Coase's work asserts, Web Services may change the nature of the firm entirely.

Complex Products and Platforms

History has provided numerous examples of modularity leading industry to component-based architectures in which platform leaders control the game and take home the lion's share of the profits. Is Web Services the missing link from pushing some industries that are prime candidates for such roles into the complex product type? That is a question that will be answered on a market by market basis, but it is the recommendation of this author that the reader be familiar with the strategic landscape of such component-based product markets. Specifically, use the Four Levers of Platform Leadership framework to examine the positioning of the firm under analysis on each lever:

- **Scope of Firm.** Attention must be paid to the where the boundaries of the platform leader's firm are drawn, and to how those boundaries translate into stimulating the growth in the platform.
- **Product Technology.** In the case of Web Services, this translates into the interfaces that are exposed. Interfaces must be fine grained enough to provide the flexibility for innovation to flourish. The decisions regarding these interfaces are not something that should be made by a programmer, but by senior management who are fully aware of the platform leadership ramifications.
- **Relationships with External Complementary Product Firms.** The platform leader must secure the trust of the complementary product firms. Only with trust will all parties commit to the platform, therefore growing the pie for all participants.
- **Internal Organization.** The structure of the firm will determine how well the platform leader is able to perform on the previous three metrics. The structure of the platform leader's firm must complement its role as the orchestrator of the platform by building trust in all parties.

Disruption Considerations

Regardless of the technology or standard involved, the basics of disruption are essential to formulating a strategic plan in response to the technology or standard. The

first question that should be asked with any new technology or standard is: “Will this disrupt our current revenues?” The answer will most likely be no, but given that the stakes are so high, senior management must always be cautious. The most notable consideration regarding Web Services as a disruptive force is that it is a low-cost, reduced-functionality alternative to an established, high-margin, mature alternative. This profile of new technology has repeatedly caught the established players off guard.⁸⁸

Standards Considerations

Web Services, above all else, is simply a standard, a standard in an area of technology that to date has been entirely non-standard and laden with incompatible proprietary technologies. At this point, it is unclear exactly how deeply the standards will evolve, or whether the coalition of major software vendors will splinter into competing standards. However, what is known is that the movement of data between heterogeneous systems is far more standard than it has ever been in the past, and the business decision-maker needs to understand the larger implications of standardization based on the established body of knowledge on standards and technology.

Network Economics

Finally, the nature of the networks that Web Services will facilitate is currently unknown. Will the scope of these networks be limited to specific verticals? To specific supply chains? Only time can reveal how the exact nature of the networks will evolve. However, at this point, it is evident from the standards already accepted that Web Services is an enabler of larger networks. Given the threat that a vicious positive network feedback can have for a firm, it is essential that business decision-maker examines the network effects that Web Services may amplify in current markets as soon as possible.

In conclusion, to understand the strategic impact of Web Services is to understand the strategic impact of transaction costs, modularity, disruption, standards, and network economics. Knowledge of the strategic impact of these five drivers, in conjunction with one's own understanding of the unique aspects of his or her industry, market, and firm, will enable coherent and consistent strategic recommendations regarding Web Services.

Bibliography

Books

Barney, Jay B., "Evaluating Firm Strengths and Weaknesses: Resources and Capabilities," Chap. 5 of *Gaining and Sustaining Competitive Advantage*. New York: Addison-Wesley, 1996.

Christensen, Clayton M., *The Innovator's Dilemma*. New York: Harper Business, 1997.

Downes, Larry, and Chunka Mui. *Unleashing the Killer App*. Boston: Harvard Business School Press, 1998.

Doz, Yves, and Gary Hamel. "The Use of Alliances in Implementing Technology Strategies," Chap. 37 of *Managing Strategic Innovation and Change: A Collection of Readings*, edited by Michael Tushman and Philip Anderson. New York: Oxford University Press, 1997: 556-580.

Evans, Phillip, and Thomas S. Wurster. *Blown to bits: how the new economics of information transform strategy*. Boston: Harvard Business School Press, 2000.

Fine, Charles H., *Clockspeed*. Reading: Perseus Books, 1998.

Fleisher, Craig S., and Babette E. Bensoussan. "S-Curve (Technology Life Cycle) Analysis," Chap 24 of *Strategic and Competitive Analysis: Methods and Techniques for Analyzing Business Competition*. New Jersey: Prentice Hall, 2003.

Fleisher, Craig S., and Babette E. Bensoussan. "Scenario Analysis," Chap 24 of *Strategic and Competitive Analysis: Methods and Techniques for Analyzing Business Competition*. New Jersey: Prentice Hall, 2003.

