Services in Industry

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Special Purpose Roadmaps

Lyndon Nixon, Graham Hench (STI2)

Ioan Toma, Emilia Cimpian (UIBK)

Dave Lambert (OU)

Agata Filipowska (PUE)

SEVENTH FRAMEWORK PROGRAMME

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Authors (Partner)	Lyndon Nixon (STI2), Graham Hench (STI2), Ioan Toma (UIBK), Dave Lambert (OU), Agata Filipowska (PUE)			
Resp. Author	Lyndon Nixon		E-mail	lyndon.nixon@sti2.org
	Partner	STI2	Phone	+43-1- 236-4002-13

Abstract (for dissemination)	The specialised roadmap Services in Industry anticipates the future emergence of an Internet of Services, and seeks to forecast the technological developments associated with a Global Service Delivery Platform 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. This document is intended to provide readers with an insight into the potential adoption of service

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Executive Summary

1. Introduction

The specialised roadmap Services in Industry anticipates the future emergence of an Internet of Services, and seeks to forecast the technological developments associated with a Global Service Delivery Platform 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. This document is intended to provide readers with an insight into the potential adoption of service technologies and commercial exploitation of the new possibilities the Service Web will provide to society and private enterprise.

After introducing in the following section the methodology taken in this roadmap to collect input and produce the roadmapping results, Section 3 provides an introduction to and overview of what the Internet of Services is all about, taking a number of different perspectives:

Section 3.1 considers some of the expected benefits of and challenges connected to an Internet of Services;

Section 3.2 gives some more concrete insight into those benefits and challenges on the basis of Internet of Services scenarios, representing business drivers for the technology;

Section 3.3 introduces some of the key technological drivers underlying the Internet of Services, and considers their maturity and development timeline;

and Section 3.4 concludes with external expert opinions and expected market trends related to the Internet of Services.

Following this, 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, based on:

- A 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;
- Input from the ServiceWeb 3.0 consortium, representing a body of research organizations with a R&D focus on enabling the Internet of Services, to the Services and Software Architectures Working Group (part of the Future Internet initiative) identifying both research gaps in and potential solutions arising from the realization of the Internet of Services.

On the basis of this, we ground our belief that the future Internet of Services will see the emergence of a "Service Web" which combines SOA and semantic technologies to make possible a Web in which billions of parties consume billions of services seamlessly and transparently.

Before we proceed, let us define briefly and generally the meaning of several terms used in this roadmap:

(Web) Service – a “service” can be considered both a reference to the provision by some agent of a specific set of actions to a consumer which usually effect some change in the real world and a reference to a software utility provisioned over a computer network (such as the Web) which gives a machine access to that service. For example, a flight booking service can refer to the offered set of actions (book a flight, change the booking, cancellation) by a travel agent (which may be accessed by phone, by e-mail, in person etc.) or to the Web-based service which gives access to the offered set of actions over a specified API or service endpoint, so that software (e.g. other services) may be programmed to make use of that service.

Internet of Services – the application of (Web) services to the scale of the Internet: “a service-oriented Internet would allow the access to complex physical compute resources, data or software functionality in the form of services” [1]

Service Web – the combination of a service-oriented Internet with semantic technologies. It is our belief that the latter are necessary to make possible automated service discovery and execution, mediation of heterogeneous data and process models and orchestration / choreography of service interactions in the complex, large scale environment of the Internet.

2. Roadmap Methodology

This section explains the methodology followed for the production of this specialized roadmap. The methodology proposed in the D1.1 “Future Internet Roadmap” was adopted as the starting point. We developed a specific methodology for Internet of Services and Industry.

The “Services in Industry” specialized roadmap was created in a multi-step process as follows:

- **Identify problem areas and propose realistic solutions –** Our project aims to play a guiding role amongst European research projects that contribute towards the overall Future Internet vision. A core building block of the Future Internet infrastructure is the Future Internet of Services that aims to provide a scalable service-oriented infrastructure that will support rich mechanisms of global service supply. The first step in our methodology is to identify concrete problem areas related to Internet of Services and to propose realistic solutions. As performed in the first general roadmap, we encouraged researchers external to our consortium to take an active role in several working/technical/interest groups co-organized and lead by Service Web 3.0 (e.g. Services and Software Architectures Working Group[1], Future Internet Interest Group[2], Semantic Technology & Ontologies Technical Group[3]). The present document is a reflection of what has been accomplished in these concentrated groups, in addition to reflecting other prioritized problem areas resulting

1 http://services.future-internet.eu/

2 http://www.serviceweb30.eu/cms/index.php/future-internet

3 http://wg.sti2.org/semtech-onto/

from the discourse lead by European Commission.[4]

- **Identify potential technologies –** To identify potential technologies and future directions of research and development in the area of Services in Industry we collected data from a number of sources, principally through: (1) our contributions to the Services and Software Architectures Working Group, (2) interviews with industry professionals about their future expectations regarding the Internet of Services and (3) an online survey which was also distributed on paper to delegates at key events. We detail below each of these methods:

  - ***Contributions to the Services and Software Architectures Working Group***

  A set of requirements on the Future Internet Services Offer (FISO) were produced within the Services and Software Architectures Working Group, which is one of the working groups within the EU Future Internet initiative. It is chaired by Prof John Domingue, from the Knowledge Media Institute in the Open University and president of STI International. These Future Internet Functional Requirements were commented on by the consortium of ServiceWeb 3.0.

  - ***Interviews with selected industry professionals***

  ServiceWeb 3.0 has actively pursued interviews with selected industry professionals to gain some individual in-depth insights into the expectations those who are in industry have regarding the uptake of service and semantic technologies.

  - ***Questionnaire***

  Another method used in the project to determine the predictions of industrial uptake of service-based solutions and the potential role of semantic technologies (in collaboration with the complementary ServiceWeb 3.0 specialised roadmap D1.2.2 on semantic technologies) was the “Services in Industry and Semantics in Services” questionnaire. With the questionnaire, we sought to identify the general consensus of the expert community in addressing industry’s most promising benefits of adopting global networked service solutions envisioned under the emerging Internet of Services. Additionally, we aimed to access a common perception of the coming challenges within the Internet of Services domain where semantic technologies could provide a viable solution. The gathered results were analyzed and are presented in this document.

- **Alignment with related Services roadmaps –** There has been considerable efforts to define roadmaps for Services and related technologies. Such efforts include the NESSI roadmap on Semantically-enabled Service Architectures (SESA) and the NEXOF-RA roadmap for the NEXOF Construction and Adoption strategy for the NEXOF reference architecture. The Service in Industry roadmap is positioned not as yet another roadmap in the same area, but rather we want to consolidate our results with the existing roadmaps in the Service area. The current roadmap can be positioned as an update of the NESSI roadmap. With respect to NEXOF-RA, the current document will be shared with the NEXOF-RA consortium as part of the next

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4 http://www.future-internet.eu/

cycle of requirements collection.

- **Publication of technical roadmap** – The roadmap will be published as a Service Web 3.0 deliverable on the project Web site and will be distributed to the target audiences through all dissemination channels used in the project. In particular we aim to release it as a report to the Future Internet Assembly (FIA) where it will be summarized as part of the FIA Book 2010.

- **Evaluation, refinement** – This roadmap for Services in Industry will be evaluated and refined in the context of the Services and Software Architectures Working Group. We expect it will feed into ongoing and future activities in the Future Internet and Internet of Services domains, such as the NEXOF-RA developments, in the European Technology Platform NESSI and in future technology roadmapping activities of EU FP7 Call 5 projects (beginning in 2010).

3. The Future Internet of Services

3.1. Benefits and Challenges

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[5]. 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 number of services,

[5] 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

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.

3.2. Scenarios

There are a number of scenarios for the Future Internet of Services already identified in several European projects. These scenarios are meant not only to identify the functionalities and the business areas addressed by the Future Internet of Services, but also to underline the existing problems as well as the research questions raised when trying to implement the scenarios. This section re-iterates through some of the scenarios identified in NEXOF Reference Architecture (NEXOF-RA[6]) project and in the Service Oriented Architectures for All (SOA4All[7]) European FP7 integrated project.

The first scenario considered in this section is the ***Service procurement*** scenario defined in NEXOF-RA S1. This scenario considers the existence of professional service providers and consumers at all levels, from complex business processes to services providing data or access to virtualized resources. The consumers search for services based on their functional requirements, such as transaction costs, and non-functional requirements like security, reliability and so on. These requirements are fed into a search engine which ideally would include semantic data for determining equivalent services, and will return the list of appropriate services to the consumer. The scenario also considers the existence of alternative mobile devices, in which case the search engine should be able to search and also provide the results in these environments.

Based on the results provided by the search engine, the consumers can further select the service(s) they want to use. Furthermore, they complete a SLA template with the quality level

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

[7] http://www.soa4all.eu/

they expect. After passing this SLA template to the provider, and obtaining agreement on the use of the service the provider has to send the end point reference, which allows the consumers to use the service.

The final activity is paying for the use of the service, which can be done either during the consumption or after the service was user. The payment conditions should also be specified in the SLA.

The research problems and challenges raised by this scenario can be summarized as follows:

1. The standard representations of SLAs, and standard protocols for their negotiation and monitoring or uniform descriptions for services of different types are not taken up by a large community?
2. Some of the devices and channels used for consuming the service may be switched off
3. The consumers are not able to generate their requirements or to select the services
4. The providers cannot fill in the SLA template for their services
5. It is not possible to find SLA descriptions of complex composed services across providers (in the case of composite services).
6. The selected services are incompatible.

A second scenario described in this section, the ***Service Lifecycle*** scenario, was also identified in the NEXOF-RA S1. In this scenario, the service lifecycle is considered to consist of the following stages: service development, identification of resource requirements, the development of the SLA template, testing and simulating the services, advertisement of the service, negotiation and sales, implementation and execution, assessment and finally, decommission. There are three actors involved in the service lifecycle, namely the service developer, the service provider, and of course, the consumer, each of them with well defined task. The service developer is responsible for developing the service and determining the resource requirements; the service provider is the one who develops the SLA template, tests and simulates the services, advertises the service, implements and executes it, makes the assessments and finally decommissions the service; the service consumer is responsible only for negotiation and sales activities.

There are a number of research questions and problems raised by this scenario:

1. The lifetime of value for services-based content is not known, it can be anything from a couple a minutes to a number of years.
2. The lifetime of service-based assets may be longer than the one of the actual service.
3. The SLA template lifecycle is a process of collaborative decision making.
4. Application and resource lifecycle is developed independently of the service lifecycle.
5. The lifecycle of customer and community interests transition faster than service development activities.
6. “too much” adaptability is offered by service providers in SLA templates and APIs
7. Customers want to know risks in networks of services offered by their providers.
8. Customers need predictions on when an SLA may be breached.
9. Services need to be developed by non-IT experts.

A further scenario is ***Semantic Business Process Management***. An industry scenario that would benefit from the Semantic Technologies and Future Internet of Services is Business Process Management in enterprises.

Business Process Management (BPM) includes methods, techniques and tools to support modelling, implementation, execution and analysis of business processes[8]. It is often combined with SOA paradigm, as together these two approaches offer additional benefits. While BPM specifies business directions, goals and processes that define how the organizational resources (including IT resources) are used to achieve business goals, SOA offers a flexible IT architecture that may be easily adapted to changing business requirements and helps to leverage IT investments through provision of reusable components[9].

Semantic Business Process Management provides extensions to the traditionally understood Business Process Management by applying Semantic Technologies in all phases of the BPM lifecycle. This enables also application of Semantic Web services while implementing business processes what is discussed later in this section.

Reviewing the existing initiatives within the SBPM field, two main groups of use cases of applying semantic technologies to BPM can be distinguished[10], namely:

- applying semantic technologies (especially reasoning) to analyse semantic enterprise models and
- applying semantic technologies to create entirely new models or to create new parts of enterprise models.

From the point of view of this roadmap the important features concern semiautomatic construction of business processes, supporting the evolution of a process, and semiautomatic retrieval and reuse of process artefacts.

Describing process models using semantics allows for their effective categorization and cataloguing. This also facilitates discovery of processes or process fragments and allows for efficient reuse of already modelled processes[11]. The semantic annotations allow not only for efficient process discovery but also auto-completion of processes as during modelling similar already existing process models can be identified with respect to a modelling context (e.g. goals, process builder's intentions and requirements)[12].

Based on description created in the modelling phase, a semantically annotated process model may be further translated into executable process descriptions thus bridging the

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[8] W.M.P. van der Aalst, A.H. M. ter Hofstede, M. Weske, "Business Process Management: A Survey" in proceedings of the International conference of Business Process Management, 2003. Eidhoven, The Netherlands, June 26-27.

[9] Michael P. Papazoglou, Paolo Traverso, Schahram Dustdar, Frank Leymann: Service-Oriented Computing: State of the Art and Research Challenges. Computer, 2007. 40(11): p. 38-45.

[10] Hepp M. et al. (2005) Semantic Business Process Management: A Vision Towards Using Semantic Web Services for Business Process Management. Proceedings of the IEEE ICEBE 2005, October 18-20, Beijing, China, pages 535-540.

[11] Markovic I., de Francisco D., Martinez J., Munoz H., Perez N. (2008) Methodological Extensions for Semantic Business Process Modeling, Proceedings of the 10th International Conference on Enterprise Information Systems, pages 410-415, Barcelona, Spain.

[12] Born M., Brelage C., Markovic I., Pfeiffer D., Weber I. (2008) Auto-completion for Executable Business Process Models. Workshop on Advances in Semantics for Web services (semantics4ws), in conjunction with BPM 2008, Milan, Italy, pages 1-6, September 2008.

business-IT divide[13]. This requires transformation of the process and linking the process model to the available IT infrastructure. Mentioned transformation is automated and is realised by the task composition functionality that assigns to each task within a process model a composition of semantic web services able to fulfil the task's goal[14]. If two interacting web services use different data structures, a mediator can be used to moderate between the different data formats. This is possible, because the data formats of services are also defined using semantics.

As SBPM applies Semantic Technologies, it may also benefit from such platforms as a global and open Service Delivery Platform defined by ICTAG[15]. The platform is to go beyond the client-server model of service delivery and support rich mechanisms of global service supply, where third parties have the capability to aggregate services, act as intermediaries for service delivery and provide innovative new channels for consuming services. The platform could apply mechanisms of the SBPM to orchestrate services and create implementations of business processes as well as may become a source of services for a typical company using distributed services in its everyday work.

The last scenario, the ***Web21c Telco Application Design*** scenario was identified in SOA4All. This scenario involves building up Web Service composition to create a new web application using a Web21c service as a starting point. As the focus of S1 is on casual users building and non-critical applications, the scenario involves minimal security or management infrastructure.

The users of the infrastructure undertake a number of steps, envisioned to be most of the times executed in the same precise order:

- log-in into the system,
- select the option to create a new application
- select the context parameters
- search for appropriate services
- select the services and load them into the workspace
- with the help of the system, create the composition structure
- design GUI or even add some necessary code
- execute/test the services
- saved and possible share the application with other users
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On the other hand, the services have to support a number of activities:

- authentication
- call flow
- conference call
- inbound SMS
- messaging

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[13] Karastoyanova D., van Lessen T., Leymann F., Ma Z., Nitzsche J., Wetzstein B., Bhiri S., Hauswirth M., Zaremba M (2008) A Reference Architecture for Semantic Business Process Management Systems. Track "Semantic Web Technology in Business Information Systems" at the Multikonferenz Wirtschaftsinformatik 2008, pages 1727-1738, Munich, Germany, February 26-28.

[14] Weber I., Hoffmann J., Mendling J., Nitzsche J. (2007) Towards a Methodology for Semantic Business Process Modeling and Configuration, SeMSoC-07: Proceedings of the 2nd International Workshop on Business Oriented Aspects concerning Semantics and Methodologies in Service-oriented Computing, September 2007, pages 176 – 187, Springer-Verlag.

[15] ftp://ftp.cordis.europa.eu/pub/ist/docs/future-internet-istag_en.pdf

- voice call

The problems raised by this scenario are:

1. Limited technical knowledge from the users part (not familiar with programming languages, not familiar with composition techniques);
2. Services availability – a service available during the initial build of the application may be unavailable when a second user wants to access it;
3. Several service composition may not be available to all the users due to restrictions imposed by a particular service. However, it may be possible to replace that service with an alternative one with the same functionality.

This section describes four scenarios representative for the existing problems faced by the future Internet of Services. |The scenarios were identified and presented in the NEXOF Reference Architecture (NEXOF-RA) project and in the Service Oriented Architectures for All (SOA4All) European FP7 integrated project. The first scenario, the ***Service procurement*** scenario defined in NEXOF-RA S1, considers the existence of professional service providers and consumers at all levels, from complex business processes to services providing data or access to virtualized resources. The problems identified in this scenario are mainly referring to the communication and collaboration. The second scenario ***Service Lifecycle*** (also identified in the NEXOF-RA S1) considers the service lifecycle consisting of multiple stages, and analyzes the problems that may appear in each of these stages. The third scenario, ***Semantic Business Process Management***, noted how semantics could be used to validate, analyse and evolve enterprise process models and the need to support the construction and re-use of the semantic process models. The final scenario described in this section, the ***Web21c Telco Application Design*** scenario was identified in SOA4All. This scenario involves building up Web Service composition to create a new web application, and the problems raised are referring to the users' background knowledge and technological infrastructure.

3.3. Fundamental Technologies

In this section we give an overview of state of the art technologies that are fundamental for driving the emergence of the Service Web. Furthermore we define for each of these technologies future direction of research. The fundamental technologies that we investigate in this section are: Web Services and Service Oriented Architectures (SOA), Semantic Web Services and SESA, Cloud Computing, Software-as-a-Service and Everything-as-a-Service.

