The Future of the Internet of Services for Industry: the ServiceWeb 3.0 Roadmap

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Abstract. The Internet of Services foresees a future Internet in which the provisioning of, access to and use of services will be as widespread as data is today. A number of challenges must be still overcome if this is to become a reality, and it is our belief that semantic technologies can address many of these challenges. We foresee as a result of the combination of SOA and semantics the creation of a "Service Web" – a web in which billions of parties expose and consume billions of services seamlessly and transparently. This paper presents the work done in the European Support Action ServiceWeb 3.0 to produce a specialized roadmap on Services in Industry. Drawing on expert opinions about the uptake of services and current R&D advances and timelines for service technologies taken from EU projects in the Future Internet activity, we present a consensus view of the future development and uptake of the Internet of Services, including expert insight on the role of semantic technologies in resolving barriers to realization.

Keywords. Internet of Services, Service Web, Roadmap, Semantics.

Introduction

The specialised roadmap "Services in Industry" by the European Support Action ServiceWeb 3.0 anticipates the emergence of an Internet of Services, forecasting the technological developments associated with the Global Service Delivery Platform (GSDP) in which we believe semantic technologies will help overcome many current barriers to realization. This combination of semantics and SOA technology will create what we call a "Service Web" in which billions of parties consume billions of services seamlessly and transparently. The roadmap aims to present a consensus view of the future development and uptake of the Internet of Services, including expert insight on the role of semantic technologies in resolving barriers to realization.

In this chapter, we present a summary of the roadmap. The full roadmap will be released at the ServiceWeb 3.0 website[1] and via the STI International roadmapping service[2]. We undertook in particular two actions which are reported here:
(1) Gathering responses to an online survey of experts from the semantics and services community, with a particular focus on professionals from industry who are potential early adopters of emerging Service Web technologies;
(2) Input from the ServiceWeb 3.0 consortium, representing a body of research organizations with a R&D focus on enabling the Internet of Services.

1. Outlook for the Service Web

What are the prospects for the Service Web? We should be cautious: not long ago, agent systems were touted as solving a similar set of problems to those addressed by web semantics and services. The AgentLink roadmap [1] predicted mainstream takeup of agent-based systems in 2010, but we can now see this will not happen. Will the Service Web succeed where agents stumbled?

Market analysts have been and still are very optimistic about the technologies which underlie the Service Web, as opposed to agent-based systems. In 2004, Gartner described Web services as "the wave of the future" and predicted SOA would be "mainstream in Global 2000 companies" by 2007[3]. Most recently, Gartner noted that SaaS sales would surpass $6.4 billion in 2008 and forecast a market of over $14.8 billion in 2012[4]. The Gartner Hype Curve for 2009 places SOA on the "slope of enlightenment", while the accompanying priority matrix for emerging technologies has SOA and Cloud Computing as transformational technologies reaching maturity in the next 2-5 years[5].

In combination with the Internet of Things, which foresees billions of new Internet enabled devices, an Internet of Services will include user-generated services and services connected to sensors and devices; in short, we expect a massive explosion of Internet-based services raising new challenges for scalability, heterogeneity and dynamicity. Here, semantic technologies are being presented as the basis for solutions in data and service management.

The World Wide Web consortium (W3C) considers semantic technologies to be on the cusp of maturity and widespread uptake[6]. This is reflected in growing industry interest and uptake, seen in W3C business use case collection and attendance figures at the main business conferences for semantic technologies (SemTech with >1000 attendees

[1] http://www.serviceweb30.eu
[2] http://roadmap.sti2.org
[3] http://www.zdnet.com.au/news/software/soa/Web-services-are-the-wave-of-the-future-Gartner/0,130061733,139149602,00.htm
[4] http://sandhill.com/opinion/daily_blog.php?id=7&post=473
[5] http://www.readwriteweb.com/archives/gartner_hype_cycle_2009.php
[6] See the presentation at http://www.w3.org/People/Ivan/CorePresentations/Applications/

in 2009, European Semantic Technologies Conference with >200 attendees in 2008). The Semantic Wave 2008 report from Mills Davis [2] forecasts:

- Public and private sector R&D relating to semantic technologies in the 2008-2010 period will exceed $8 billion.
- Global ICT markets for semantic technology infused products and services will grow from $2.1 B in 2006 to $52.4 B in 2010.
- Enterprise adoption of semantic technologies will increase dramatically. Public and private sector enterprises represent three-fourths of global ICT spending.

In Gartner's priority matrix for emerging technologies, on the other hand, Semantic Web is a high priority development which is expected to emerge earliest in 2018.

