DO WEB SERVICES FOSTER SPECIALIZATION? AN ANALYSIS OF WEB SERVICE DIRECTORIES

Christine Legner[1]

Abstract
Web service technologies are expected to foster the creation of networks of specialists which expose their digital services over the internet for the dynamic discovery of services by other organizations. Although the idea of a global Web service directory, which was considered a key enabler of e-commerce in the dot.com era, has failed with the shutdown of the Universal Business Registry in 2006, the vision of an open market for Web services has regained popularity lately in the context of the SOA and Web 2.0 concepts. Given these latest developments, the interesting question is whether there is empirical evidence of an emerging market for Web services. Based on a longitudinal study of Web services directories, this paper aims at analyzing the evolving offering and market structure of B2B Web services. The study suggests that commercial Web services which enable companies to out-task discrete, repetitive tasks to specialized service providers continue to be relatively scarce. However, Web services specialists emerge in specific domains, such as compliance, online validation and alerting. In addition, Web services directories are extending their scope beyond service discovery and evolve into either 'real' electronic marketplaces or infomediaries.

1. Introduction

The increasing capabilities of information technology are widely acknowledged as causing fundamental changes in organizational and industry structures [2, 3]. Since the emergence of the Web services paradigm, many scholars have argued that the wide acceptance of open Web service standards will dramatically reduce interaction costs within and across organizations and generate greater operational flexibility [4-6]. Web services are expected to promote the unbundling of functions and activities within and across organizations and to foster the creation of networks of specialists [7, 8]. For businesses, this vision implies the dynamic discovery of services in a global electronic marketplace and an increased level of outsourcing of single tasks (also denoted as 'outtasking') to specialist service providers [9, 10]. Although most industry experts recognize the potential of Web services [11], the idea of a global Web service directory, which was considered a key enabler of e-commerce in the dot.com era, has failed with the shutdown of the Universal Business Registry in 2006. However, the vision of a global Web services market has regained popularity lately: First, large software vendors are re-architecting their software platforms to reflect the paradigm of a service-oriented architecture (SOA). These efforts are complemented by the establishment of service catalogs, e.g. the IBM SOA Business Catalog or SAP's Enterprise Services

[1] Institute of Research on Information Systems, European Business School, D-65375 Oestrich-Winkel.

Repository. Second, Web 2.0 technologies are gaining popularity. Among them are mashups, i.e. composite web applications which are built reusing content from third parties via a public API. Last but not least, a very active research community is exploring the semantic Web. They argue that it will be much easier to locate providers of particular services and establish (semi-)automated cooperation with them if semantics are explicitly added to Web service descriptions [12].

In the context of B2B networks, the interesting question is whether Web service technologies generate more specialization and lead to commercial offerings of reusable Web services. Hence, this paper investigates the market for B2B Web services supporting discrete, repetitive tasks and may be sourced from specialist service providers in order to benefit from economies of scale. A thorough review of the existing Web services directories seems to be valuable in order to extract insights into the global market for specialized Web services. Based on a longitudinal study, this paper aims at answering the following the following questions:

- Is there practical evidence that Web service technologies foster specialization, thus resulting in an increased offering of B2B Web services by providers?
- What is the role of Web services directories in facilitating the Web services market?

This paper is organized as follows: The next section outlines the research approach and process. In order to derive the theoretical propositions that guide our analysis, section 3 reviews Web services literature and relates it to the existing body of research from IS and economic theory. Section 4 summarizes key findings of our study related to the Web services offering and the market structure. The paper concludes with a summary and an outlook on the evolving market for Web services.

2. Research Approach

Our research process consisted of two stages: Fist, we reviewed the existing body of research and developed theoretical propositions on the evolving market for Web services and the increasing specialization. For this purpose, we related concepts from the more technically oriented Web services research to prior studies which have investigated the impact of information technology on organizational coordination [2, 3]. In a second step, we collected data related to Web services offerings and the market structure, which we confronted to our theoretical propositions. Since empirical data related to the Web services market and the transaction volumes is not publicly available, our study relies on data that a team of researchers has collected over the last 5 years. Since 2002, this team has been observing all major Web services registries and directories, among them the Universal Business Registry as well as a dozen commercial directories and registries (c.f. Table 1). In view of our research objectives, five Web services directories were selected for a detailed analysis of their Web service offering and the overall structure of the market. The following selection criteria were applied: (1) The Web services directories represent different levels of sophistication, i.e. from simple Web services listings to more advanced trading platforms; (2) due to their Web services offering they are expected to be the major players, and (3) all of them have survived the shakeout phase in 2006. Thus, our analysis focuses on the following directories which account for two thirds of the commercial Web services which are traded using intermediaries:

- *e-Sigma.com* was launched in 2003 with the mission “to provide a secure and standards-based platform for the global discovery, consumption and management of Web Service-based business processes”. Today, e-Sigma.com operates a comprehensive Web service directory for publishing, searching and testing Web services.
- *RemoteMethods* started in 1999 as a Web development directory. Today, the company operates a Web service directory which comprises service descriptions and pricing information as well as rating and review mechanisms.

- *StrikeIron*, located in Raleigh, North Carolina, was founded in 2003 and operates two directories, a global Web service directory as well as a marketplace. The company offers a broad range of services including Web service hosting, monitoring and commercialization. StrikeIron has teamed up with systems integrators and content providers.
- *X-Methods* provides a flat listing of services from individuals and organizations. In addition to the browser interface, it offers programmatic interfaces to the registry.

Table 1: Overview of Web services directories

Name and Link	Operated by	Status (October 2007)
Universal Business Registry (UBR) - *Inactive*	IBM, Microsoft, NTT Com, SAP	Active: 2002 – 2006 Discontinued in January 2006 with more than 50,000 entries ('the objective of the UDDI project was reached")
BindingPoint *Inactive*	Acclaim IT Solutions Ltd.	Active: N/A – 2006 Discontinued in 2006 with >4000 services [1] ('market too slow to adopt Web services')
eSigma.com *www.esigma.com*	eSigma	Active: 2003 – today 159 Web services
RemoteMethods *www.remote-methods.com*	InfoGenius Inc.	Active: 1999 – today Started as Web development directory; 337 Web services
StrikeIron *www.strikeiron.com*	StrikeIron	Active: 2002 – today 618 Web services in Global Directory; 74 Web services in StrikeIron Marketplace
WebServiceList *www.webservicelist.com*	IT Netix, Inc.	Active: N/A – today 483 Web services
WebserviceX.NET *www.webservicex.net*	Generic Objects Technologies Ltd.	Active: N/A – today 71 Web services

In order to test our propositions, we counted and analyzed the Web services entries in the selected Web service directories. A first analysis was performed in October 2005 and provided an overview of the Web services offering and the market characteristics. The analysis was repeated and enhanced two years later. Since most directories publish Web services in multiple categories, particular attention has been given to data cleansing in this second analysis. Most importantly, we have eliminated duplicates and created a list with unique service entries for every Web service directory. These entries have been categorized according to the following dimensions:

- *Functional scope of the Web services*: Ten categories have been defined in order to reflect the functional scope, from data-oriented to application-oriented and technical functionality.
- *Price model:* Web services have been classified according to the price model that is applied.
- *Service provider:* Service providers comprise specialized Web service providers, organizations offering complementary Web services to their product/service offering and individuals.
- Besides the categorization of the service entries, we investigated the functions provided by the Web service directory using the taxonomy described in the next section.

3. Research Propositions

3.1. Web Services and Specialization

From a technical perspective, Web services represent interfaces which provide stable, reusable software functionality [4, 15]. In order to ensure interoperability across platforms, they build on a set of standards [4, 16]: (1) the Extended Markup Language (XML) for defining messages, (2) the Simple Object Access Protocol (SOAP) for transmitting messages, (3) the Web Services Description Language (WSDL) for describing interfaces and (4) the Universal Description, Discovery and

Integration (UDDI) protocol for publishing metadata about Web services. Whereas the technical research stream is mostly concerned with enhancing Web services concepts architectures [4, 5, 17], the business literature focuses on the emerging Web service-based business applications and their economic potential. Many business experts argue that Web services – in combination with a service-oriented architecture – will allow companies to replace their proprietary information system landscape with an open, modular architecture [8, 18]. Hence, companies will increasingly leverage shared services, i.e. centrally managed, one-to-many services, and rely on the capabilities of third parties for managing their information system resources [6]. Whereas Web services may be used as mere integration technology, shared services rely on more coarse-grained Web services which are sufficiently generic to allow their reuse in several processes and/or by several users [17, 19].
Proposition 1: With the increasing maturity of Web services technologies, the offering of coarse-grained Web services which provide reusable business-level functionality will increase.