Web Services and Service Oriented Architectures (SOA)

One of the concepts that changed the current industrial landscape in terms of how distributed computing is done is the concept of ”Web services”. Web services are ”modular, self-describing, self-contained applications that are accessible over the Internet” 0. They can be seen as an effort to build a distributed platform on top of the current Web, adding a new level of functionality to it. A set of Web services technologies, most of them standardized by various standardization bodies (e.g., OASIS, W3C), provide the means to communicate and integrate Web services-based applications. Three of these technologies form the foundation of most Web services based systems, namely: (1) WSDL 0 as an XML description language for Web services, (2) SOAP 0 as an XML-based message format to exchange arbitrary XML data between services and clients, and (3) UDDI 0 as data model and API for Web service registries. We briefly describe below the three technologies mentioned before.

One of the technologies that gathered a lot of momentum in the last years is SOA, the Service Oriented Architecture. SOA is the architecture that supports services-orientated computing being centered around the notion of service. Using SOA various pieces of functionalities can be exposed, assembled and re-used in a standardized manner. Services are the central pillars being the entities that really count for a customer. In a world of services, users are concerned only about the services and not about any software or hardware components that implement the service. However, services will not be able to interact automatically and SOAs will not scale without signification mechanization of service discovery, negotiation, adaptation, composition, invocation, and monitoring as well as service interaction requiring data, protocol, and process mediation. For SOA to reach its full potential we need automatization and accuracy to the service related tasks mentioned before. Semantic technologies could provide real benefits with respect to automatization and accuracy. The next generation of SOAs will integrate semantics moving towards a semantically enabled architecture, Semantically Service Oriented Architecture (SESA). This new paradigm will introduce a set of new challenges that need to be addressed. Future research will focus on realizing the SESA vision, on providing scalable techniques for all service related tasks.

Semantic Web Services

Semantic Web services are building on top of Web services technology by describing various aspects of services using explicit, machine-understandable semantics that enables a certain degree of automation for various service related tasks. In a nutshell, the work in the area of Semantic Web 0 is being applied to Web Services in order to keep the intervention of the human user to a minimum. Semantic mark-up can be exploited to automate the tasks of discovering services, executing them, composing them and enable seamless interoperation between them, thus providing what are also called intelligent Web Services. The description of Web Services in a machine-understandable fashion is expected to have a great impact in areas of e-Commerce and Enterprise Application Integration, as it can enable dynamic, scalable and reusable cooperation between different systems and organizations. These great potential benefits have led to the establishment of an important research area, both in industry and academia, to realize Semantic Web services. A set of approaches for Semantic Web Services were developed so far (e.g. WSMO 0, OWL-S 0, SWSF 0, WSDL-S 0 and SAWSDL 0).

Semantic Web services technologies have the potential to play a decisive role in the defining and realizing the global platform that enables easy access and consumption of billions of services in the future. As identified by the European Commission, on important building block of the Future Internet is the Internet of Services that is strong related to the concept of a global and open Service Delivery Platform. Such a platform will go beyond the client-server model of service delivery and will support rich mechanisms of global service supply, where third parties have the capability to aggregate services, act as intermediaries for service delivery and provide innovative new channels for consuming services. The role of Semantic Web services is to enable and support the automation, to a certain degree, of all the service related tasks. To achieve this goal we need to provide new techniques, methods and tools that enables easy to personalize, combine and use of services by the end-user. Further research is needed in the areas of service parameterization, service federation, lightweight descriptions and modeling of services.

Cloud Computing

Cloud Computing is the term used to describe the ability to provide computing resources (power, storage and communication) as a service. Nowadays, important IT players have in place such services. For example Amazon offers infrastructure as a service in two forms: a storage service (S3 service) which allow clients to write and read objects up to 5GB and a computational service (EC2) which allow clients to rent computers on which to run their own computer applications. A Cloud Computing infrastructure could bring a lot of benefits for companies. They will rely on the on cloud computing instead of relying on their own in-house services. The impact of an Internet of Services increases dramatically and, moreover, it has to be able to deal with service delivery on a web-scale. At the data level, which in the end can be seen as a resource, we have been noticing lately an increase of semantic data, inter-liked data available on the Web. Most noticeable is the Linked Open Data initiative[16] that connects islands of data from various domains. We believe that more research is needed in the area of Cloud Computing-based infrastructures that will allow easy and fast management of data and other resources. Especially in the context of linked data one would need solutions for robust and scalable virtualization infrastructure for analyzing and processing large amount of data sets, solutions for data management of the semantic data as well as fast access and retrieval.

Software-as-a-Service (SaaS)

We are continuously witnessing an abstraction process in Computer Science, starting with the abstraction from hardware resources to software and nowadays from software to services, with the emergence of Service Oriented Architectures. Software, as any other resources, is seen as a service in a Service Oriented Architecture. On the other hand hardware advances have vastly outpaced those of software in part due to the lack of complexity, layering, and challenges of legacy software. There is much cost and complexity in developing software solutions and thus the question of reusability in different context of existing software is becoming more important. Luckily, Service Oriented Architectures provide the means to abstract the software at the level of services that are reusable pieces of functionalities. However, as was mentioned before, solutions for providing existing software products as services only through the SOA means will not scale. Semantics will easy the integration of software components, which is done largely manually. Integration must be resolved largely dynamically between millions of services that abstract from software components. This underscores the critical role of semantics in SOA. Further research is needed to redefining the way software engineering is to be performed. We need new approaches that enable easy design, personalize, combination and usage of software components as services.

Everything-as-a-Service (XaaS)

The abstraction process mentioned above is progressing to “service-ize” more than just the applications which are executed. Platform-as-a-Service refers to the provision of a computing environment via a service in which applications can be remotely implemented, tested and executed. Hardware-as-a-Service refers to the provision of computing hardware, or the virtualization thereof, by a service so that available storage, memory or computing performance can be dynamically adapted to running application needs. As not only software but hardware and other real world functionalities are recreated virtually and offered as services, the trend is referred to of “Everything as a Service” which underlies the expected

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[16] www.linkeddata.org/

growth of the future Internet of Services.

3.4. Future projections

The services wave – where are we now in the Internet of Services? What are the projections for 5, 10, 15, 20 years from now? What role can semantic technologies play in enabling and bringing to maturity the Internet of Services, what we call the "Service Web"?

What are the prospects for the Internet of Services? In this section, we lay out the current position of services and semantics as they apply to the emergence of an Internet of Services, look at the views of influential opinion makers, and look at potential downsides from legal conflicts in this fundamentally new arena.

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 [12] predicted mainstream takeup in 2010, but we can now see this will not happen. Will the Internet of Services 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[17]. 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[18]. 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[19].

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[20]. 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 in 2009, European Semantic Technologies Conference with >200 attendees in 2008). The Semantic Wave 2008 report from Mills Davis [13] 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.

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[17] http://www.zdnet.com.au/news/software/soa/Web-services-are-the-wave-of-the-future-Gartner/0,130061733,139149602,00.htm
[18] http://sandhill.com/opinion/daily_blog.php?id=7&post=473
[19] http://www.readwriteweb.com/archives/gartner_hype_cycle_2009.php
[20] See the presentation at http://www.w3.org/People/Ivan/CorePresentations/Applications/

A well-known graphic[21] from Twine creator Nova Spivak shows his view of the Web's trajectory, where he marks the transitions from the first Web to 2.0, and beyond, simply by the Web's age in decades. Such a scheme makes a lot of sense: there are no clear criteria for demarcating the Web's progress, and a time-based segmentation of the continuum of progress makes more sense than an arbitrary selection of technologies. Interestingly, 'web services' as a term does not appear in that figure—'SaaS' (Software as a Service) is not quite the same. We believe that the addition of services and semantics will bring profound change, there will be no discontinuity in the Web, but rather a continuous accretion of increased functionality. As such, the future Internet of Services as a combination or evolution of SaaS, mashups and semantics must be seen as emerging in the Web 3.0 decade, i.e. 2010-2020.

3.4.1 Evolution of the Future Internet of Services

Recent reports concerning the future of the Internet focus on many aspects of the Web, underlining issues such as mobility, personalization and virtual reality. Services and Semantic Web services must address challenges identified in these areas to be widely accepted and adopted. Paragraphs below shortly elaborate on these topics.

Mobility and the Future Internet

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 [14] 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 [15] in half a year since the App Store for the iPhone was launched more than 10,000 applications were offered.

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.

User interfaces and augmented reality

[21] http://novaspivack.typepad.com/RadarNetworksTowardsAWebOS.jpg

New user interfaces in the Future Internet will probably follow the 4T principle: typing, talking, touching and thinking. There is no agreement however on possible success of voice-recognition, wireless keyboard advances or interfaces involving touch and gestures[22]. Some experts predict introduction of a thought-based interface - neural networks-based interface offering mind-controlled human-computer interaction. Another phenomenon of growing importance is virtual worlds and augmented reality. Currently, in the web one may play games such as Second Life, but also visit a museum or public institution. According to the presented survey by 2020 augmented reality and virtual reality might reach the point of blurring with reality. This may provide new opportunities for conferencing, teaching, and work, however the interfaces have to be much more intuitive to become universally adopted.

3.4.2 Business 3.0

There are already many companies active in the web services area. The concept itself is solidly established in business, being responsible for a large amount of revenue both directly as services are sold, and through the efficiency gains made possible by them. Moreover, services architectures are becoming the default for fielding new IT infrastructure.

Companies directly offering services include Amazon, with a large set of industry-scale services including global, replicated file storage and distribution, and an 'elastic computing cloud' where customers can run their own software on Amazon's servers. Free or 'freemium' services like Flickr, Google Maps, and others are popular with the public and are often seen in 'mashups'[23]. These mashups themselves can now be created through other services, like Yahoo!'s Pipes[24].

Semantics have an important role in connecting business services with web services. Companies like Telefónica and France Telecom are excited by the prospect of using software tools—such as those produced in the SUPER project—to tie together their business process management with the technical and implementation level[25].

Businesses exploiting or based on Semantic Web technologies are less common, but are appearing. High profile ones include Radar Network's Twine6 , which lets users add a semantic overlay to their online usage, and Garlik[26], which uses Semantic Web technologies to manage online privacy.

3.4.3 Delphic View

For better or worse, the opinions issued by major analysts like Forrester, Gartner, and IDC have a major impact on the direction many companies take in their use of IT. What do the big-name analysts make of the Internet of Services? These analysts have been silent on the issue of semantic web services, since they are currently still in the lab. They have, however, expressed many and varied opinions on services and semantics taken independently.

Some are still highly dubious of the prospects for the semantic web[27], let alone semantic

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[22] ANDERSON Janna Quitney, RAINIE Lee, The Future of the Internet III, http://www.pewinternet.org/pdfs/PIP_Future_of_Internet.pdf.
[23] http://en.wikipedia.org/wiki/Mashup_(web_application_hybrid)
[24] http://pipes.yahoo.com/pipes/
[25] http://www.sciencedaily.com/releases/2009/08/090807091202.htm
[26] http://www.garlik.com/
[27] http://blogs.forrester.com/business_process/2009/03/after-so-many-years-of-ballyhoo-semantic-web-still-

services. Gartner has been less than enthusiastic about the Semantic Web:

> “. . . not providing the same kind of fundamental change as blogs, wikis and social networking tools. . . It’s not going to be another era like Web 2.0. However, there will be some very interesting innovative things coming out. If you’re in love with numbering schemes, maybe it’s Web 2.1.”---Gene Phifer, Gartner[28]

This is especially odd given Gartner’s ‘Top 10 technologies for 2009’: virtualisation, cloud computing, servers beyond blades, Web-oriented architectures, enterprise mashups, specialised systems, social software and networking, unified communications, business intelligence and green IT. Every one of these would benefit from semantic technologies, and several will depend on it as they become more widely adopted and lack of semantic technology support limits their scalability.

Where blogs and other Web 2.0 approaches made it incrementally easier for humans to communicate, Web 3.0 will make human-machine and machine-machine communication of knowledge a reality. To believe that blogs and wikis are somehow more ‘fundamental’ than a global, formal knowledge-base—a giant logic program—seems incredible to those engaged in semantics research, but it may be a common view amongst those from other backgrounds. If the impact of thoroughgoing semantics is really in a blind-spot for much of the industry, we predict that that semantics will be truly disruptive in a way that Web 2.0 was not, but the ambivalence will make encouraging uptake more difficult. These two facts combine to make semantics a potentially enormous competitive advantage for companies that invest early and deeply.

On services themselves, the consultancies are more upbeat: but then, the bandwagon there is already rolling.

3.4.4 A Legal Cloud

As ever in computing, patents, copyright, and privacy concerns add to the technological obstacles facing adopters. Microsoft has recently been granted a patent for using XML to store word processing documents [1]. Opening gambits in Semantic Web lawsuits have already been made. Media company Thompson Reuters sued George Mason University over the Zotero semantic bibliography management system, claiming that Zotero’s import filter for EndNote styles infringed its technology and business[29]. The lawsuit was dismissed, but Zotero now carries a specific extra license condition for use of EndNote files, and the fact that the suit was ever filed is concerning. Thompson is the ultimate owner of OpenCalais, a promising Semantic Web venture, which uses a Thompson controlled vocabulary to tag data: will Thompson claim ownership of data mixed up with the OpenCalais vocabulary?

Prior art, and lack of innovation aside, these kinds of threats to the very foundations of the Semantic Web are disturbing. Those who understand the benefits of Semantic Web technologies must be more active in directing policy decisions to ensure that the Web of data can be used as intended. While some benefits accrue even in a world of closed shops, the

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searching-for-killer-app.html

[28] http://www.networkworld.com/news/2007/092107-gartner-web20.html?netht=092107dailynews2&&nladname=092107dailynews

[29] http://chronicle.com/blogPost/Maker-of-EndNote-Citation-S/4272/

real benefits of semantics come when they are opened up. Businesses must decide how they will balance the future of open data and services: will they have confidence in their own ability to innovate with open data and services, or put up walls to keep their own offerings special?

3.4.5 Conclusion

Future Internet will involve other application areas such as virtual reality or personal applications. It will be accessed by a wide palette of devices including plethora of mobile devices.

The applications and their interfaces will differ – they will be processed by machines using semantic technologies but also accessed by users using 4T methods. The number of applications and their providers will increase, so new business models will evolve. Users will use Internet more frequently and intensively than they do now. They will tag information, combine mash-ups and evaluate. This may however not extend to the companies, that still have doubts connected with relying on company-external providers and combination of services coming from different providers to obtain software supporting their work. Even flexibility and agility in creating and changing cross-enterprise applications (using merely visual, complexity-hiding modeling interface) may not be appealing. However, if or when the competitive advantage of using a services-based approach significantly exceeds the non-services-based approach, it may be that even this "late majority" will eventually join the Internet of Services.

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 at http://survey.sti2.org/index.php?sid=23161&lang=en

The survey is attached in Appendix I.

5. Technical requirements and projections

For the Future Internet Assembly held in Prague, May 2009, the Future Internet Services and Architectures WG formulated a set of Future Internet Functional Requirements[30], which summarized the foreseen research and technical challenges to the Future Internet of Services, including the underlying Global Service Delivery Platform which provides the infrastructure and services for global access to the Internet of Services. These requirements were split into Visionary (disruptive change from today, with a timespan over 3 years) and Incremental (less than 3 years), and were further placed into categories.

The ServiceWeb 3.0 consortium considered here the important role of semantic technologies to address these requirements through focused research work on ontologies, Semantic Web Services and the infrastructure such as mediators and reasoners. It is our belief that these

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[30] http://services.future-internet.eu/index.php/FIA_Prague#Future_Internet_Functional_Requirements

requirements may only be addressed satisfactorily and at scale through semantics, i.e. through the provision of a semantically-supported Service Web.

Selected functional requirements and the ServiceWeb 3.0 view on how to address the requirement are given below.

Visionary	
Network Technology: availability of network services	The Internet of Services will be enabled by a scalable, ubiquitous service layer (the Global Service Delivery Platform). This layer goes beyond the classical client-server model into global service supply, which means it will need to include components for ensuring spatial-temporal (i.e. from any place, at any time) constant availability of the network services which make possible service delivery. To cope with the added strain from the growth in Internet-connected devices and the shift from data to service communication, we expect network services to become part of the shared (cloud) Internet infrastructure. Hence, service providers and consumers will make use of a network service infrastructure to ensure service availability by offering, finding and consuming network services (Core Internet Infrastructure Services) just as they use the Internet service infrastructure to offer, find and consume Internet services.
Network Technology: translating semantic names into routable entities	The Future Network Infrastructure will work beyond that of the DNS infrastructure, where often cryptic URLs are mapped onto IP addresses, into an address look-up layer which can take as input semantic names (e.g. formal expressions of user's goal, or even informal descriptions) and result in the appropriate routing of data packets across the network (in a richer way than HTTP POST/GET).
Context Awareness: Intelligent environments	In combination with the Internet of Things, the Internet of Services will be able to make use of physical world information in order to support intelligent environments. In fact, it will be the global service supply provided by the Service Delivery Platform that will be able to provide the adaptable and required functionalities in different contexts and environments at a cost much lower than hard-coded location and time-specific service development.