Internet visionary Nova Spivack's chart of the Web's trajectory[7] marks the transitions from the first Web to 2.0, and beyond, simply by the Web's age in decades. As such, the future Internet of Services as a combination or evolution of SaaS, mashups and semantics must be seen as emerging in this, the "Web 3.0" decade, i.e. 2010-2020.

However this is far from certain; Mills Davis and Nova Spivack belong very strongly in the highly optimistic corner – Gartner is being more conservative in placing mainstream adoption of service technologies to 2011-2013 and semantic technologies in 2018. As such, the Service Web as combination of both may still be a decade away (2020+).

2. Market and Technology Drivers

Recent reports concerning the future of the Internet focus on many aspects of the Web, underlining issues such as mobility and personalization. These can act as market drivers for the Service Web, while at the same time the Service Web technology must address challenges identified in these areas to be widely accepted and adopted.

Mobile Web

Future prospects of Internet of Services should take into account that in next 10 years mobile phones may become a dominant connection tool. In 2020 according to [3] mobile phones may become the primary Internet communication platform based on internationally accepted standards. New mobile phones differ from the ones used 3-5 years ago. Recent developments changed the way of interaction with mobile devices. Multi-touch, large displays, ability to access Internet over 3G networks or using WiFi, capability for sensing and reacting to motion and changing orientations, built in GPS enabling for locating themselves are important features of today's mobile phones. Moreover, mobile applications and services are delivered currently not only by a company providing the phone, but also by many other providers. These applications are easy to acquire and install and relatively cheap. According to [4] in half a year since the App Store for the iPhone was launched more than 10,000 applications were offered.

7 http://novaspivack.typepad.com/nova_spivacks_weblog/2007/02/steps_towards_a.html

Personal Web

The division between personal and professional time is disappearing. More powerful devices, as well as growing integration capabilities between various devices, enable users to stay connected and react to professional challenges in a moment. On one hand, this brings a hyperconnected future, but on the other adds stress to family and social life. Moreover, users start to personalize information and services they use – which might pose a challenge, taking into account today's approach to web services provisioning models. This trend started with personalized start pages, customizable widgets, but currently users benefit from a growing set of applications that enable reorganizing, configuring and managing online content. The online material may be saved, tagged, categorized, and repurposed using simple point-and-click tools that thanks to open APIs work together seamlessly.

3. Benefits and Challenges in the Internet of Services

The competitiveness of companies depends more and more on their capability of quickly meeting clients' requirements and adapting to changing business environment. Considering new challenges, companies outsource tasks and processes to external service providers in order to focus on the growth of their core activities and competencies. This process may lead to the creation of service ecosystems in the Future Internet with new markets of vendors offering their services[8]. It also causes a number of challenges that need to be addressed, as identified below.

The evolution of service ecosystems is envisioned to progress in the direction of semantically-enabled open marketplaces supporting the concept of dynamic processes and offering services for various stakeholders, namely enterprises, communities, public bodies, citizens and consumers. The emergence of new markets and services as well as new ways of their applications, requires defining **new approaches to ownership** (e.g. in case of composite services) as well as defining and utilizing **new business models** that could be followed by service and platform providers.

The idea of dynamic processes supported by the Future Internet where different services may be used during execution depending on the current state of the environment as well requirements of a specific actor, also impacts the **pricing and billing strategies** that should be utilised by providers and vendors. In contrast to previous situations, consumers are not longer attached to any specific provider and the variety of services offering similar functionality allows for flexible and dynamic selection of services to be used. It will cause unpredictability of the level of service consumption as well as would make some of the pricing models obsolete.

The key element of the Future Internet should be the appropriate service description focusing also on non-functional properties of services. The appearance of a high

[8]Abramowicz, W., K. Haniewicz, et al. (2008). E-Marketplace for Semantic Web Services. Service-Oriented Computing - ICSOC 2008, 6th International Conference, Sydney, Australia, December 1-5, 2008, Springer Berlin/Heidelberg. Volume 5364/2008: 271-285

number of services, including service surrogates, requires more complex approach to the issue of **quality of service and its result.** The main challenge is connected with the creation of relevant quality models that could be used in automated interactions as well as development of methods and tools that would allow for automated assessment (independently of service providers) of quality of services and results delivered by them. The quality of service will become the main factor influencing the organizations choice which partner to collaborate with, thus the available information on various services should allow for performing automated comparisons and analysis of quality characteristics of single services and their compositions.

The Future Internet will facilitate collaboration of partners and development of various **value chain structures**. Various network structures require different **cooperation models** to be developed and followed. The collaboration models need to allow for management of these networks, define the responsibilities of each partner, terms of collaboration as well as data access policies. In addition, the appropriate tools need to be developed that would offer for various forms of collaboration.