Transaction cost theory postulates that the falling interaction costs promote the unbundling of functions and activities within and across organizations [2], and Brynjolfsson et al. [3] demonstrate that advances in IT lead to smaller firm size. In the context of Web services, it has been argued that companies encapsulate their business expertise as Web services and make it available throughout the entire value network, thus stimulating the external integration with their business partners [11]. If Web services are to dramatically reduce interaction costs and to encapsulate electronic support of non-strategic transactions [13], they are likely to increase the level of external sourcing. Sanders et al. [13] and Keen and McDonald [14] denote this particular form of outsourcing as out-tasking given that a specific task is assigned to an outside supplier. By out-tasking to external service providers, companies will benefit from scale efficiencies due to specialization [9].
Proposition 2: Due to the falling transaction costs, specialist service providers will be able to realize scale efficiencies in repetitive tasks and establish a commercial offering of B2B Web services.

3.2. The Role of Web Service Directories

From the very beginning, Web services have been associated with the idea of online service discovery [4]. This is manifested by the integral role that directories storing service descriptions play in a Web services architecture [15]. Directories allow service providers to register new services and service consumers to search for and locate services. In a centralized approach, they are hosted and managed by a trusted entity. In the early days of the dot.com era, Web services registries were considered the key technology for facilitating global e-commerce. Hence, the publication of the first version of the UDDI specifications in 2000 inspired the launch of several Web services directories and registries. Since directories establish many-to-many interactions between organizations that publish Web services and organizations which consume Web services, Web services ecosystems show typical characteristics of an electronic market. Similar to a physical marketplace, an electronic market represents a social arrangement which allows buyers and sellers to carry out a voluntary exchange of goods or services. It serves three main functions, namely to match buyers and sellers, to facilitate transactions and to provide the institutional infrastructure for business [20, 21].

Proposition 3: Web service directories assume typical functions of an electronic market which facilitates voluntary exchanges of digital services between Web service publishers and consumers.

Given the fact that, of the 1520 electronic marketplaces that were identified in 2000 [22], only a minority survived the subsequent shakeout phase, IS research has intensively investigated the particular role and evolution of electronic markets. Whereas early e-business research mostly emphasized their role in online matchmaking between supply and demand [23], a more differentiated view has developed over the past years (c.f. Table 2). Some authors argue that marketplaces in the B2B

space are evolving into so-called exchanges or e-hubs which facilitate supply chain collaboration within a vertical industry [22, 24, 25]. Other scholars observe the emergence of so-called infomediaries or cybermediaries [26-28], like Autobuytel or Expedia, which reduce information asymmetries for consumers. Since the concept of infomediation has also been applied to the B2B space with a very broad view of information-based services [29], the borderline between the different concepts is blurred. Table 2 summarizes the characteristics and roles played by online intermediaries according to prior IS research and will serve as a basis for analyzing the role of Web service directories: Based on the taxonomy developed by Barnes & Hinton [31], informational, transactional, logistical, assurance and customization functions can be distinguished. In addition, we explicitly include matching [23, 24] and additional collaboration, integration and standardization functions. Table 2 visualizes the differences between the original concept of electronic marketplaces, the more collaboration-focused B2B exchanges and the cyber- or infomediaries. Reflecting the evolution of electronic markets, it can be concluded that basic informational services, namely e-catalogs, will most likely not provide a sustainable value proposition [32]. In order to attract the critical mass of Web service consumers and publishers, it might be expected that Web services intermediaries assume additional functions related to matchmaking and facilitation of transactions.

Proposition 4: Informational services, notably service discovery, will not provide a sustainable value proposition for Web service directories on the medium and long term.