Context Awareness: Ease of use	Capturing, expressing and allowing manipulation of context can be both a very complex and very personal activity. A specific horizontal service domain will be context-related services to aid both human and machine users of context to manage it through appropriate interfaces and APIs.
Assistive Technology: Active personal assistance based on context information	Complementing horizontal context services which may handle as third parties the capturing, expressing and manipulation of context would be vertical services focused on personal assistance based on that context information. Placing personal assistance technology in the Internet service layer makes it ubiquitously available as well as benefiting from the inherit service functionality in the Service Delivery Platform (trust, identity management, dependability, reliability...).
Semantic Development: Semantic modeling of personal services	We foresee the Internet of Services to include user generated services such as the Web 2.0 trend includes an increasing amount of user generated content. Personal services benefit from modelling in semantic technologies to better enable their publication, discovery, adaptation, mediation, composition and consumption. Since the added value for users to create personal services will lie in the discovery and sharing of those services (just as with data in Web 2.0), the modelling in semantic technologies will prove to be a vital aspect.
Semantic Development: Semantic modeling of environmental effects	Capturing environmental effects can involve large amounts of data and a need for very effective and efficient processing of that data by services. Semantic modelling of the data and services can aid in the selection of data for processing as well as the actual processing of the data. The Internet of Services will support strongly the processing of environmental effects due to its global functional reach which will have to be scalable and reliable enough for modern challenges such as climate change research.
Semantic Development: Semantic modeling of health conditions	Health care is already an important early adopter of semantic technologies as part of individual IT solutions. Providing for the necessary security and trust functionalities, added value is achievable where health data is shared in the cloud as improvements in data processing, e.g. for diagnosis or trend

	identification, are made possible by higher scales of data. The semantic modelling of health conditions can underlie new services – global and personal – whose added value is achieved by the possibility of data inference and validation on the basis of ontologies.
Semantic Development: learning & adaptation	Semantic services have the potential to learn and adapt throughout their lifecycle. In cases, the methodology for learning and adaptation may be shared for many services and could be captured itself in a horizontal service. Hence the Internet of Services could include among its inherent functionalities for services (Core Business Services) also services for service learning and adaptation.
Semantic Development: service modeling	The creation of Internet-based services is facilitated by the use of semantic technologies in service modelling,providing a means to map from a high level goal-centred description of the service to the lower level functional implementation. Equally, by storing service models at a higher level (semantic) form the original intention of the service developer can be preserved and the service implementation adapted to different contexts and environments.
Semantic Development: Support for service semantics and composition	The Internet of Services will require means to discover and combine services to achieve goals, which is based upon a machine understanding of service descriptions. Semantics will hence be a core part of the Internet of Services and will not only be usable in service descriptions but also in automated service compositions to achieve more complex goals as a combination of individual goal-fulfilling services.
Large Scale Computing: Real time route and capacity planning for millions of goods, people, services	The Internet of Services will be made up of billions of services. The Global Delivery Platform provides an Internet scale layer for the exchange of service messages (data). With appropriate large scale data processing technologies and ensuring correct security and trust provision, global data collection about goods, people and services themselves from dedicated services combined with route and capacity planning tools can lead to a more effective and efficient organization of data and services in the Internet of Services. Such route and capacity planning capability with respect to

	services themselves will prove vital to the scalability of the Internet of Services.
Large Scale Computing: Virtualization of cross-business boundaries	The movement of data and services into the cloud already leads to a greater virtualisation of real world business boundaries. This will be further facilitated by the extended (horizontal) functionalities of the Internet of Services to include, into this “cloud”, adaptive and mediated data and service exchange which further abstracts from individual business boundaries.
Service Orchestration	The existence of billions of services on the Internet of Services will require the organisation of these services through different types of horizontal services (“services for services”). From an end user point of view this can include services for renting services, services for personalizing services or services for trading services.
Community Development: Use communities for real-life advantages and services	We expect that the Internet of Services will lead to the building up of different user communities around specific sets of services, just as Web 2.0 has generated different social networks meeting the needs of different types of user.
Community Development: Medicine social network	Services may not only be usable in an automated fashion for data exchange between machines but also manually by end users to access needed functionalities. In that respect, noting the early adoption role of the healthcare industry with semantic technologies, we expect that this industry will also form a significant user block on the emerging Internet of Services. This will lead to new social networks centred around specific sets of healthcare services.
Community Development: Voting	Electronic voting has not yet achieved wide usage due to the many technological concerns involved. The Internet of Services should provide the functional support to meet those concerns with respect to trust, security, identity and reliability. The service metaphor will make voting as a service more ubiquitously available.
Mixed Reality World: Personalised collaborative environments for social interaction, gaming and innovative business concepts	Rather than a classical client/server service infrastructure (1-to-1 communication),the Internet of Services will provide an infrastructure where service functionality is available collaboratively (many-to-many

	communication) and can be used to provide group shared environments. These environments, due to the service paradigm, may be accessible abstracted from individual user devices, location, time or context. Core shared environment functionalities such as data or user management may be provided in turn by other services.
Incremental	
Notification Services: SOS Services	The global, ubiquitous and reliable nature of the Internet of Services can provide a basis for improved emergency notifications through composition of appropriate services, e.g. over a mobile device in combination with geolocation services to provide an automatic delivery of emergency location data to the emergency services together with collected sensor data, image/video, or routing for the endangered public to places of safety.
Notification Services: Context-aware reminder	A service infrastructure is not only made up of pull-services (responding to a request) but also push-services (a la RSS, needing a subscription and then responding when new content is available). Push-services function with always-online devices to give users in-time reminders of relevant information based on appropriate context, user profile and preferences processing.
Service Orchestration	The existence of billions of services on the Internet of Services will require the organisation of these services through different types of horizontal services ("services for services") in order to facilitate both user and machine initiated service search and selection. This includes the aggregration of multiple services into single services, as well as integrating services which are complementary.
Community Development: Social gaming and communications	The Internet of Services will underlie new types of social collaborative services such as gaming and communications.
Content: Adaptation	Services for content will form part of the service offer on the Internet of Services. Just as content storage is already being abstracted from the home device into the "Internet" as general storage platform, so content management will be abstracted from end device-based applications into the "Internet of Services" as a general content

	management platform, where content can be created, composed, and adapted without ever being stored on the end device.
Content: Recommendation systems	Internet-based recommendation systems offered as a service can be optimised in terms of their precision by Internet-scale data processing.
Content: Quality of service	Content delivery on the Internet, especially streaming content (audio, video) in possibly real time, can be supported by (third party) services which provide guarantees with regard to QoS.
Trust: SLAs	It will be vital in the Internet of Services that trust can be established between users and services, and between services themselves. This will require the automatable exchange of SLAs between actors, including negotiation, adaptation and agreement. SLAs must themselves be trustable in that the infrastructure can guarantee that what they promise is fulfilled, and that in the case of non-fulfillment, that remedial measures do in fact take place.
Service Infrastructure	It is our central vision for the Internet of Services to provide for a Global Service Delivery Platform (GSDP). This platform is intended to virtualise from specific services, I.e. “things get done” without needing to know the specific (combination of) services involved. Instances of the GSDP will need to include GSDP-core services for their own set-up and configuration, energy management and lifecycle management. As in any virtual environment, considerations must be made for the mapping to physical infrastructure, including optimal usage of computing resources and efficient distribution of services geographically.

6. Roadmapping the Future Internet of Services

6.1. Online Survey

Between June and December 2009, a Service Web 3.0 survey was distributed to research and industry experts in the areas of semantic and service technologies. Through both online and paper distribution, 80 responses were collected. The full results from the survey can be seen in Appendix II. Here, we will restrict ourselves to a summary of the main findings.

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	9%	9%	16%

Management (CRM)			
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 scale content access	21%	19%	16%
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.

6.2. Interviews with Industry Professionals

To gain also some individual insights into how industry professionals see the future update of service technologies and the role of semantics in that, we conducted interviews with two selected professionals.

Interviewee: Marek Kowalkiewicz, SAP Research

1. What is the current state of the art within your organization with respect to the uptake and usage of services-based technologies such as SOA, Web Services, Cloud and SaaS?

SOA is an important component of SAP's strategy. We specifically focus on an open-standards approach to SOA, with enterprise services – highly integrated Web Services combined with business logic and harmonized semantics – being core. We focus on enabling end-to-end business processes, both relying on SOA in our internal operations as well as providing solutions for our customers.

SAP is also a coordinator of a large Enterprise Services community, with 333 member companies, as of January 2010.

With Business ByDesign, SAP is showing its commitment to Cloud and SaaS. Also, recently, the SaaS strategy of SAP has been unveiled. SAP will develop function specific software applications, available by subscription, extending customers' on-site Business Suite. SAP will host these applications using a multitenant architecture.

2. What developments do you expect in the next few years in that regard?

We will see SAP products being open to more and more users. Not only traditional users of SAP systems, but information workers, and even consumers. The distinction between users of enterprise systems and casual users may begin to blur soon.

3. Is your organization aware of or using semantic technology (RDF, ontologies, reasoners...)? Which technical challenges is it used or envisioned to resolve?

SAP is actively researching the applicability of semantic technologies in enterprise systems. Semantics technologies are used in SAP's business intelligence tools. There are multiple other research activities where prototype applications of semantic technologies are being built.

Apart from supporting business intelligence, we see a lot of potential of semantic technologies in areas such as business process management, service engineering, or information management.

Interviewee: Radoslaw Hofman, Sygnity Group, Poland

1. What is the current state of the art within your organization with respect to the uptake and usage of services-based technologies such as SOA, Web Services, Cloud and SaaS?

Our organization is absorbing new technologies although this process is highly dependent on customers' acceptance since we are developing mainly dedicated software. The use of SOA and Web Services for the purpose of service integration in financial institutions is rather good, for the last years this approach is dominating IT projects. We were not adopting SaaS nor Cloud technologies.

2. What developments do you expect in the next few years in that regard?

As mentioned above, we expect continuous increase of the use of SOA/WS technologies. We are also planning to prepare two large applications adopting SaaS technologies and one platform supporting Cloud computing for our own purposes.

3. Is your organization aware of or using semantic technology (RDF, ontologies, reasoners...)? Which technical challenges is it used or envisioned to resolve?

Our organization is aware but hardly uses these technologies. We are now taking part in a consortium aiming to develop a project adopting all of these for a tool supporting loan risk assessment process.

4. Which issues currently act as barriers to a quicker uptake of services-based technologies in your organisation?

Mainly it is the problem with our customer perception – financial organizations are interested in using well known and stable technologies rather than modern ones.

5. How would the resolution of those issues change the expected uptake of services-based technologies in your organisation?

In our company the customers are deciding on technologies which will be used in the software developed for them. If they decide to use one of the above mentioned technologies we would use them.

7. Conclusion

This document 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 NEXOF-RA and SOA4all 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[31]. 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 and the interviews 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 (see the last paragraph), 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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Appendix I. ServiceWeb 3.0 survey

SERVICES IN INDUSTRY and SEMANTICS IN SERVICES

Service Web 3.0 Roadmap Survey

The Service Web 3.0 roadmap survey primarily aims to obtain the general consensus of the expert community in addressing industry's most promising benefits of adopting global networked service solutions envisioned under the European Commission's proposed Internet of Services. Additionally, we aim to access a common perception of the coming challenges within the Internet of Services domain where semantic technologies could provide a viable solution.

Please take 10 minutes to share with us your predictions on industrial uptake of networked, service-based solutions and the potential role of semantic technologies.

Later this year, Service Web 3.0 will publish two specialized roadmaps that will include the collective opinions of this survey.

This survey is taken anonymously. However, if you would like to be notified about the outcome of the survey, please let us know your e-mail address (you will find the appropriate form at the end of the survey). Also, check our website: www.serviceweb30.eu

Thank you for participating.

1) Which of the following best describes your current position?

a. CEO/Director
b. CTO/Head of Department
c. Principal Investigator/Senior Researcher
d. IT Professional
e. Student
f. Trainee/Intern
g. Freelancer
h. Other:

2) Which of the following best describes your organization?

a. Academic institution
b. Research organization
c. Industry
d. Other

____

3) How many employees work at your organization (for academic institutions, please refer to your college, department or institute)?

a. 1-10
b. 10-50
c. 50-150
d. 150-300
e. 300-1,000
f. 1,000-5,000
g. 5,000-10,000
h. More than 10,000

4) How would you rate your organizations' level of expertise with regard to SOA, Web services and future applications based upon an Internet of Services?

a. Expert
b. Advanced
c. Intermediate
d. Novice
e. Unfamiliar

5) Has your organization already adopted, or does you organization plan to adopt any of the following technologies (internally or externally):

	Yes	No
a. Web Services	☐	☐
b. Service Oriented Architectures	☐	☐
c. Cloud storage	☐	☐
d. Cloud applications	☐	☐
e. Software-as-a-Service	☐	☐

6) From the following research domains, which will have the greatest effect (hindrance or support) on the adoption of services in industry? Please only select three domains.

a. Network Architectures and Mobility
b. Content Creation Media Delivery
c. Security, Privacy and Trust
d. Internet of Things
e. Real World/3-D Internet
f. Cloud Computing
g. Future Internet Socio-Economics
h. Other:

____

7) From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?

Industrial Domain	**Potential (1-10)**
Ecommerce	
Business Process Management	
Supply Chain Management	
Customer Relationship Management	
Content Management Systems	
Financial/Accounting Management	
Enterprise Resource Planning	
Marketing/Advertising	
Other: ______________________________	

8) Which three factors will have the strongest positive effect on the use of services in industry? Please only select the three most important factors.

a. Providing access to various resources anywhere and anytime
b. Combining services to create composite applications/business process
c. Integration aspects
d. Facilitation of IT outsourcing
e. Ease of exchanging data between various systems (facilitator of communication)
f. Manageability of the service-based solutions
g. Reusability of developed functionalities
h. Ease of deployment
i. Flexibility of the developed service based solutions
j. Other:

____

9) Which three factors will pose the greatest challenge in the adoption of services in industry? Please only select the three most important factors.

a. The costs of implementation
b. Lack of standardization
c. Inability (due to unwillingness or high costs) to change from current software paradigm
d. Unclear economic benefits
e. Lack of available, reliable, online services
f. Lack of qualitative services
g. Lack of technical knowledge
h. Inadequate service engineering support
i. Total costs of ownership
j. Other:

____

10) Which functionalities will be adequately provisioned for industrial uptake by the future Internet of Services? Please only select the three most important functionalities.

a. Mobile device & access technology
b. Context awareness
c. Notification
d. Service orchestration
e. Remote collaboration
f. Content management
g. Security, privacy, and trust
h. Semantic capabilities
i. Assistive technology
j. Large-scale computing
k. Community development
l. Other:

____

11) How would you rate your organizations' level of expertise with regard to the Semantic Web and semantic technologies?

a. Expert
b. Advanced
c. Intermediate
d. Novice
e. Unfamiliar

12) From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?

Research Domain	**Potential (1-10)**
Online services and applications	
Business process management	
Business intelligence	
Information management	
Enterprise management systems	
Multimedia and content	
Social networks	
Life sciences	
Collaboration systems	
Other: ________________________________	

13) From a scale of 1-10 (1 being the least promising, 10 being the most promising), which semantic technology research challenges are achievable in the next 10 years?

Research Challenge	**Potential (1-10)**
Intelligent large scale content access	
Scalable security, trust, and identity systems	
Scalable interoperability	
Reasoning/inference-based search and discovery	
Reasoning/inference-enabled collaboration	
Other: ________________________________	

14) Which three factors will have the strongest positive effect on the use of semantic technologies? Please only select the three most important factors.

a. Providing one common vocabulary for an organization/community etc.
b. Automation of data and information management
c. Opportunity to reduce human factor in various operations
d. Providing better (semi-automatic) support for knowledge-intensive processes
e. New possibilities for data mining and business intelligence
f. Reasoning possibilities over semantically annotated resources
g. Efficient combination of data, information and knowledge
h. Knowledge management
i. Other:

____

15) Which three factors will pose the greatest challenge in the adoption of semantics in service technologies? Please only select the three most important factors.

a. Total costs of ownership
b. Complexity of semantic technologies
c. Immaturity of semantic technologies
d. Lack of tangible benefits
e. Lack of training and experts to use/develop/maintain systems
f. Business and real world problems remain too complex and heterogeneous to be solved with semantic technologies
g. Other:

____

16) Has your organization already adopted, or does you organization plan to adopt any of the following technologies (internally or externally):

	Yes	No
a. RDF	☐	☐
b. Ontologies	☐	☐
c. Reasoners/Inference engines	☐	☐
d. Semantic storage/repositories	☐	☐
e. Semantic Web services	☐	☐
f. Semantic applications (i.e. middleware/modeling tools)	☐	☐
e. Semantic wiki	☐	☐

17) Semantic technologies will be fundamental in the realization of the Internet of Services vision.

a. Strongly agree
b. Agree
c. Impartial
d. Disagree
e. Strongly Disagree

*****OPTIONAL*****

Please leave your name and email address and we will inform you when the survey results have been compiled.

Name: ______________________________ Email address: ______________________________

Thank you very much for taking part in our survey.

Appendix II. Survey results

STI International Surveys

Quick statistics: (Service Web 3.0 Survey)

Filter settings

Results

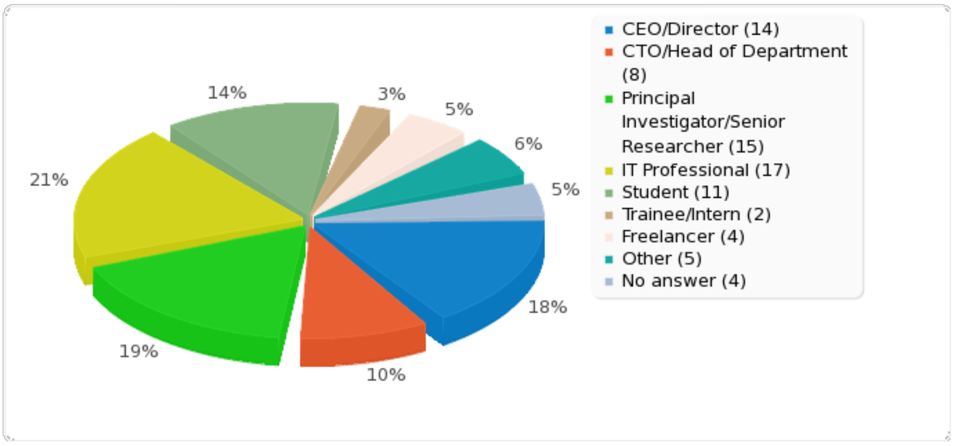
Number of records in this query:	80
Total records in survey:	80
Percentage of total:	100.00%

Browse Export

Field summary for current_position

Which of the following best describes your current position?