Foster, Richard N., *Innovation, the Attackers Advantage*. New York: Summit Books, 1986.

Gawer, Annabelle, and Michael Cusumano. *Platform Leadership*. Boston: Harvard Business School Press, 2002.

Hagel, John III. *Out of the Box*. Boston: Harvard Business School Press, 2002.

Hamel, Gary. "Business Concept Innovation," Chap. 3 of *Leading the Revolution*. Boston: Harvard Business School Press, 2002.

von Hippel, Eric. *The Sources of Innovation*. New York: Oxford University Press, 1987.

Porter, Michael E., *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: Free Press, 1980.

Rogers, Everett M., "Innovativeness and Adopter Categories," Chap. 7 of *Diffusion of Innovations*. New York: Free Press, 1995.

Shapiro, Carl, and Hal R. Varian. *Information Rules*. Boston: Harvard Business School Press, 1999.

Sterman, John D.,. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Boston: McGraw Hill, 2000.

Utterback, James M., *Mastering the Dynamics of Innovation*. Boston: Harvard Business School Press, 1994

Articles and Papers

Anderson, P., and Tushman, M., (1991). "Managing through cycles of technology change," *Research-Technology Management*, May-June, 26-31.

Baldwin, Carliss Y. and Kim B. Clark, "Managing in an Age of Modularity," *Harvard Business Review*, September-October 1997.

Christensen, Clayton M. and Mark W. Johnson, Darrell K. Rigby, "Foundations for Growth: How to Identify and Build Disruptive New Business", *MIT Sloan Management Review*, Spring 2002.

Christensen, C. M. (1992), "Exploring the Limits of the Technology S-Curve. Part I: Component Technologies," *Production and Operations Management*, Volume 1, Number 4, Fall 1992.

Christensen, C. M. (1992), "Exploring the Limits of the Technology S-Curve. Part II: Architectural Technologies," *Production and Operations Management*, Volume 1, Number 4, Fall 1992.

Coase, Ronald H. (1937), "The Nature of the Firm," *Economica*, New Series, Volume 4, Number 16, pp. 386-405.

Cooper, Arnold C. and Clayton G. Smith, "How established firms respond to threatening technologies," *Academy of Management Executive*, 1992 Volume 6, Number 2.

Evans, Phillip B. and Thomas S. Wurster (1997), "Strategy and the New Economics of Information," *Harvard Business Review*, September-October, pp. 71-82.

Fleming, Lee and Olav Sorenson (2003), "Navigating the Technology Landscape of Innovation," *MIT Sloan Management Review*, Volume 44, Number 2, pp. 15-23.

Fleming, Lee and Olav Sorenson (2001), "The Dangers of Modularity," *Harvard Business Review*, September-October, pp. 15-23.

Henderson, R. and Kim Clark. (1990). "Architectural innovation: The reconfiguration of existing technologies and the failure of established firms," *Administrative Science Quarterly*, Volume 35, Number 1, pp. 9-30.

Iansiti, Marco, "How the Incumbent Can Win: Managing Technological Transitions in the Semiconductor Industry," *Management Science*, Volume 46, Number 2, February 2000 pp. 169-185.

Pistorius, C.W.I. and J.M. Utterback, "Multi-mode interaction among technologies," *Research Policy*, Volume 26, pp. 67-84.

Tassey, Gregory (2000) "Standardization in technology-based markets" *Research Policy*, Volume 29, pp. 587-602.

Domain Specific Bibliography

Books

Russell, Stuart and Peter Norvig. *Artificial Intelligence, A Modern Approach*, New Jersey: Prentice Hall, 1995

Cusumano, Michael. *The Software Business, Strategies for Managers, Programmers, and Entrepreneurs in Good Times and Bad*, New York: Free Press/Simon & Schuster, 2003

Clabby, Joe. *Web Services Explained*, New York: Prentice Hall, 2002

Apshankar Kapil and Dimple Sadhwani, Gunjan Samtani, Bilal Siddigui, Mike Clark, Peter Fletcher, J. Jeffery Hanson, Romin Irani, Mark Waterhouse, Liang-Jie Zhang. *Web Services Business Strategies and Architectures*, Expert Press, 2002.

Articles and Papers

Aral, Sinan, "Automating Orchestration: Bridges toward Semantic Web Services," Working Paper.

Berners-Lee, Tim and James Hendler and Ora Lassila, "The Semantic Web," <http://www.scientificamerican.com>, May 17, 2001.

Grosof, Benjamin N. and Terrence C. Poon, "Representing Agent Contracts with Exceptions using XML Rules, Ontologies, and Process Descriptions", *MIT Process Handbook*.