Moreover, value chain networks would require creating trusted environments for collaborating partners. The automated interactions as well as personalization of delivered content and services, would also require development of **identity tracking and management mechanisms** for all actors. The automated data collection and identity tracking will definitely facilitate the provision of personalised content and services; however it will also pose a serious threat to privacy in the Future Internet.

4. User Requirements and Projections

In order to acquire the views of industry regarding the Internet of Services, and also insight on their perspective regarding semantic technologies' role in its future, a Service Web 3.0 survey was created and placed online. Through both online and paper distribution, 80 responses were collected.

As was intended with the survey, a significant number of respondents were seniors (CEO, CTO) and IT professionals (Q1). Almost half of the respondents came from industrial organizations (Q2). There was an interesting split between mostly smaller organizations (1-150 employees; 61% of responses) and a significant sample of very large organizations (more than 10 000 employees; 15% of responses) (Q3). Given that the survey was promoted largely to members of the semantics and services community, it is unsurprising that the vast majority of respondents came from organizations which were already considering themselves well versed in SOA and Web Services (84% ranked intermediate or above) (Q4). This is seen in the actual level of uptake of the technologies, when asked if their organization has adopted or planned to adopt one of the following, the percentage of the respondents answering yes was as follows (Q5):

Web Services	85%
Service Oriented Architectures (SOA)	71%
Cloud Storage	37%
Cloud Applications	37%

Software as a Service (SaaS)	55%

Given that the survey reflects the opinions of mostly industrial or research center experts in SOA and Web Services with an early adopter profile regarding these technologies, they can provide us with valuable insights about the preparedness of their representative organizations to take up the next generation of service-based technology and the barriers to that uptake.

Asked which research domains will be most significant for the adoption of future service technology (either as a hindrance or support), it was Security, Privacy and Trust which topped the list (62% choosing it), followed by Network Architectures (50%), Internet of Things (46%) and Cloud Computing (40%) (Q6). Asked which industry domains would be standing to gain most from a future Internet of Services, E-Commerce was the clearest benefactor (39% gave it the highest ranking of 10); on the other domains rankings were more distributed but Supply Chain Management had a majority for a significant benefit (55% ranked 8 or more) closely followed by Business Process Management and Marketing/Advertising (50% and 49% respectively) (Q7).

Domain	Ranked 10/10	Ranked 9/10	Ranked 8/10
E-Commerce	39%	16%	20%
Business Process Management (BPM)	10%	15%	25%
Supply Chain Management	15%	11%	29%
Customer Relationship Management (CRM)	9%	9%	16%
Content Management Systems (CMS)	12%	10%	17%
Financial/Accounting Management	2%	5%	10%
Enterprise Resource Planning (ERP)	5%	10%	20%
Marketing/ Advertising	16%	19%	14%

The three factors identified as having the strongest positive effect on the use of services in industry were (Q8):

- Providing access to various resources anywhere and anytime (50%)
- Ease of exchanging data between various systems (facilitator of communication) (46%)
- Reusability of developed functionalities **and** combining services to create composite applications/business processes (tied with 34%)

The three factors identified as posing the greatest challenge in the adoption of services in industry were (Q9):

- Lack of standardization (52%)

- Unclear economic benefits (42%)
- Inability (due to unwillingness or high costs) to change from current software paradigm (37%)

In terms of the functionalities which could be provisioned for industrial uptake by the future Internet of Services, the respondents saw a clear opportunity in mobile device and access technology (51%), followed by semantic capabilities (36%) and context awareness (32%) (Q10).

More than a third of respondents considered the future Internet of Services as being an enabler for semantic capabilities in industry, i.e. giving enterprises service-based access to functionalities realized through the use of semantic technology such as knowledge management, validation, reasoning or ontology management. Regarding their own organizations expertise in Semantic Web and semantic technology, the majority (51%) was expert or advanced (Q11). The areas of research standing to gain most from semantic technology were considered to be online services and applications (32% ranked it 10, 70% ranked it 8 or higher) and information management (30% ranked it 10, 70% ranked it 8 or higher) (Q12).