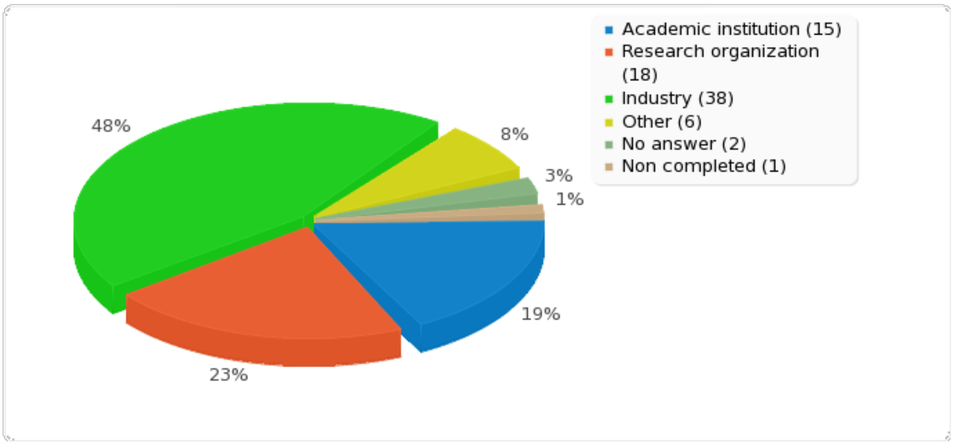
Answer	Count	Percentage
CEO/Director (a)	14	17.50%
CTO/Head of Department (b)	8	10.00%
Principal Investigator/Senior Researcher (c)	15	18.75%
IT Professional (d)	17	21.25%
Student (e)	11	13.75%
Trainee/Intern (f)	2	2.50%
Freelancer (g)	4	5.00%
Other Browse	5	6.25%
No answer	4	5.00%
Non completed	0	0.00%



Field summary for org_description

Which of the following best describes your organization?

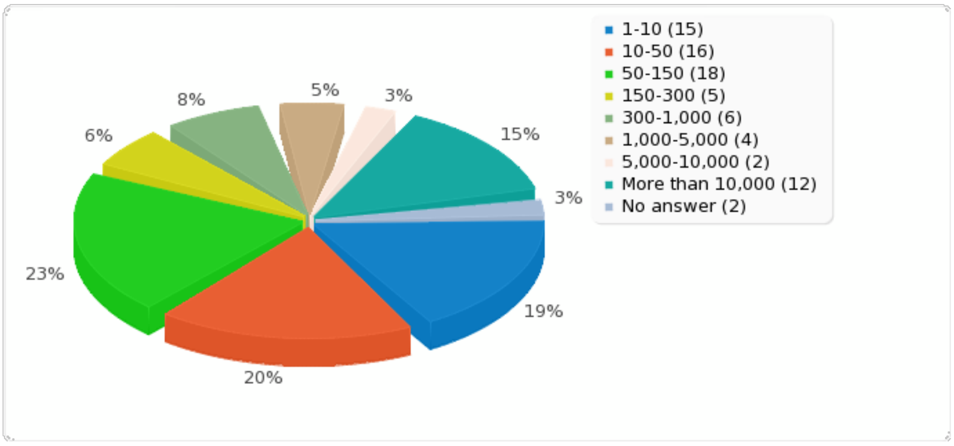
Answer	Count	Percentage
Academic institution (2a)	15	18.75%
Research organization (2b)	18	22.50%
Industry (2c)	38	47.50%
Other Browse	6	7.50%
No answer	2	2.50%
Non completed	1	1.25%



Field summary for numbr_employees

How many employees work at your organization (for academic institutions, please refer to your college, department or institute)?

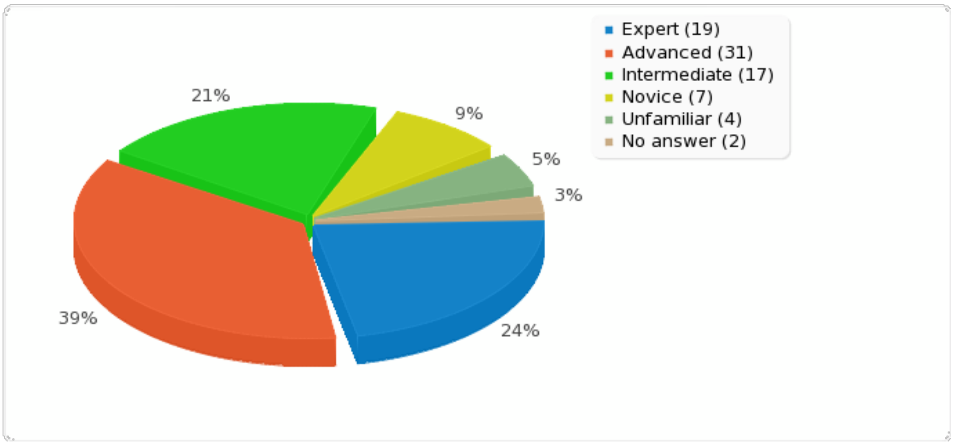
Answer	Count	Percentage
1-10 (3a)	15	18.75%
10-50 (3b)	16	20.00%
50-150 (3c)	18	22.50%
150-300 (3d)	5	6.25%
300-1,000 (3e)	6	7.50%
1,000-5,000 (3f)	4	5.00%
5,000-10,000 (3g)	2	2.50%
More than 10,000 (3h)	12	15.00%
No answer	2	2.50%
Non completed	0	0.00%



Field summary for level_expertise

How would you rate your organizations' level of expertise with regard to SOA, Web services and future applications based upon an Internet of Services?

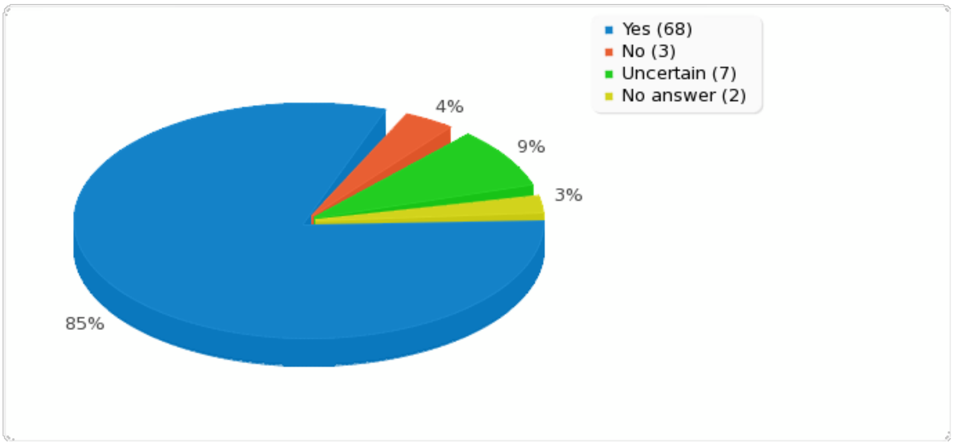
Answer	Count	Percentage
Expert (4a)	19	23.75%
Advanced (4b)	31	38.75%
Intermediate (4c)	17	21.25%
Novice (4d)	7	8.75%
Unfamiliar (4e)	4	5.00%
No answer	2	2.50%
Non completed	0	0.00%



Field summary for addopt_techn(5a)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally)?
[Web Services]

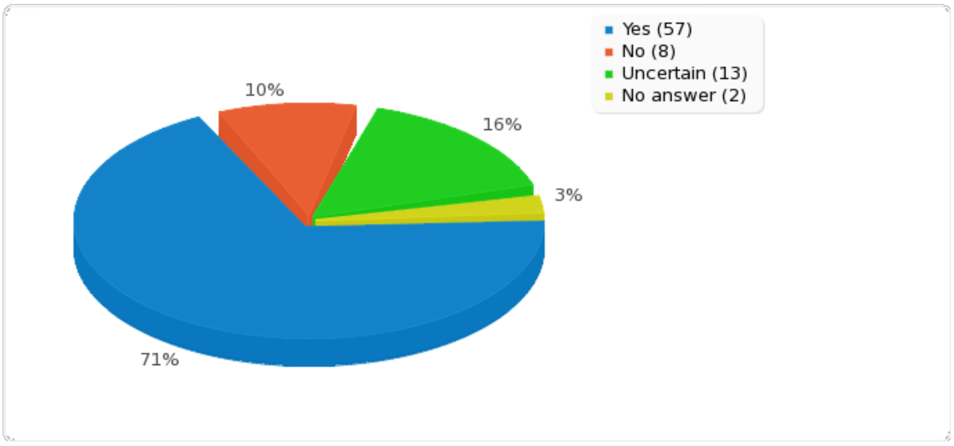
Answer	Count	Percentage
Yes (Y)	68	85.00%
No (N)	3	3.75%
Uncertain (U)	7	8.75%
No answer	2	2.50%
Non completed	0	0.00%



Field summary for addopt_techn(5b)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally)?
[Service Oriented Architectures]

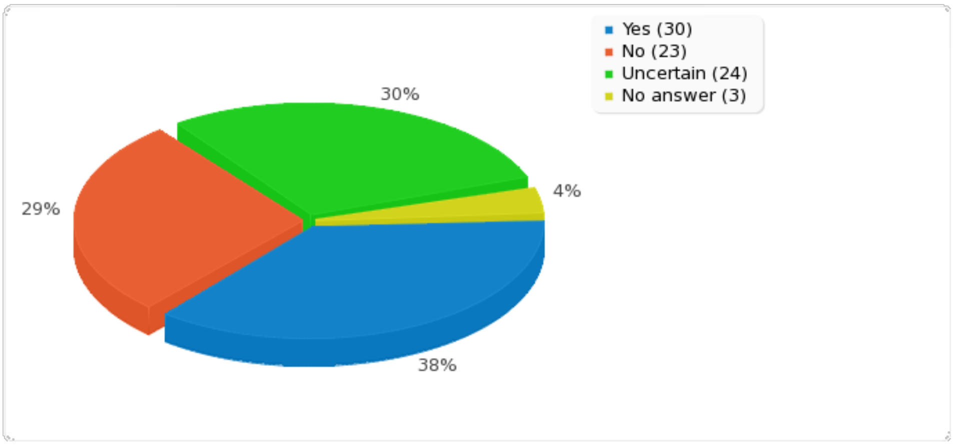
Answer	Count	Percentage
Yes (Y)	57	71.25%
No (N)	8	10.00%
Uncertain (U)	13	16.25%
No answer	2	2.50%
Non completed	0	0.00%



Field summary for addopt_techn(5c)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally)?
[Cloud storage]

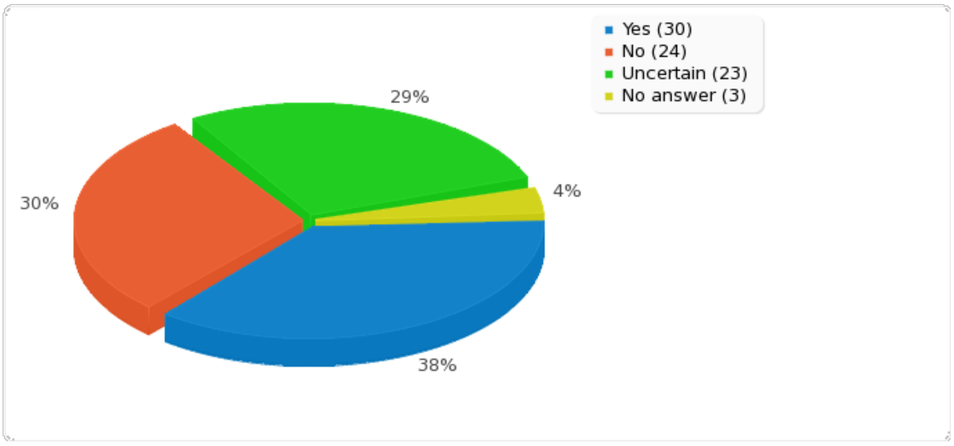
Answer	Count	Percentage
Yes (Y)	30	37.50%
No (N)	23	28.75%
Uncertain (U)	24	30.00%
No answer	3	3.75%
Non completed	0	0.00%



Field summary for addopt_techn(5d)

**Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally)?
[Cloud applications]**

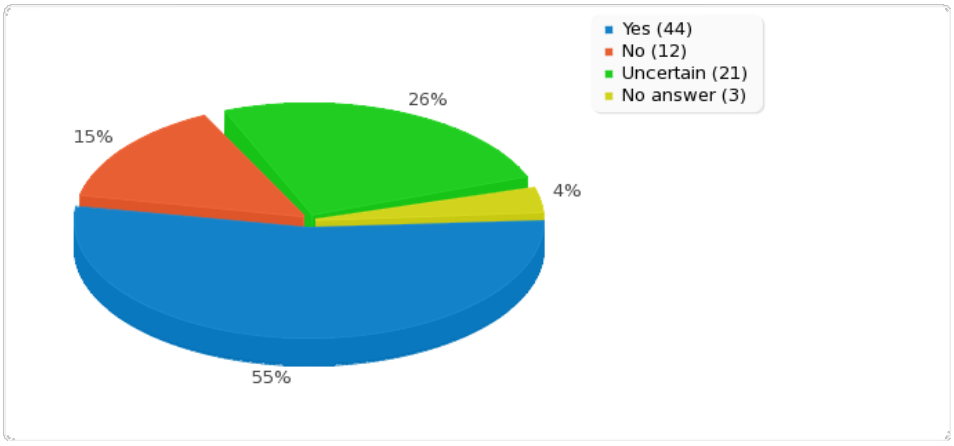
Answer	Count	Percentage
Yes (Y)	30	37.50%
No (N)	24	30.00%
Uncertain (U)	23	28.75%
No answer	3	3.75%
Non completed	0	0.00%



Field summary for addopt_techn(5e)

**Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally)?
[Software-as-a-Service]**

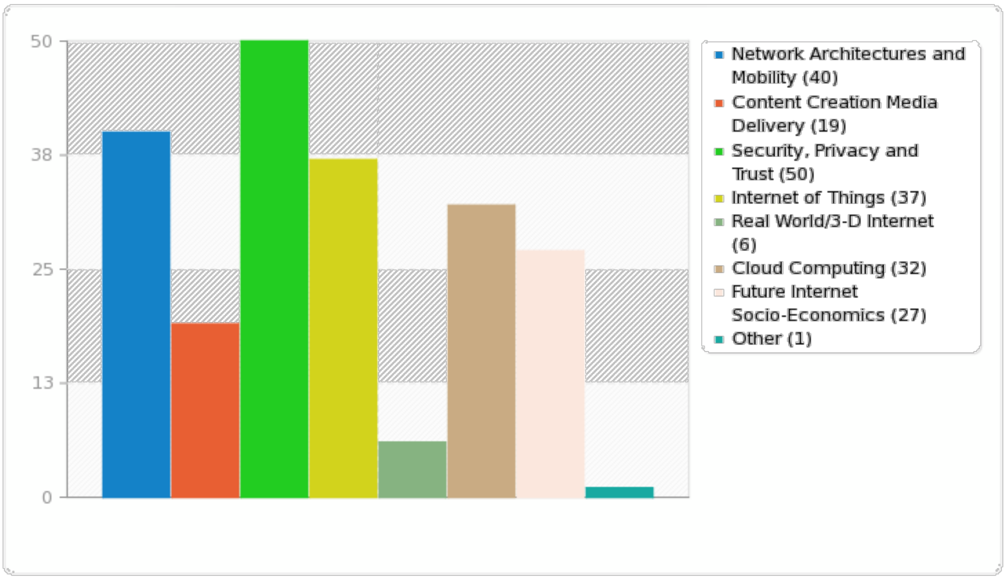
Answer	Count	Percentage
Yes (Y)	44	55.00%
No (N)	12	15.00%
Uncertain (U)	21	26.25%
No answer	3	3.75%
Non completed	0	0.00%



Field summary for adoption_effect

From the following research domains, which will have the greatest effect (hindrance or support) on the adoption of services in industry?