Hagel, John III and John Seely Brown, "Your Next IT Strategy," *Harvard Business Review*, October 2001.

McIlraith, Sheila A., Tran Cao Son and Honglei Zeng, "Semantic Web Services," *IEEE Intelligent Systems*, 2001.

Nukala Murthy and M.R. Rangaswami, "The Web Service Derby: Winning Strategies for Enterprise Software Vendors," 2003.

Interviews

Bryar, Colin. Interviewed by author. Seattle, Washington, 18 February 2003.

O'Donnell, John. Interviewed by author. Cambridge, Massachusetts, 1 May 2003.

Reeves, Cliff. Interviewed by author. Philadelphia, Pennsylvania, 28 February 2003.

Sutor, Bob. Interviewed by author. Philadelphia, Pennsylvania, 28 February 2003.

Lectures

Gerstner, Louis V. "The Networked World: Are We Ready For It?." Lecture., MIT, 2002.

Grosof, Benjamin. "Web Services and Semantic Web." Lecture., MIT, 2003.

Gerstner, Louis V. "The Networked World: Are We Ready For It?." Lecture., MIT, 2002.

Madnick, Stuart. "Web Aggregators," Lecture., MIT, 2003.

Pond, Randy. "\$2.2 billions write-off: What Happened?," Lecture., San Jose, 2003.

Appendix A – Interview Materials



The Future of Web Services

In-Depth Interview
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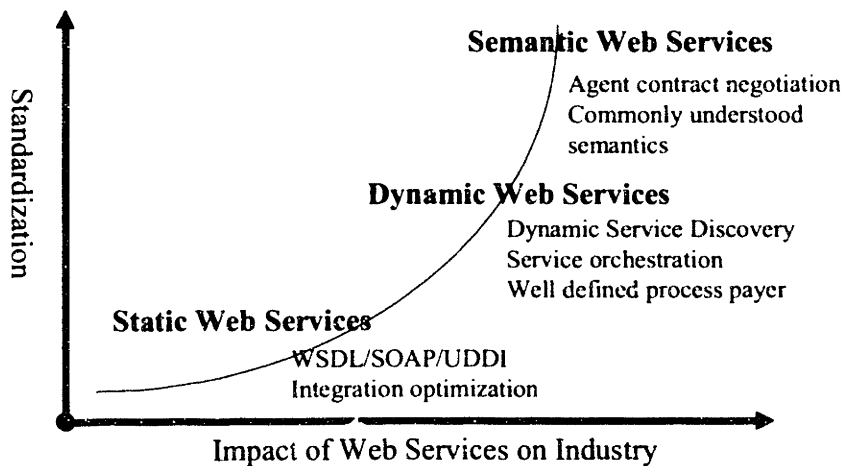
Agenda

- Thesis Background
- Discussion of Web Service Roadmap
- Standards
- Value Chain Impact
- Open ended discussion

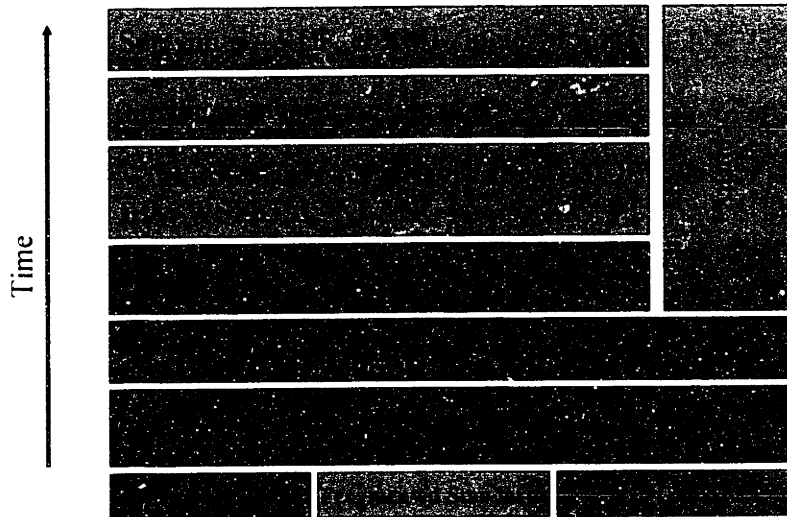
Thesis Background

- Develop better understanding of future Web Service landscape.
 - Application of established technology diffusion frameworks.
- Examine potential affects on Value Chains
 - Application of established frameworks on modular industry forces.