Table 2: Characteristics and roles played by different type of online intermediaries

		Electronic market [23]	**Exchange / e-Hub** [24, 30]	**Info-mediary** [26-28]
Informational	Collection and distribution of information	Y	K	Y
	Search and evaluation	Y	∀	Y
Customization	Tailoring of products and services	Y	∀	Y
Matching	Matching buyers and sellers	Y	K	Y
	Price determination	Y	K	K
Transactions	Settlement of transactions	Y	K	K
Assurance	Transaction securitization	K	K	K
	Insurance and liquidity	K	∀	K
Logistical	Product distribution services	K	Y	K
Collaboration	Collaborative business processes	∀	Y	∀
Integration	Electronic connectivity	Y	Y	Y
Standardization	Message semantics and syntax	∀	K	∀
	Transport / communication	∀	K	∀
Legend: Y key feature; K optional feature ; ∀ no feature				

4. Findings

4.1. Characteristics of Web Services Offering

With 500 to 700 service entries which are provided by more than 100 service providers, XMethods and StrikeIron Global Directory offer the largest number of Web services entries Table 3). Interestingly, their attractiveness is decreasing, as they have been shrinking over the last two years. Even though eSigma.com, RemoteMethods and StrikeIron's Marketplace are significantly smaller in terms of the number of entries, they seem to be gradually expanding their service offering and have experienced at least moderate growth lately.

Table 3: Overview of Web services offering

	e-Sigma	Remote Methods	StrikeIron Global Direct.	StrikeIron Marketplace	X-Methods
Number of Web services (own data collection)					
October 2005	N/A (N/A)	N/A (246)*	N/A (1779)*	50 (155)*	555
October 2007	192 (259)*	337 (344)*	618 (1037)*	74 (218)*	509
Trend	N/A	+40%	-42%	+41%	-8%
Number of Web services according to [1]					
January 2006	N/A	322	N/A	207	490
Web services offering (as of October 2007 / own data collection)					
Address, Location & Identity Verification	17.76%	34.88%	2.41%	11.47%	-
Business & Finance	45.95%	25.87%	37.51%	56.42%	-
Communications	10.04%	6.10%	14.08%	0.92%	-
Consumer	6.95%	0.00%	0.39%	1.83%	-
Government	2.70%	0.00%	1.83%	0.92%	-
IT Services	0.00%	0.00%	17.16%	0.46%	-
Media	2.32%	2.62%	0.00%	0.00%	-
Miscellaneous	0.00%	9.30%	1.54%	3.21%	-
Utilities	11.20%	7.85%	8.68%	1.83%	-
Value & Manipulation	3.09%	13.37%	16.39%	22.94%	-
Price model (as of October 2007 / own data collection)					
Chargeable WS (%)	80.7%	41.2%	17.0%	100%	26.7%
Functions provided by Web service directory (as of October 2007 / own data collection)					
Informational	Service description incl. quality reporting;	Service description incl. quality reporting; reviews, rating;	Service description;	Detailed service description incl. quality reporting;	Short service description;
Matching	Search; Price discovery	Search; Price discovery;	Basic search;	Basic search; Price discovery;	N/A
Customization	N/A	N/A	N/A	N/A	N/A
Transactions	N/A	Monitoring	N/A	Settlement (subscription); Monitoring; Testing	Testing
Assurance	N/A	N/A	N/A	Commercial agreements	N/A
Logistical	N/A	N/A	N/A	N/A	N/A
Collaboration	N/A	N/A	N/A	N/A	N/A
Integration	RSS; UDDI	N/A	N/A	Marketplace API; Excel integration	RSS; SOAP interface; WS-Inspection; DISCO; UDDI
Standardization	WSDL; UDDI	WSDL	WSDL	WSDL	WSDL; SOAP; UDDI

* Depending on the realization of the directory, Web services and providers are only displayed according to predefined categories. The resulting numbers may include duplicates due to multiple categorizations.

Although Web services intermediaries claim to provide business-level services, the detailed analysis reveals that many services are extremely fine granular and data-centric. Many Web services offerings still comprise simple transformation and conversion services, e.g. SMS services, the transformation of simple text files in XML format or currency converters. However, Web service providers address specific business requirements and realize small chunks of business logic for

specific scenarios. Among them are validation and verification services which enhance postal address, e-mail or phone information and may be useful in marketing campaigns, credit checking or death index services which can be easily integrated in ordering applications and facilitate real-time fraud detection. The growing number of services in the category 'Address, Location & Identity Verification' as well as 'Business & Finance' underpins this trend. Another emerging focus area of service offerings is regulatory compliance, with the Patriot Act compliance service, safety and product recall services as examples. In addition, services are increasingly customized as notification services that send out alerts as a reaction to specified events. Interestingly, the Web services directories which experienced growth over the last two years have a slightly higher portion of business-level services, i.e. services in the categories 'Address, Location & Identity Verification' and 'Business Services', while the other Web services directories comprise more technical or utility services. Thus, proposition 1 can only partly be confirmed.