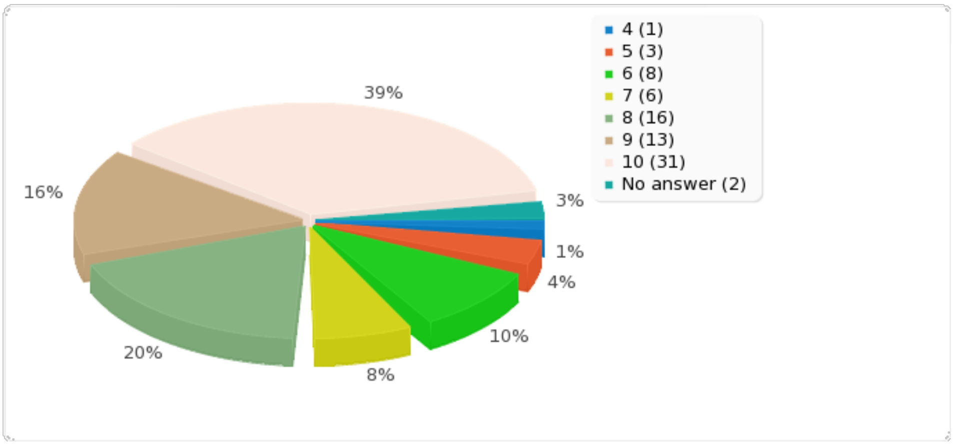
Answer	Count	Percentage
Network Architectures and Mobility (6a)	40	50.00%
Content Creation Media Delivery (6b)	19	23.75%
Security, Privacy and Trust (6c)	50	62.50%
Internet of Things (6d)	37	46.25%
Real World/3-D Internet (6e)	6	7.50%
Cloud Computing (6f)	32	40.00%
Future Internet Socio-Economics (6g)	27	33.75%
Other Browse	1	1.25%



Field summary for industrial_domain(7a)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?
[Ecommerce]

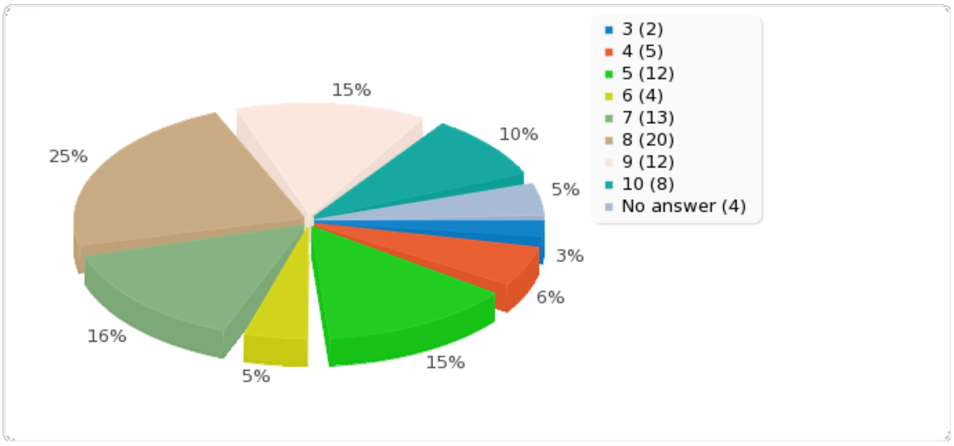
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	0	0.00%
3 (3)	0	0.00%
4 (4)	1	1.25%
5 (5)	3	3.75%
6 (6)	8	10.00%
7 (7)	6	7.50%
8 (8)	16	20.00%
9 (9)	13	16.25%
10 (10)	31	38.75%
No answer	2	2.50%
Non completed	0	0.00%



Field summary for industrial_domain(7b)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?
[Business Process Management]

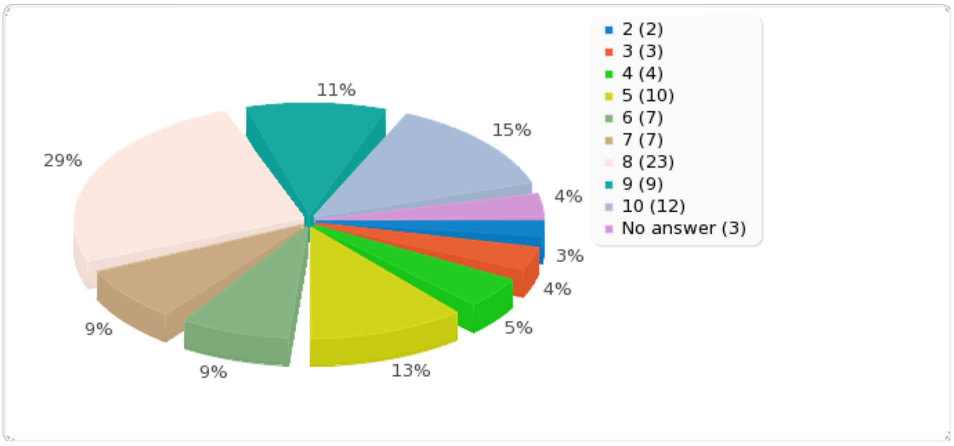
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	0	0.00%
3 (3)	2	2.50%
4 (4)	5	6.25%
5 (5)	12	15.00%
6 (6)	4	5.00%
7 (7)	13	16.25%
8 (8)	20	25.00%
9 (9)	12	15.00%
10 (10)	8	10.00%
No answer	4	5.00%
Non completed	0	0.00%



Field summary for industrial_domain(7c)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?
[Supply Chain Management]

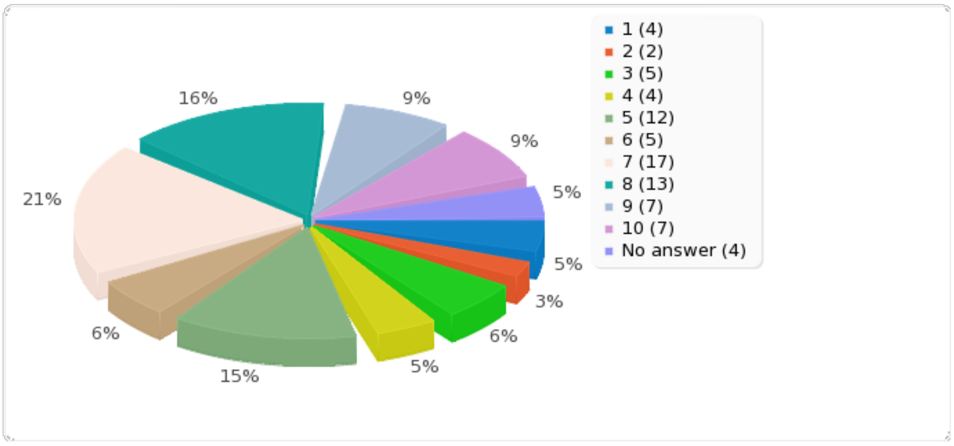
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	2	2.50%
3 (3)	3	3.75%
4 (4)	4	5.00%
5 (5)	10	12.50%
6 (6)	7	8.75%
7 (7)	7	8.75%
8 (8)	23	28.75%
9 (9)	9	11.25%
10 (10)	12	15.00%
No answer	3	3.75%
Non completed	0	0.00%



Field summary for industrial_domain(7d)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?
[Customer Relationship Management]

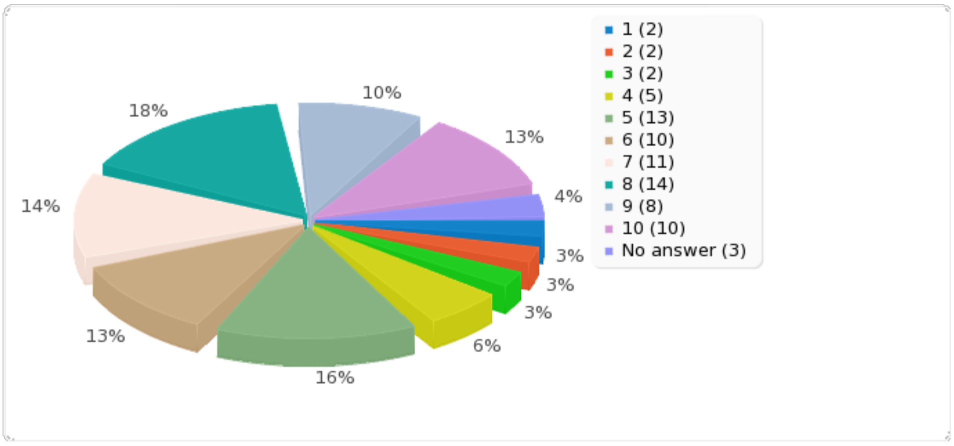
Answer	Count	Percentage
1 (1)	4	5.00%
2 (2)	2	2.50%
3 (3)	5	6.25%
4 (4)	4	5.00%
5 (5)	12	15.00%
6 (6)	5	6.25%
7 (7)	17	21.25%
8 (8)	13	16.25%
9 (9)	7	8.75%
10 (10)	7	8.75%
No answer	4	5.00%
Non completed	0	0.00%



Field summary for industrial_domain(7e)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?
[Content Management Systems]

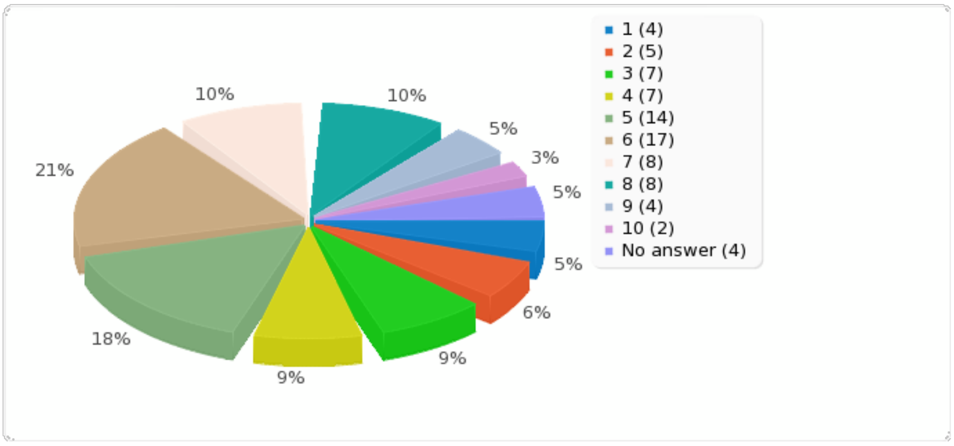
Answer	Count	Percentage
1 (1)	2	2.50%
2 (2)	2	2.50%
3 (3)	2	2.50%
4 (4)	5	6.25%
5 (5)	13	16.25%
6 (6)	10	12.50%
7 (7)	11	13.75%
8 (8)	14	17.50%
9 (9)	8	10.00%
10 (10)	10	12.50%
No answer	3	3.75%
Non completed	0	0.00%



Field summary for industrial_domain(7f)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?
[Financial/Accounting Management]

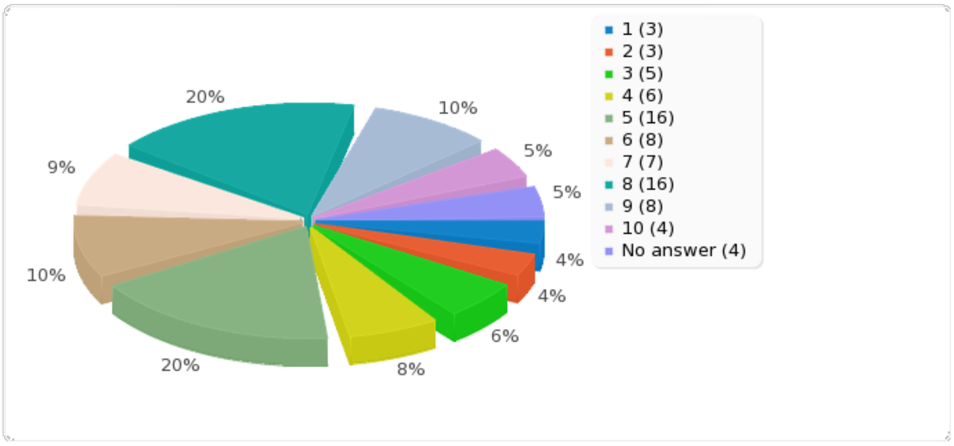
Answer	Count	Percentage
1 (1)	4	5.00%
2 (2)	5	6.25%
3 (3)	7	8.75%
4 (4)	7	8.75%
5 (5)	14	17.50%
6 (6)	17	21.25%
7 (7)	8	10.00%
8 (8)	8	10.00%
9 (9)	4	5.00%
10 (10)	2	2.50%
No answer	4	5.00%
Non completed	0	0.00%



Field summary for industrial_domain(7g)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?
[Enterprise Resource Planning]

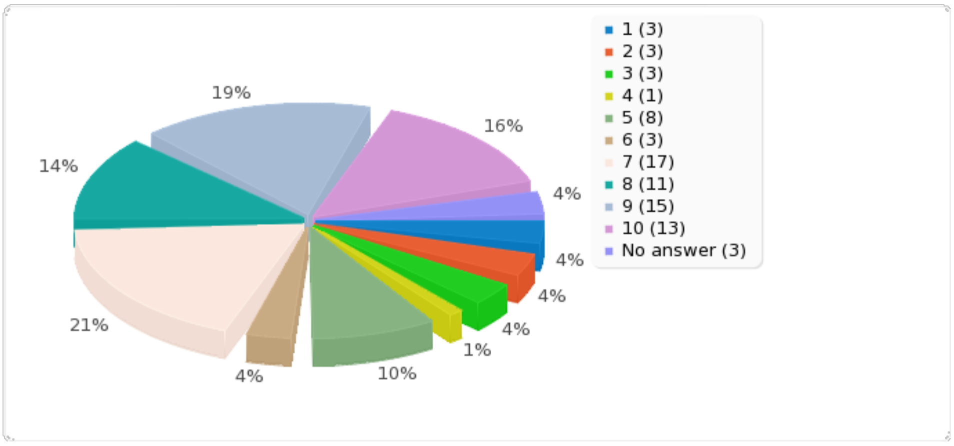
Answer	Count	Percentage
1 (1)	3	3.75%
2 (2)	3	3.75%
3 (3)	5	6.25%
4 (4)	6	7.50%
5 (5)	16	20.00%
6 (6)	8	10.00%
7 (7)	7	8.75%
8 (8)	16	20.00%
9 (9)	8	10.00%
10 (10)	4	5.00%
No answer	4	5.00%
Non completed	0	0.00%



Field summary for industrial_domain(7h)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which industrial domains stand to gain the most from a realized Internet of Services?
[Marketing/Advertising]

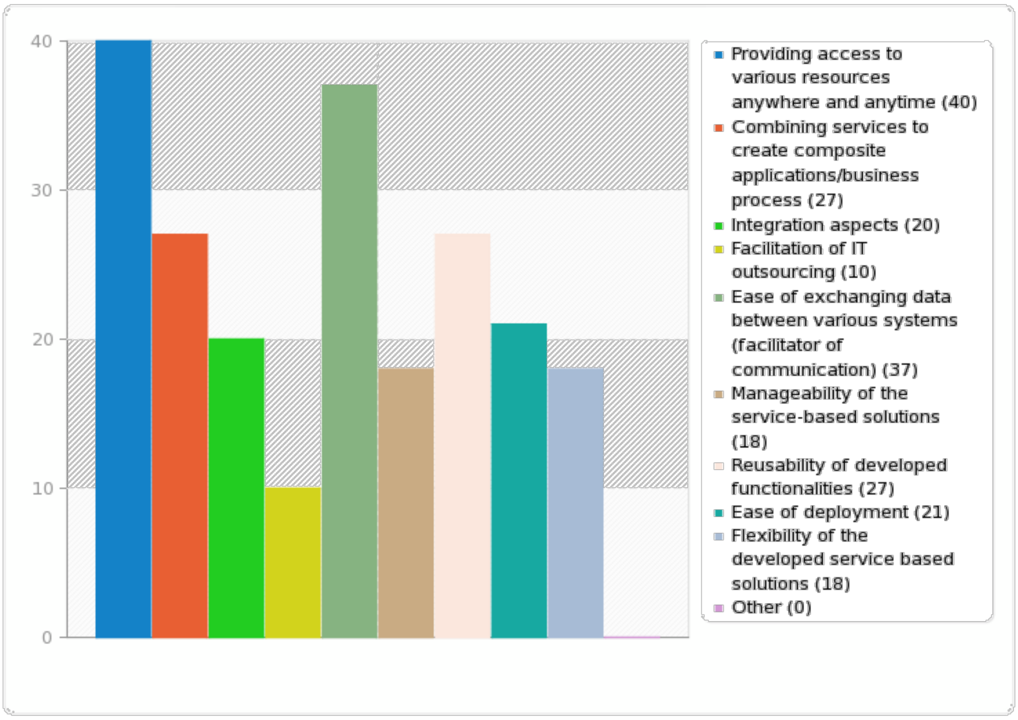
Answer	Count	Percentage
1 (1)	3	3.75%
2 (2)	3	3.75%
3 (3)	3	3.75%
4 (4)	1	1.25%
5 (5)	8	10.00%
6 (6)	3	3.75%
7 (7)	17	21.25%
8 (8)	11	13.75%
9 (9)	15	18.75%
10 (10)	13	16.25%
No answer	3	3.75%
Non completed	0	0.00%



Field summary for positiv_effect

Which three factors will have the strongest positive effect on the use of services in industry?