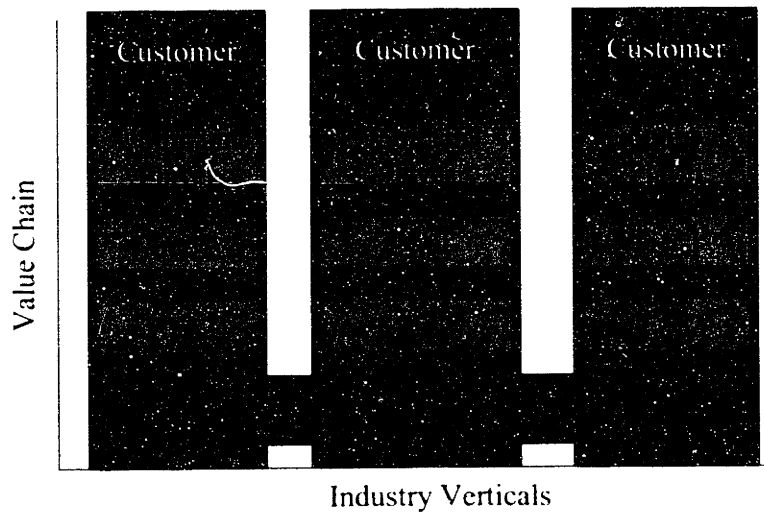
Web Service Roadmap



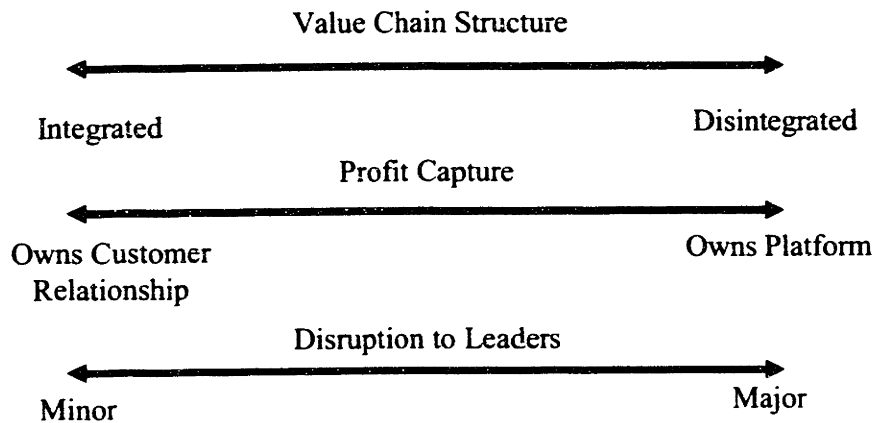
Standards – How Deep?



Standards – From where?



Impact of Web Services



Open Discussion

■ Potential Topics

- ☐ Semantic Web
- ☐ Role of MSFT, IBM, BEA
- ☐ Vision for .NET in overall web service adoption

Appendix B – List of Equations, Figures and Tables

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- ¹ Colin Bryar, interview by Author, Seattle, Washington, 18 February 2003.
- ² Webster's Collegiate Dictionary, Tenth Edition.
- ³ Stuart Scantlebury and David Ritter, "Web Services: Miracle or Mirage" (Lecture, MIT Sloan School, Cambridge MA, 7 November 2002)
- ⁴ Scantlebury and Ritter.
- ⁵ Scantlebury and Ritter.
- ⁶ John Hagel III, *Out of the Box* (Boston: Harvard Business School Press, 2002).
- ⁷ Hagel.
- ⁸ Cliff Reeves, interview by Author, Philadelphia, Pennsylvania, 28 February 2003.
- ⁹ Dr. Bob Sutor, interview by Author, Philadelphia, Pennsylvania, 28 February 2003.
- ¹⁰ Michael E. Porter, *Competitive Strategy*, (New York: The Free Press, 1980).
- ¹¹ Larry Downes and Chunka Mui, *Unleashing the Killer App* (Boston: Harvard Business School Press, 1998).
- ¹² Benjamin Grosf, "Semantic Web & Web Services" (Lecture. MIT Sloan School, Cambridge MA. 25 January 2003).
- ¹³ Ronald H. Coase, "The Nature of the Firm," *Economica*, New Series, Volume 4, Issue 16 (1937) : 386-405.
- ¹⁴ Coase, 386-405.
- ¹⁵ Downes and Mui.
- ¹⁶ O'Donnell.
- ¹⁷ O'Donnell.
- ¹⁸ Reeves.
- ¹⁹ Carliss Y. Baldwin and Kim B. Clark, "Managing in the Age of Modularity," *Harvard Business Review* 75 (1997): 84-93.
- ²⁰ Baldwin and Clark.
- ²¹ Baldwin and Clark.
- ²² Baldwin and Clark.
- ²³ Lee Fleming, "Navigating the Technology Landscape of Innovation" *Sloan Management Review*, 44(2003): 15-23.
- ²⁴ Fleming.
- ²⁵ Fleming.
- ²⁶ Annabelle Gawer and Michael Cusumano, *Platform Leadership* (Boston: Harvard Business School Press, 2002).
- ²⁷ Gawer and Cusumano.
- ²⁸ Gawer and Cusumano.
- ²⁹ Bryar.
- ³⁰ Bryar.
- ³¹ Richard N. Foster, *Innovation: The Attackers Advantage*, (New York: Summit Books, 1986).
- ³² Foster.
- ³³ Jonh D. Sterman, *Business Dynamics: Systems Thinking for Modeling for a Complex World*, (Boston: McGraw Hill, 2000).
- ³⁴ R.H. Becker, "Putting the S-Curve concept to work," *Research Management* (1983).
- ³⁵ Foster.
- ³⁶ Foster.
- ³⁷ Clayton H. Christensen, *The Innovator's Dilemma* (New York: Harper Business, 1997).
- ³⁸ Foster.
- ³⁹ P. Anderson & M. Tushman, "Managing Through Cycles of Technology Change," *Research Technology Management* (1991).