By analyzing price models and service providers, our study identifies three different business models with regard to proposition 2:

- *Type 1 – Web services as core competency:* This business model comprises chargeable Web services provided by professional service providers. Table 3 depicts some prominent examples of these emerging service specialists which offer services in the field of address, location and identity verification as well as business services. Pricing models are either transaction-based or subscription-based (monthly or yearly). Prices range from <0.01$ per invocation (one-time purchase), to monthly and yearly fees of more than USD 10,000 (subscriptions with either limited or unlimited number of invocations). Type 1 Web services account for 35% of the total number of Web services in this study.
- *Type 2 – Complementary Web services:* In this case, companies offer complementary Web services to their business partners. Prominent examples include logistics service providers, e.g. UPS or Fedex, which offer Web services for direct access to their online tracking systems, or e-shops, e.g. Amazon.com, which expose e-commerce functions as Web service. The services are offered free of charge and represent the smallest group in this analysis.
- *Type 3 – "Gadget" Web services:* This type of Web service is offered free of charge mostly by individuals, often students or software developers. Type 3 Web services account for around 50% of the Web services listed in the five directories.

Our analysis confirms proposition 2 given that a number of service providers specialize in the provisioning of digital services and have been able to establish a Type 1 business model. With exception of the StrikeIron Marketplace and e-Sigma, which exclusively focus on Type 1 Web services, Web service directories address all three types of business models.

4.2. Web Services Directories

As of today, most Web services directories limit their scope to decreasing the search costs of buyers looking for a particular Web services offering which suits their requirements. As depicted in Table 3, they provide a service catalog with some enhanced trial functionality. However, the level of detail and the reliability of the service description varies widely. Whereas XMethods and RemoteMethods provide short descriptions and link to the service provider for detailed information, the StrikeIron Marketplace and e-Sigma.com deliver a comprehensive documentation including detailed feature lists and example data documentation. With the exception of XMethods, each directory provides one or more means to search for Web services. Despite the fact that private UDDI registries allow for advanced categorization and identification schemes, the investigated Web services intermediaries use rather simplistic search and categorization mechanisms. Searching functionality is reduced to keyword search and simple category browsing with very basic predefined

categories. Unlike in other electronic markets, we were not able to observe increasing personalization and customization of the Web services offerings. Most interestingly and in contrast to the paradigm of an electronic market, not all intermediaries support matching and notably price discovery. Of the 'pure' directories, only RemoteMethods and e-Sigma.com announce the price of a Web service. The StrikeIron Marketplace offers a harmonized subscription model for Web services from different providers, in which subscribers pay either a monthly or annual fee to gain access to and invoke Web services. This fee is based upon the number of actual invocations (from a few hundreds to several millions) the client uses. With regard to the settlement, a decentralized approach prevails and transactions are directly settled between providers and consumers. The StrikeIron Marketplace is the only directory which facilitates B2B transactions between Web service providers and consumers. It establishes the contractual agreement between buying and selling parties as well as the processing of credit card payments and the related payment monitoring and accounting with service providers. All service invocations and replies are resolved through the platform. It provides authentication and authorization against a consumer's subscription and then forwards the request to the service provider. In addition, it offers availability monitoring and usage metering. StrikeIron additionally supports systems integration at the Web service consumer's end by offering pre-defined authentication mechanisms and out-of-the box integration. Using the StrikeIron Marketplace API, software vendors are able to embed service invocations in their applications. As an example, the Salesforce.com administrator can call StrikeIron's US Address Verification Service to correct and enhance customer address information. Besides browser access, some directories support the discovery of services by programmatic interfaces: XMethods provides the most advanced options with SOAP interfaces, RSS feeds, WS-Inspection, DISCO documents and a UDDI Private Registry interface. Given the brief service descriptions and the limited support for price discovery and settlement, it is questionable whether all Web service directories satisfy the requirements of B2B users and are able to facilitate the voluntary exchanges of digital services between Web service publishers and consumers. This particularly applies to XMethods where service descriptions are outdated and incomplete and many links are broken. Whereas proposition 3 only holds for the more advanced Web services directories (e-Sigma.com, StrikeIron Marketplace, RemoteMethods), our analysis confirms proposition 4: Directories with a broader portfolio of services experience growth whereas directories which only provide a service catalog are stagnating.