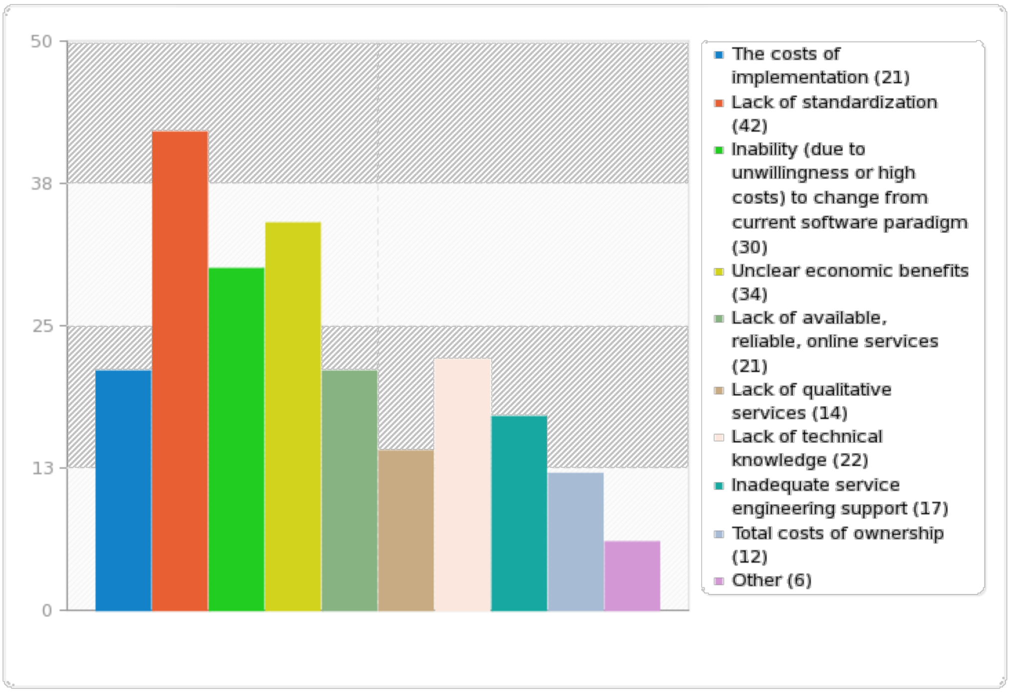
Answer	Count	Percentage
Providing access to various resources anywhere and anytime (8a)	40	50.00%
Combining services to create composite applications/business process (8b)	27	33.75%
Integration aspects (8c)	20	25.00%
Facilitation of IT outsourcing (8d)	10	12.50%
Ease of exchanging data between various systems (facilitator of communication) (8e)	37	46.25%
Manageability of the service-based solutions (8f)	18	22.50%
Reusability of developed functionalities (8g)	27	33.75%
Ease of deployment (8h)	21	26.25%
Flexibility of the developed service based solutions (8i)	18	22.50%
Other Browse	0	0.00%



Field summary for challange_factors

Which three factors will pose the greatest challenge in the adoption of services in industry?

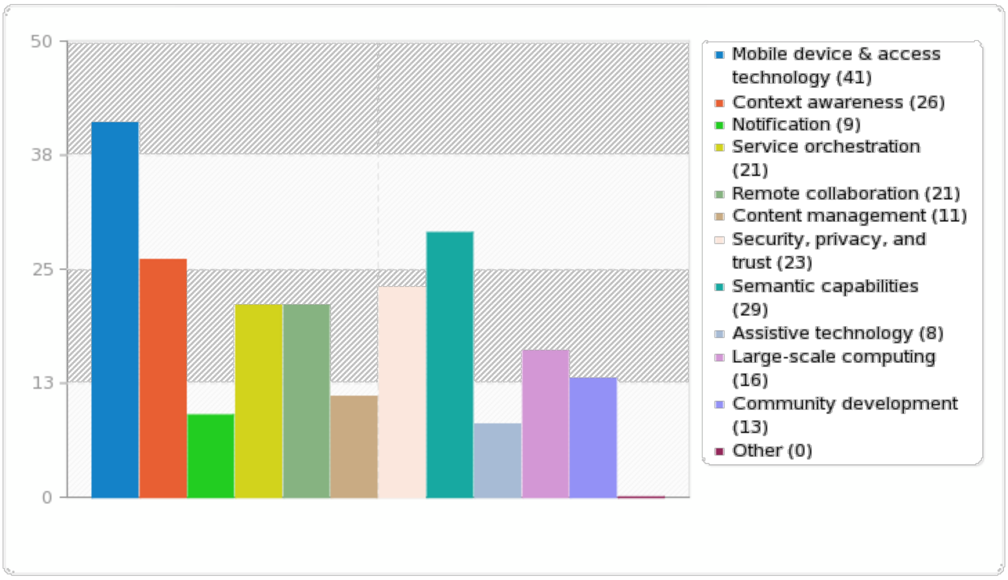
Answer	Count	Percentage
The costs of implementation (9a)	21	26.25%
Lack of standardization (9b)	42	52.50%
Inability (due to unwillingness or high costs) to change from current software paradigm (9c)	30	37.50%
Unclear economic benefits (9d)	34	42.50%
Lack of available, reliable, online services (9e)	21	26.25%
Lack of qualitative services (9f)	14	17.50%
Lack of technical knowledge (9g)	22	27.50%
Inadequate service engineering support (9h)	17	21.25%
Total costs of ownership (9i)	12	15.00%
Other Browse	6	7.50%



Field summary for industrial_update

Which functionalities will be adequately provisioned for industrial uptake by the future Internet of Services?

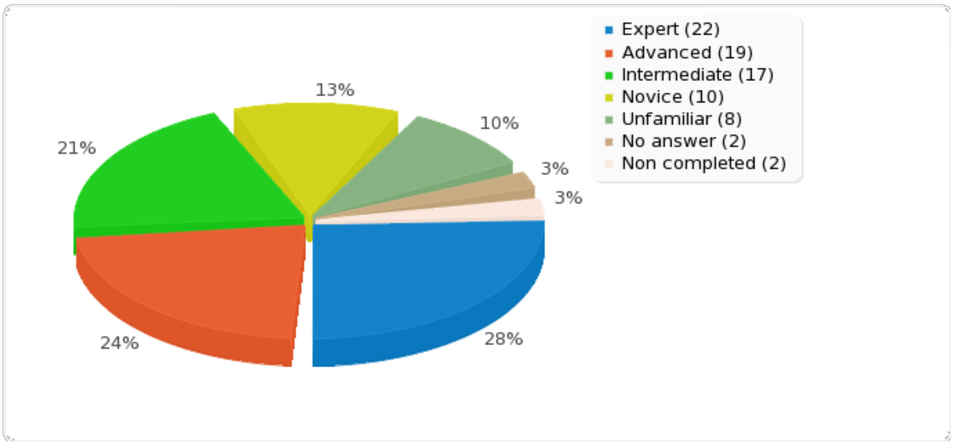
Answer	Count	Percentage
Mobile device & access technology (10a)	41	51.25%
Context awareness (10b)	26	32.50%
Notification (10c)	9	11.25%
Service orchestration (10d)	21	26.25%
Remote collaboration (10e)	21	26.25%
Content management (10f)	11	13.75%
Security, privacy, and trust (10g)	23	28.75%
Semantic capabilities (10h)	29	36.25%
Assistive technology (10i)	8	10.00%
Large-scale computing (10j)	16	20.00%
Community development (10k)	13	16.25%
Other Browse	0	0.00%



Field summary for semantic_expertise

How would you rate your organizations' level of expertise with regard to the Semantic Web and semantic technologies?

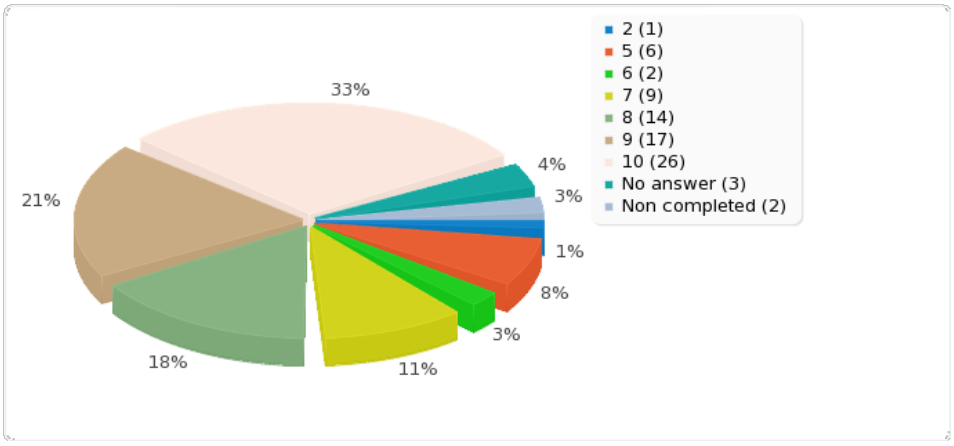
Answer	Count	Percentage
Expert (11a)	22	27.50%
Advanced (11b)	19	23.75%
Intermediate (11c)	17	21.25%
Novice (11d)	10	12.50%
Unfamiliar (11e)	8	10.00%
No answer	2	2.50%
Non completed	2	2.50%



Field summary for research_domains(12a)

**From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Online services and applications]**

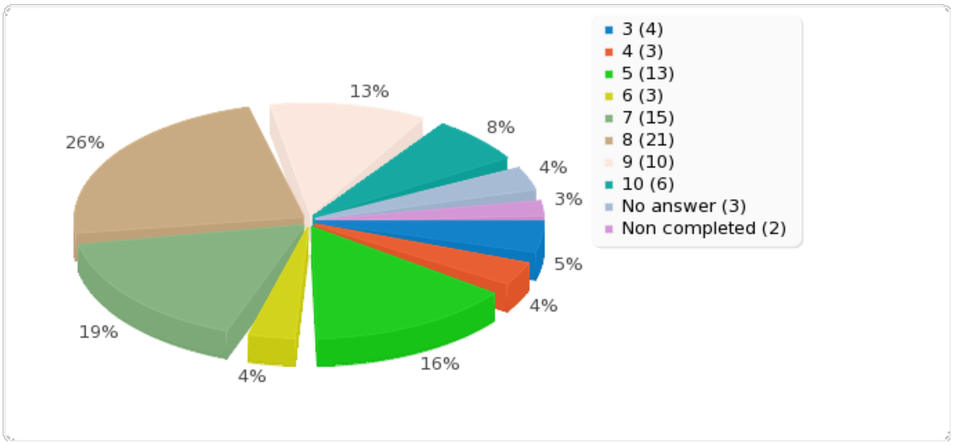
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	1	1.25%
3 (3)	0	0.00%
4 (4)	0	0.00%
5 (5)	6	7.50%
6 (6)	2	2.50%
7 (7)	9	11.25%
8 (8)	14	17.50%
9 (9)	17	21.25%
10 (10)	26	32.50%
No answer	3	3.75%
Non completed	2	2.50%



Field summary for research_domains(12b)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Business process management]

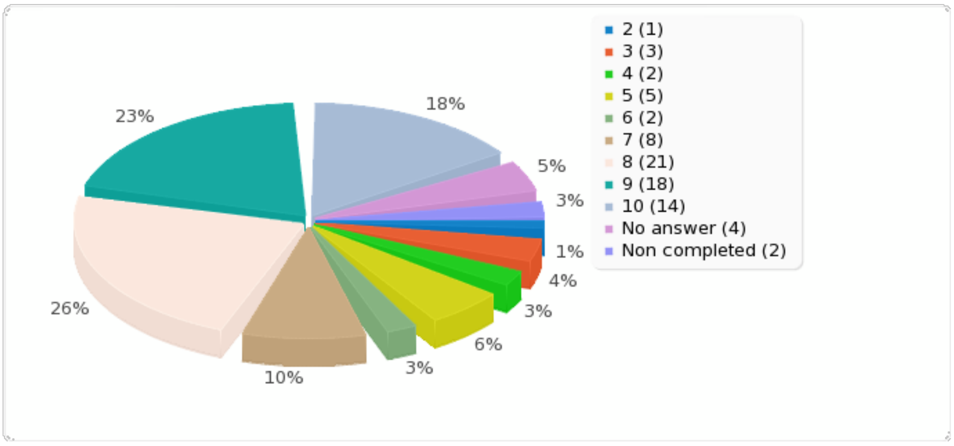
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	0	0.00%
3 (3)	4	5.00%
4 (4)	3	3.75%
5 (5)	13	16.25%
6 (6)	3	3.75%
7 (7)	15	18.75%
8 (8)	21	26.25%
9 (9)	10	12.50%
10 (10)	6	7.50%
No answer	3	3.75%
Non completed	2	2.50%



Field summary for research_domains(12c)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Business intelligence]

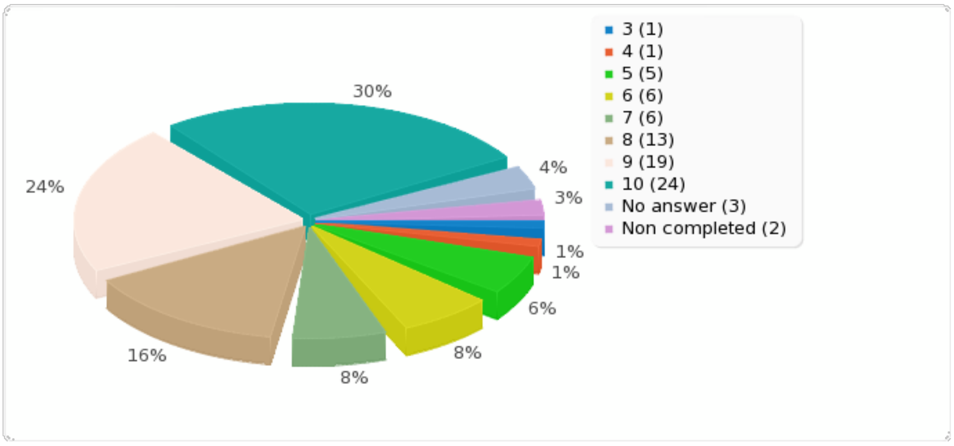
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	1	1.25%
3 (3)	3	3.75%
4 (4)	2	2.50%
5 (5)	5	6.25%
6 (6)	2	2.50%
7 (7)	8	10.00%
8 (8)	21	26.25%
9 (9)	18	22.50%
10 (10)	14	17.50%
No answer	4	5.00%
Non completed	2	2.50%



Field summary for research_domains(12d)

**From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Information management]**

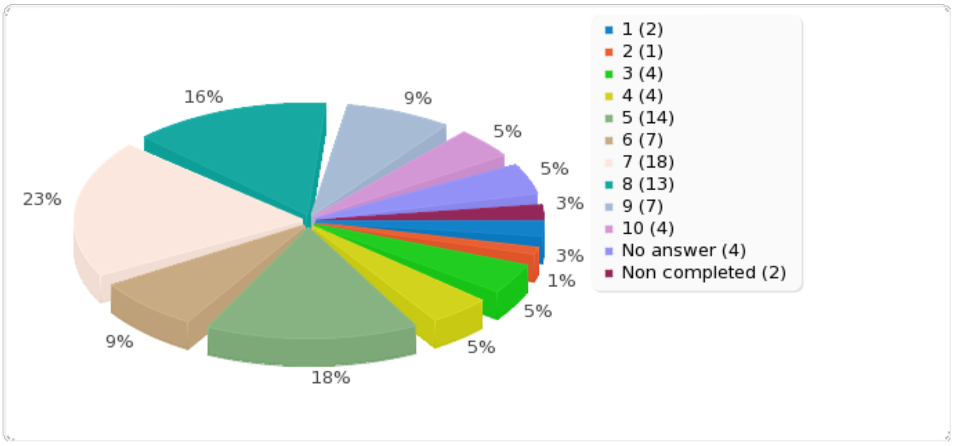
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	0	0.00%
3 (3)	1	1.25%
4 (4)	1	1.25%
5 (5)	5	6.25%
6 (6)	6	7.50%
7 (7)	6	7.50%
8 (8)	13	16.25%
9 (9)	19	23.75%
10 (10)	24	30.00%
No answer	3	3.75%
Non completed	2	2.50%



Field summary for research_domains(12e)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Enterprise management systems]

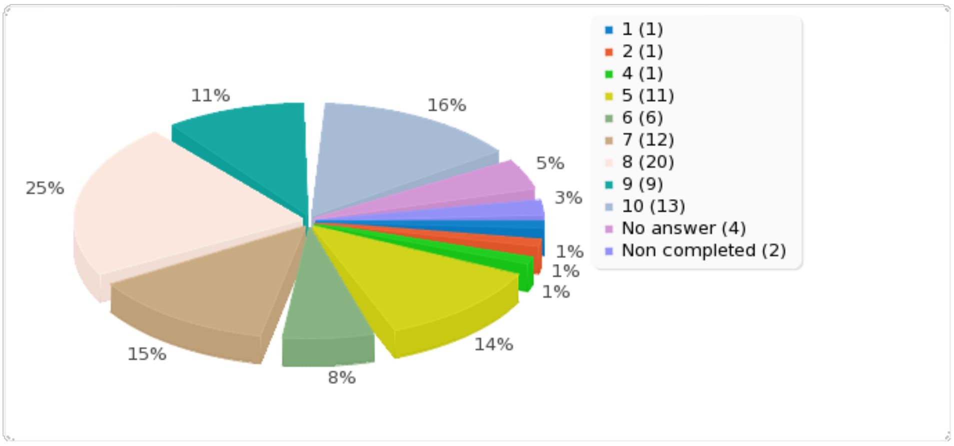
Answer	Count	Percentage
1 (1)	2	2.50%
2 (2)	1	1.25%
3 (3)	4	5.00%
4 (4)	4	5.00%
5 (5)	14	17.50%
6 (6)	7	8.75%
7 (7)	18	22.50%
8 (8)	13	16.25%
9 (9)	7	8.75%
10 (10)	4	5.00%
No answer	4	5.00%
Non completed	2	2.50%



Field summary for research_domains(12f)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Multimedia and content]