Endnotes continued on next page

Endnotes Continued

- ⁴⁰ Clayton M. Christensen, "Exploring the Limits of the Technology S-Curve. Part I Component Technologies," *Productions and Operations Management* (1992).
- ⁴¹ Foster.
- ⁴² Clayton M. Christensen "Exploring the Limits of the Technology S-Curve: Part II: Architectural Technologies," *Production and Operations Management* (1992).
- ⁴³ Christensen, *The Innovator's Dilemma*.
- ⁴⁴ Christensen, *The Innovator's Dilemma*.
- ⁴⁵ Louis V. Gerstner, "The Networked World: Are We Ready For It?" (Lecture. MIT Sloan School, Cambridge MA. 10 October 2002).
- ⁴⁶ Christensen, *The Innovator's Dilemma*.
- ⁴⁷ C. Germon, La normalisation, cle d'un nouvel essor, la documentation francais. Report to the Organization for Economic Cooperation and Development. OECD, Paris. 1986.
- ⁴⁸ Gregory Tasse, "Standardization in technology-based markets," *Research Policy* 29 (2000) : 587-602.
- ⁴⁹ Tasse.
- ⁵⁰ Tasse.
- ⁵¹ James M. Utterback, *Mastering the Dynamics of Innovation*, (Boston: Harvard Business Press, 1996).
- ⁵² Tasse.
- ⁵³ Tasse.
- ⁵⁴ Carl Shapiro and Hal R. Varian, *Information Rules: A Strategic Guide to the Network Economy*, (Boston: Harvard Business School Press, 1999).
- ⁵⁵ Shapiro and Varian.
- ⁵⁶ Tasse.
- ⁵⁷ Tasse.
- ⁵⁸ Shapiro and Varian.
- ⁵⁹ Shapiro and Varian.
- ⁶⁰ Shapiro and Varian.
- ⁶¹ Shapiro and Varian.
- ⁶² Tasse.
- ⁶³ Dr. Stuart Madnick, "Web Aggregators?" (Lecture. MIT Sloan School, Cambridge MA. 20 February 2003).
- ⁶⁴ Shapiro and Varian.
- ⁶⁵ Philip Evans and Thomas S. Wurster, *Blown to Bits: How the New Economics of Information Transform Strategy*, (Boston: Harvard Business School Press, 2000).
- ⁶⁶ Shapiro and Varian.
- ⁶⁷ Randy Pond, "\$2.2 billion write-off: What happened?" (Lecture. Cisco Corp. Headquarters, San Jose CA. 20 March 2003).
- ⁶⁸ Shapiro and Varian.
- ⁶⁹ Shapiro and Varian.
- ⁷⁰ Shapiro and Varian.
- ⁷¹ Shapiro and Varian.
- ⁷² Shapiro and Varian.
- ⁷³ Matthew Gray (<http://www.mit.edu/people/mkgray/>)
- ⁷⁴ Sterman.
- ⁷⁵ Shapiro and Varian.
- ⁷⁶ Sterman.
- ⁷⁷ Utterback.
- ⁷⁸ Utterback.
- ⁷⁹ Shapiro and Varian.
- ⁸⁰ Shapiro and Varian.
- ⁸¹ Shapiro and Varian.

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⁸² Shapiro and Varian.

⁸³ Shapiro and Varian.

⁸⁴ Sterman.

⁸⁵ Grosf.

⁸⁶ Reeves.

⁸⁷ Bryar.

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