Domain	Ranked 10/10	Ranked 9/10	Ranked 8/10
Online services and applications	32%	21%	17%
Business process management	7%	12%	26%
Business intelligence	17%	22%	26%
Information management	30%	24%	16%
Enterprise management systems	5%	9%	16%
Multimedia and content	16%	11%	25%
Social networks	24%	12%	22%
Life sciences	17%	19%	17%
Collaboration systems	15%	17%	25%

In terms of what research challenges were expected to become achievable in the next 10 years, the respondents were most bullish about intelligent large scale content access (21% ranked it 10 and 56% ranked it 8 or higher). Search and discovery, collaboration and scalable interoperability were seen generally positively (44-47% ranking them 8 or higher) while pessimism was clear regarding security, trust and identity (<29% for the same rankings) (Q13). This is particularly interesting as security, trust and identity in particular was seen as significant for the adoption of future service technologies.

Research challenge	Ranked 10/10	Ranked 9/10	Ranked 8/10
Intelligent large	21%	19%	16%

scale content access			
Scalable security, trust and identity systems	7%	12%	10%
Scalable interoperability	12%	12%	20%
Reasoning/ inference-based search and discovery	16%	15%	16%
Reasoning/ inference-enabled collaboration	12%	17%	17%

The three factors seen as going to have the strongest positive effect on the use of semantic technologies were considered to be (Q14):

- Efficient combination of data, information and knowledge (56%)
- Providing better (semi-automatic) support for knowledge intensive processes (45%)
- Automation of data and information management (40%)

The three factors seen as posing the greatest challenge in the adoption of semantic technology were considered to be (Q15):

- Complexity of semantic technology (63%)
- Immaturity of semantic technology (60%)
- Lack of training and experts to use/develop/maintain systems (47%)

In terms of actual or planned adoption of semantic technologies, 49% responded yes to RDF, 51% responded yes to ontologies, 35% use reasoners and 42% dedicated triple stores. Regarding related semantic technology, 40% adopted or plan to adopt Semantic Web Services, 37% adopted or plan to adopt semantic middleware, and 31% adopted or plan to adopt Semantic Wikis (Q16).

Asked if semantic technology would be fundamental in the realization of the Internet of Services vision, 35% strongly agreed and 42% agreed.

5. Conclusion

The Service Web 3.0 roadmap on Services in Industry has collected insight and expertise on the current and future uptake of service technologies in industry, with a particular interest in the role and importance of semantic technologies for the realization of our vision of a Service Web, in which billions of services can seamlessly and transparently be found, executed, composed and mediated over the Web.

There are many benefits for industry in the future Internet of Services but there are also many challenges which must have clear solutions if there is to be significant growth in technology uptake, in particular we see both new business models for the service-oriented economy and resolution of privacy and trust concerns are critical. Usage

scenarios from projects such as NEXOF-RA[9] and SOA4all[10] reflect enterprise benefits and raise mainly as issues the need to lower the barrier to enabling service creation and usage (i.e. for non-experts) as well as service and service infrastructure availability.

Considering technology projections from visionaries, experts and analysts we can note that semantic technologies are regarded to be on the cusp of entering the mainstream, and becoming standard solutions in key enterprise areas such as energy and health over the next decade (2010-2019), approaching ubiquity in urban, industrial and media sectors by 2024[11]. Service technology without semantics (Web Services, SOA, cloud) is equally regarded as on the cusp of wider industry usage and may be considered to be on a similar trajectory with mainstream establishment in many enterprise domains over the next decade. This is backed up by our survey we carried out with professionals, who noted that the usage of SOA technologies are quite progressed and the introduction of semantic technology with the service infrastructure is largely "under consideration", indicating a later timepoint for potential uptake.

Predicated on the overcoming of some significant challenges to the service-centred enterprise vision, we estimate the semantic services technology to be around 5 years behind the semantic and service technologies respectively, since research is already quite advanced and the mainstreaming of the component approaches (semantics and services) appear to be the main prerequisite for wider uptake (the cart not coming before the horse, so to say). This leads us to the prediction that Semantic Web Services (and associated SOA and Cloud approaches) will begin to be taken up significantly in enterprises by 2015 (the next 5 years being for the "early adopters" such as 40% of the respondents of our survey), the Internet of Services (the SOA infrastructure applied at Internet scale) by 2020 (with early adopter usage of semantics in that infrastructure) and the Service Web, the convergence of semantic and service technology at Web scale, by 2025. Leading domains for the technology could be E-commerce, Business Process Management and Marketing/Advertising. As we noted, this is not without the need to address important barriers to the uptake of semantic service technology. Here, our findings indicate that addressing privacy and trust will be critical, together with usability of the service infrastructure for non-experts, standardization and reducing the cost of the technology uptake.

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[9] http://www.nexof-ra.eu/

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[11] For more, see the complementary specialised roadmap D1.2.2 on Semantic Technologies, also from the ServiceWeb 3.0 project http://www.serviceweb30.eu