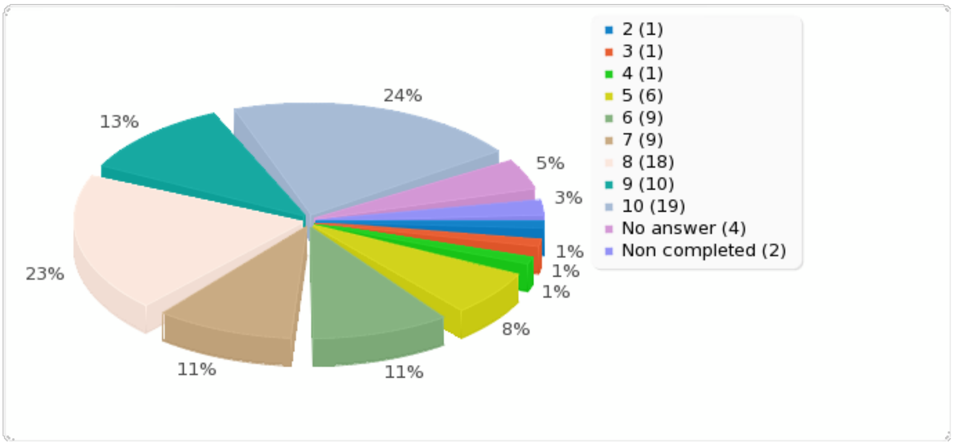
Answer	Count	Percentage
1 (1)	1	1.25%
2 (2)	1	1.25%
3 (3)	0	0.00%
4 (4)	1	1.25%
5 (5)	11	13.75%
6 (6)	6	7.50%
7 (7)	12	15.00%
8 (8)	20	25.00%
9 (9)	9	11.25%
10 (10)	13	16.25%
No answer	4	5.00%
Non completed	2	2.50%



Field summary for research_domains(12g)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Social networks]

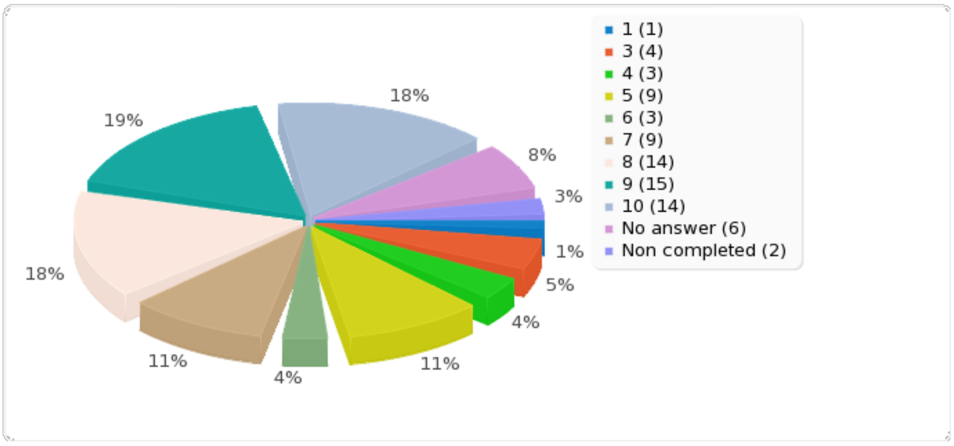
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	1	1.25%
3 (3)	1	1.25%
4 (4)	1	1.25%
5 (5)	6	7.50%
6 (6)	9	11.25%
7 (7)	9	11.25%
8 (8)	18	22.50%
9 (9)	10	12.50%
10 (10)	19	23.75%
No answer	4	5.00%
Non completed	2	2.50%



Field summary for research_domains(12h)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Life sciences]

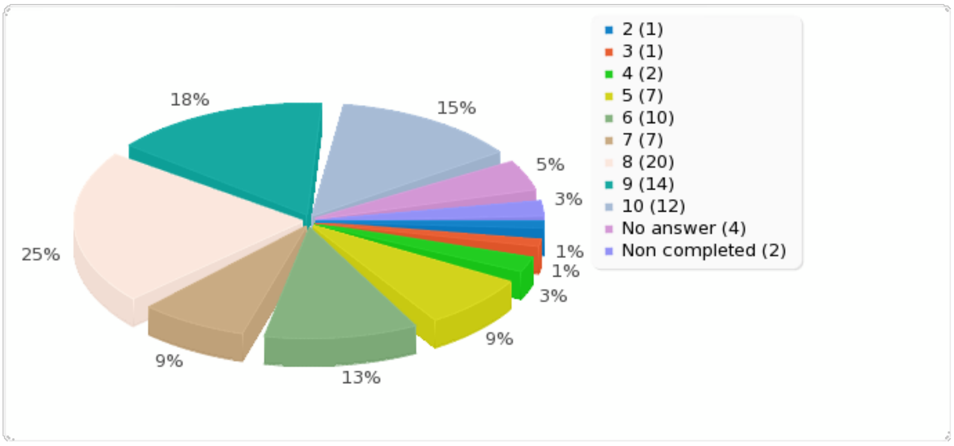
Answer	Count	Percentage
1 (1)	1	1.25%
2 (2)	0	0.00%
3 (3)	4	5.00%
4 (4)	3	3.75%
5 (5)	9	11.25%
6 (6)	3	3.75%
7 (7)	9	11.25%
8 (8)	14	17.50%
9 (9)	15	18.75%
10 (10)	14	17.50%
No answer	6	7.50%
Non completed	2	2.50%



Field summary for research_domains(12i)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which research domains stand to gain the most from semantic technologies?
[Collaboration systems]

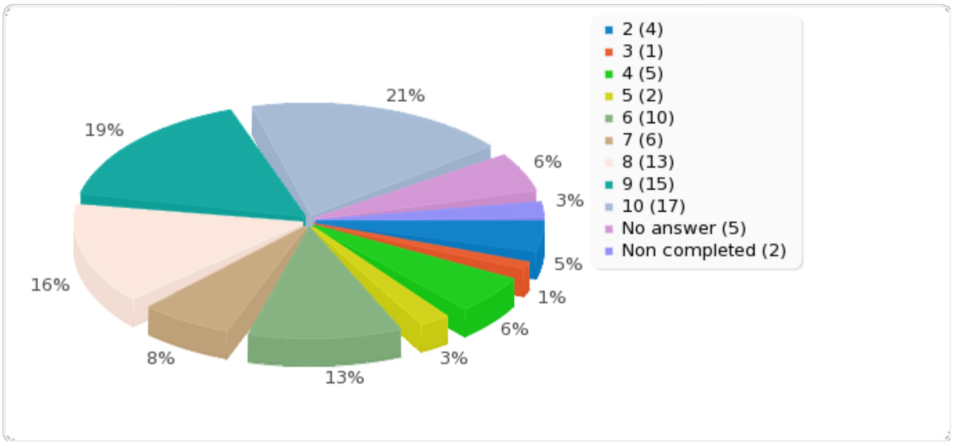
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	1	1.25%
3 (3)	1	1.25%
4 (4)	2	2.50%
5 (5)	7	8.75%
6 (6)	10	12.50%
7 (7)	7	8.75%
8 (8)	20	25.00%
9 (9)	14	17.50%
10 (10)	12	15.00%
No answer	4	5.00%
Non completed	2	2.50%



Field summary for research_challanges(13a)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which semantic technology research challenges are achievable in the next 10 years?
[Intelligent large scale content access]

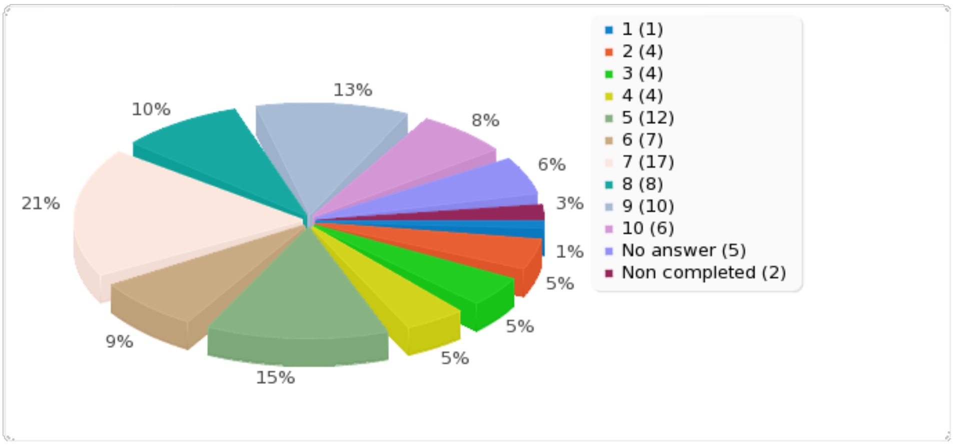
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	4	5.00%
3 (3)	1	1.25%
4 (4)	5	6.25%
5 (5)	2	2.50%
6 (6)	10	12.50%
7 (7)	6	7.50%
8 (8)	13	16.25%
9 (9)	15	18.75%
10 (10)	17	21.25%
No answer	5	6.25%
Non completed	2	2.50%



Field summary for research_challanges(13b)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which semantic technology research challenges are achievable in the next 10 years?
[Scalable security, trust, and identity systems]

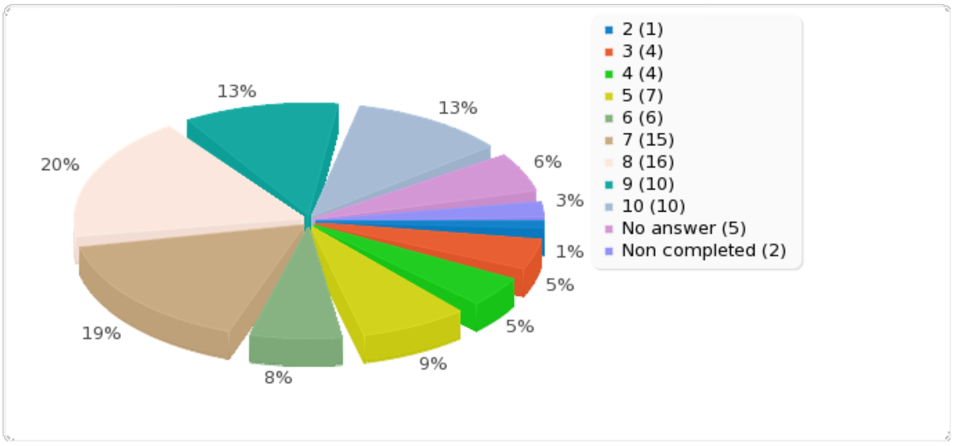
Answer	Count	Percentage
1 (1)	1	1.25%
2 (2)	4	5.00%
3 (3)	4	5.00%
4 (4)	4	5.00%
5 (5)	12	15.00%
6 (6)	7	8.75%
7 (7)	17	21.25%
8 (8)	8	10.00%
9 (9)	10	12.50%
10 (10)	6	7.50%
No answer	5	6.25%
Non completed	2	2.50%



Field summary for research_challanges(13c)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which semantic technology research challenges are achievable in the next 10 years?
[Scalable interoperability]

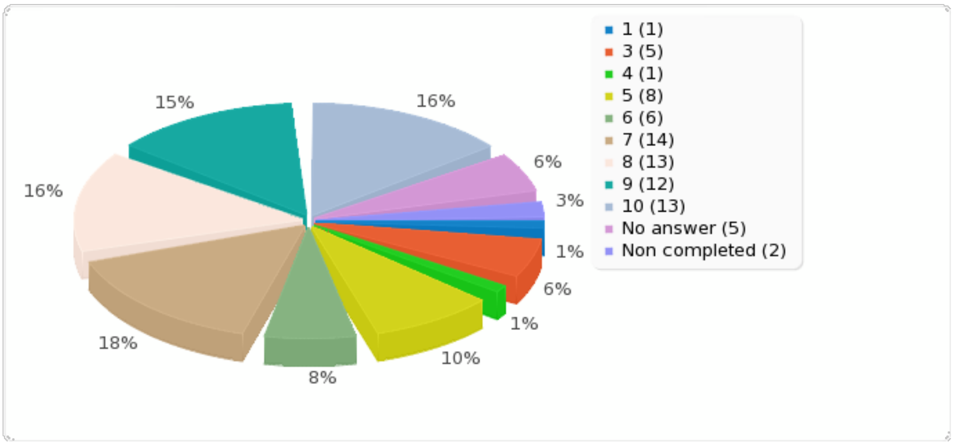
Answer	Count	Percentage
1 (1)	0	0.00%
2 (2)	1	1.25%
3 (3)	4	5.00%
4 (4)	4	5.00%
5 (5)	7	8.75%
6 (6)	6	7.50%
7 (7)	15	18.75%
8 (8)	16	20.00%
9 (9)	10	12.50%
10 (10)	10	12.50%
No answer	5	6.25%
Non completed	2	2.50%



Field summary for research_challanges(13d)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which semantic technology research challenges are achievable in the next 10 years?
[Reasoning/inference-based search and discovery]

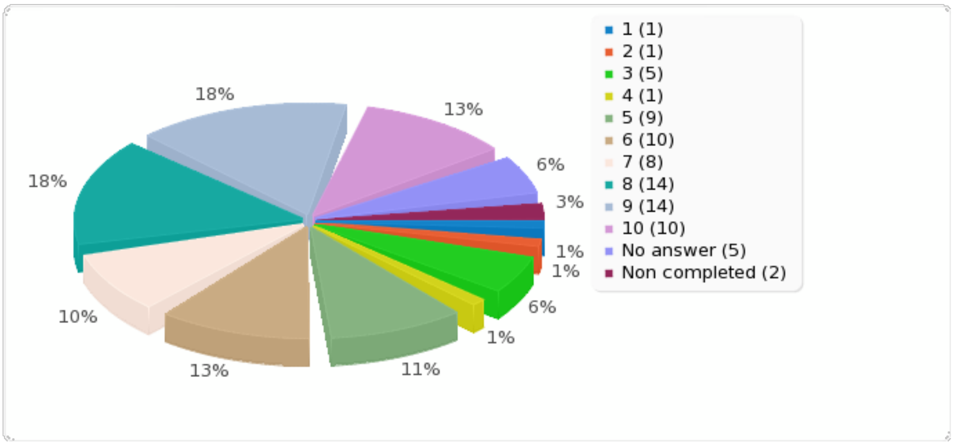
Answer	Count	Percentage
1 (1)	1	1.25%
2 (2)	0	0.00%
3 (3)	5	6.25%
4 (4)	1	1.25%
5 (5)	8	10.00%
6 (6)	6	7.50%
7 (7)	14	17.50%
8 (8)	13	16.25%
9 (9)	12	15.00%
10 (10)	13	16.25%
No answer	5	6.25%
Non completed	2	2.50%



Field summary for research_challanges(13e)

From a scale of 1-10 (1 being the least promising, 10 being the most promising), which semantic technology research challenges are achievable in the next 10 years?
[Reasoning/inference-enabled collaboration]

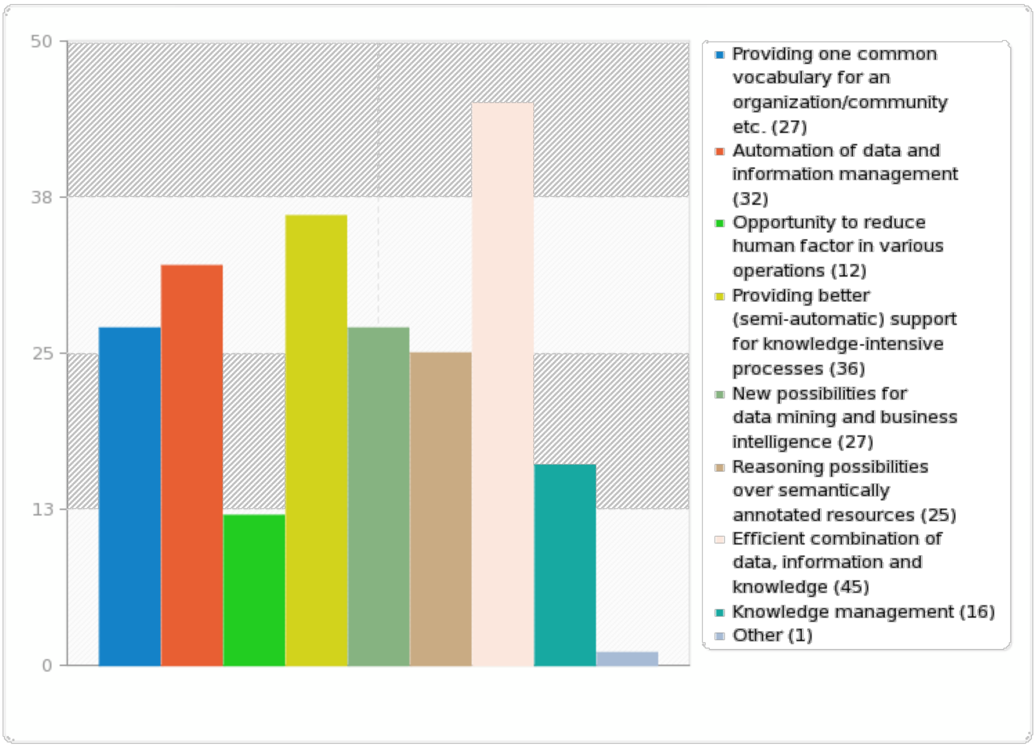
Answer	Count	Percentage
1 (1)	1	1.25%
2 (2)	1	1.25%
3 (3)	5	6.25%
4 (4)	1	1.25%
5 (5)	9	11.25%
6 (6)	10	12.50%
7 (7)	8	10.00%
8 (8)	14	17.50%
9 (9)	14	17.50%
10 (10)	10	12.50%
No answer	5	6.25%
Non completed	2	2.50%



Field summary for positiv_effect2

Which three factors will have the strongest positive effect on the use of semantic technologies?