5. Conclusions and Outlook

In this study, we investigated whether there is practical evidence that Web service technologies foster specialization, thus resulting in an increased offering of B2B Web services by specialist service providers. Despite the great enthusiasm about Web services and its revitalization in the context of Web 2.0, we found that the commercialization of B2B Web services faces a rather slow evolution. With a total amount of several 100s Web services, there is only weak empirical evidence that Web services technologies have generated significant market opportunities for Web service providers so far. Recently, we have been able to observe an increasing 'professionalization' with a number of commercial Web services specialists, such as Dun & Bradstreet, ServiceObjects or Xignite, that have entered the market and continue to expand. In view of this development, it might be argued that the Web services market has still not reached maturity and that a number of factors might foster market take-off in the near future. On the one hand, businesses have started implementing service-oriented architectures and are better prepared to adopt Web services today than they were in 2002. On the other hand, our study suggests that Web service providers in the area of compliance, online validation and alerting are setting up Type 1 business models. Due to the increasing availability of digital content and real-time information, more services of this type are to be expected.

From the growth rates of the different Web services directories we conclude that service discovery, i.e. the provisioning of a service catalog, does not provide a sustainable value proposition for Web service intermediaries. From our study, we conclude that the role of intermediaries is evolving and that the existing players have taken different evolution paths: Whereas at the one extreme X-Methods provides a flat listing of Web services targeted at the large technical community and in particular the many individual software developers, e-Sigma.com, StrikeIron and RemoteMethods are focussing on business users and the commercial Web services market. RemoteMethods positions itself as 'the source for finding reliable Web Service Providers (WSP)', i.e. a neutral platform providing review and rating mechanisms as well as price and service transparency, and thereby evolves into a typical infomediary. e-Sigma provides a comprehensive self-service discovery and publication platform with a focus on facilitating standard-based process collaboration. It might evolve into an exchange at a later stage. StrikeIron has established a transaction-based remuneration model as so-called Web Services Marketplace and assumes the role of an electronic market. For Web service consumers, StrikeIron acts as a single point of contact, which facilitates transactions with multiple service providers and provides a reliable institutional infrastructure for conducting business. In order to develop its Web services offering and to increase its attractiveness as a sales channel, StrikeIron supports service providers with co-marketing efforts, flexible pricing mechanisms, billing and account management. Intermediaries will have a role to play in facilitating interactions with a wider spectrum of trusted service providers, as long as the market is fragmented. However, disintermediation is also a possible scenario, if the specialist Web services providers evolve into a handful of well-known 'brands' and establish their own online sales channels.

The results from the present research cannot be interpreted without taking the study's limitations into account. Most importantly, our empirical base has been restricted to open Web services directories and Web services that are publicly accessible. Whereas our study focuses on the Web services directories which have been established around 2002, it does not consider the emerging service catalogs which have been built by software vendors and a number of newer service registries, such ProgrammableWeb.com and Mashable.com, that introduce newer Web 2.0 styles services. It should be also noted that the focus of our study is strictly on Web services (as defined by the use of the core Web service standards). Consequently, we have not addressed the more general theme of digital services (which some authors also denote as Web services).

With regard to related work, only two other empirical studies related to the Web services market exist to our knowledge: van den Heuvel and Smits [1] analyze the structure of the Web service market in comparison to software components. Bachlecher, Siorpaes, Fensel and Toma [33] review the existing approaches toward Web service discovery based on an analysis of Web services directories and Web services search engines. While focusing on the role of Web service directories, both studies do not provide any details on the commercialization of Web services and the structure of the Web service offering. In a recent publication, Nüttgens and Dirik [34] identify business models for Web services based on a multiple-case study research design. Their findings confirm the results from our study, notably the three business models outlined in section 4.

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