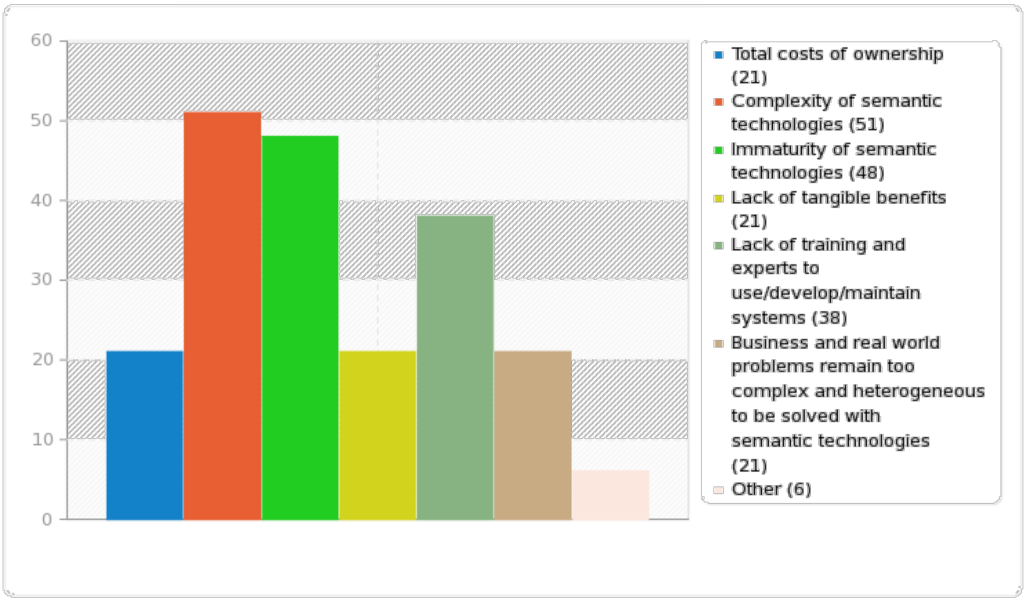
Answer	Count	Percentage
Providing one common vocabulary for an organization/community etc. (14a)	27	33.75%
Automation of data and information management (14b)	32	40.00%
Opportunity to reduce human factor in various operations (14c)	12	15.00%
Providing better (semi-automatic) support for knowledge-intensive processes (14d)	36	45.00%
New possibilities for data mining and business intelligence (14e)	27	33.75%
Reasoning possibilities over semantically annotated resources (14f)	25	31.25%
Efficient combination of data, information and knowledge (14g)	45	56.25%
Knowledge management (14h)	16	20.00%
Other Browse	1	1.25%



Field summary for challange_factors2

Which three factors will pose the greatest challenge in the adoption of semantics in service technologies?

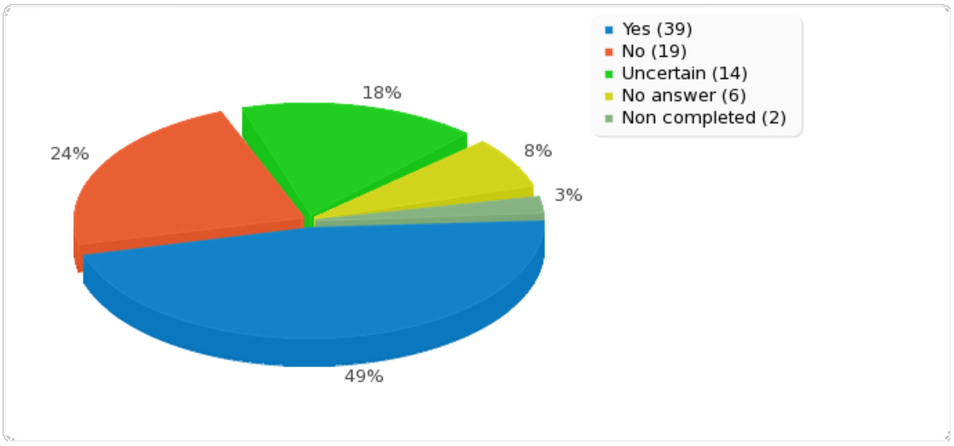
Answer	Count	Percentage
Total costs of ownership (15a)	21	26.25%
Complexity of semantic technologies (15b)	51	63.75%
Immaturity of semantic technologies (15c)	48	60.00%
Lack of tangible benefits (15d)	21	26.25%
Lack of training and experts to use/develop/maintain systems (15e)	38	47.50%
Business and real world problems remain too complex and heterogeneous to be solved with semantic technologies (15f)	21	26.25%
Other Browse	6	7.50%



Field summary for adopting_techn(16a)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally):
[RDF]

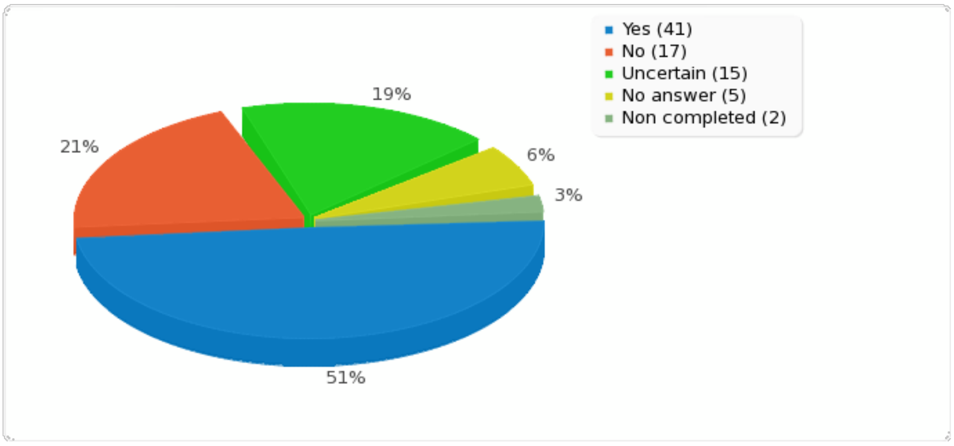
Answer	Count	Percentage
Yes (Y)	39	48.75%
No (N)	19	23.75%
Uncertain (U)	14	17.50%
No answer	6	7.50%
Non completed	2	2.50%



Field summary for adopting_techn(16b)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally):
[Ontologies]

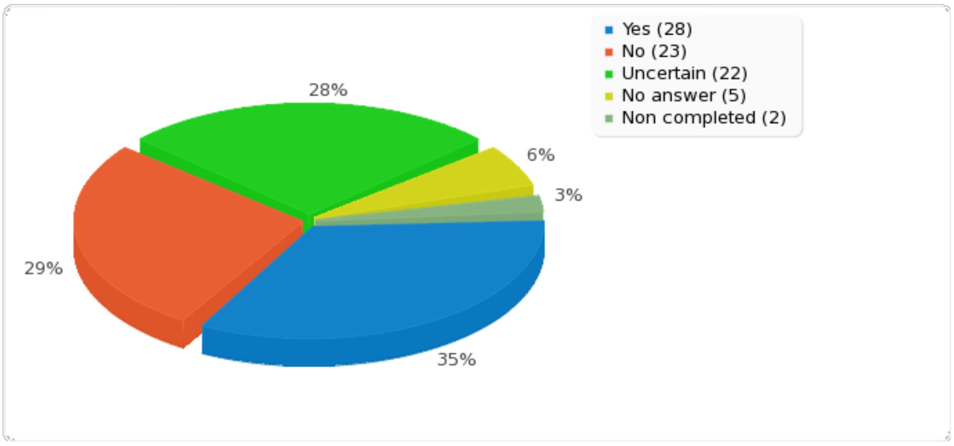
Answer	Count	Percentage
Yes (Y)	41	51.25%
No (N)	17	21.25%
Uncertain (U)	15	18.75%
No answer	5	6.25%
Non completed	2	2.50%



Field summary for adopting_techn(16c)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally):
[Reasoners/Inference engines]

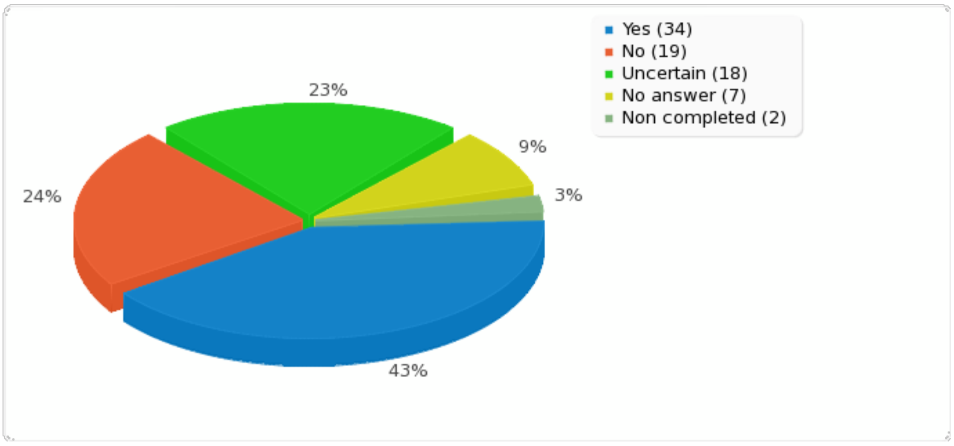
Answer	Count	Percentage
Yes (Y)	28	35.00%
No (N)	23	28.75%
Uncertain (U)	22	27.50%
No answer	5	6.25%
Non completed	2	2.50%



Field summary for adopting_techn(16d)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally):
[Semantic storage/repositories]

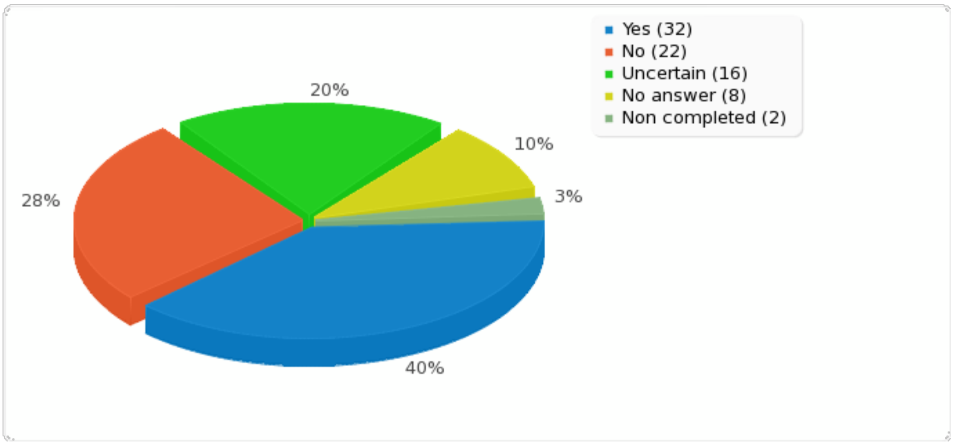
Answer	Count	Percentage
Yes (Y)	34	42.50%
No (N)	19	23.75%
Uncertain (U)	18	22.50%
No answer	7	8.75%
Non completed	2	2.50%



Field summary for adopting_techn(16e)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally): [Semantic Web services]

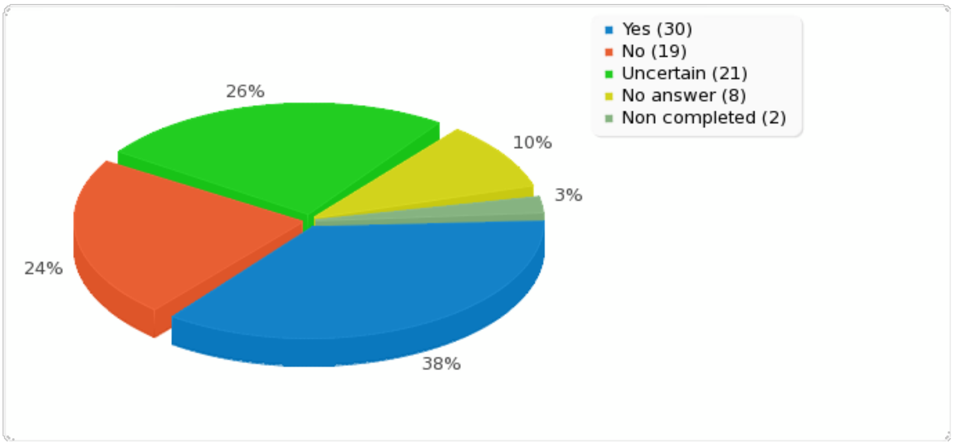
Answer	Count	Percentage
Yes (Y)	32	40.00%
No (N)	22	27.50%
Uncertain (U)	16	20.00%
No answer	8	10.00%
Non completed	2	2.50%



Field summary for adopting_techn(16f)

Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally): [Semantic applications (i.e. middleware/modeling tools)]

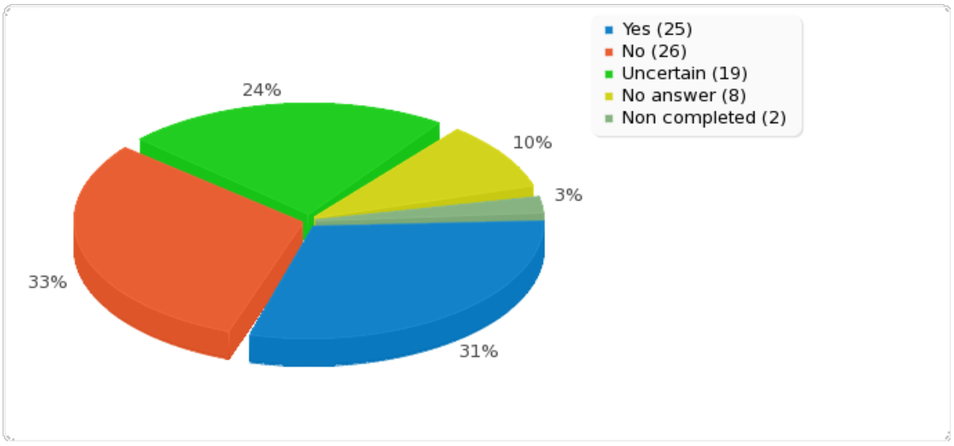
Answer	Count	Percentage
Yes (Y)	30	37.50%
No (N)	19	23.75%
Uncertain (U)	21	26.25%
No answer	8	10.00%
Non completed	2	2.50%



Field summary for adopting_techn(16g)

**Has your organization already adopted, or does your organization plan to adopt any of the following technologies (internally or externally):
[Semantic wiki]**

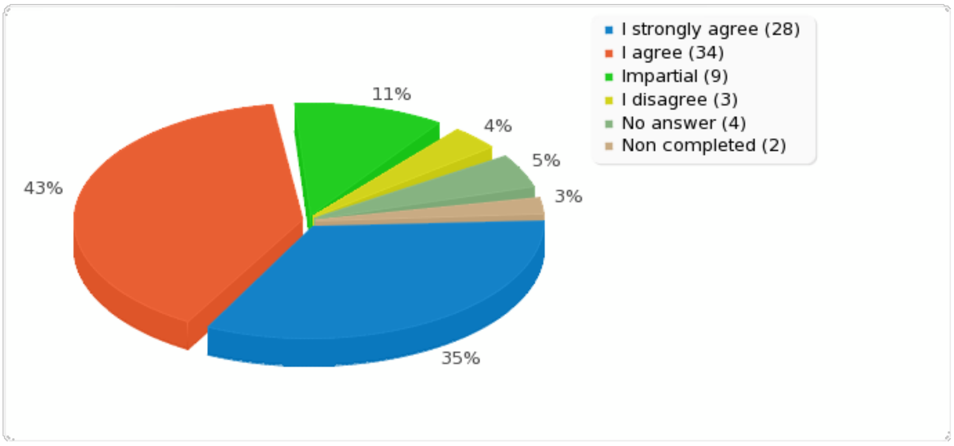
Answer	Count	Percentage
Yes (Y)	25	31.25%
No (N)	26	32.50%
Uncertain (U)	19	23.75%
No answer	8	10.00%
Non completed	2	2.50%



Field summary for semtech_fundamental

Semantic technologies will be fundamental in the realization of the Internet of Services vision.

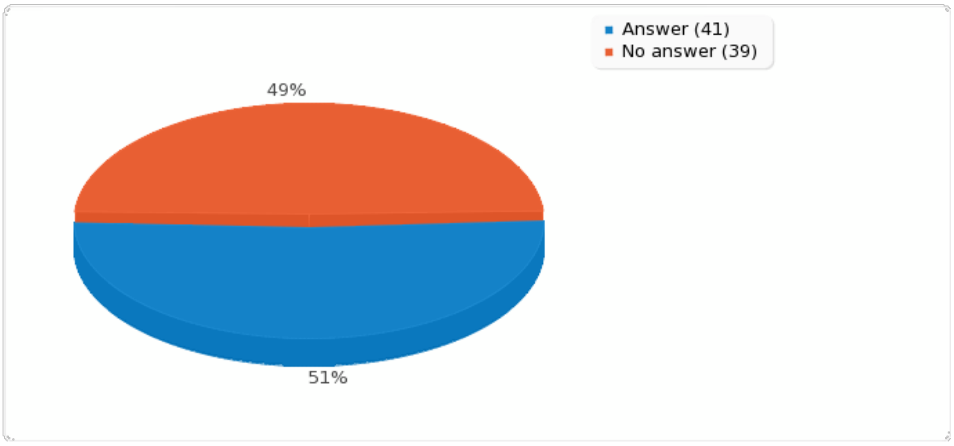
Answer	Count	Percentage
I strongly agree (17a)	28	35.00%
I agree (17b)	34	42.50%
Impartial (17c)	9	11.25%
I disagree (17d)	3	3.75%
I strongly disagree (17e)	0	0.00%
No answer	4	5.00%
Non completed	2	2.50%



Field summary for personal_data

Please enter your email address if you would like to be informed when the survey results have been compiled.

Answer Browse	41	51.25%
No answer	39	48.75%
Non completed	0	0.00%



LimeSurvey
Version 1.85+ (7253)