MASTER OF SCIENCE BY RESEARCH

Distributed systems and web services a critical investigation

Kumar, Uttam

Award date:
2011

Awarding institution:
Coventry University

Distributed Systems and Web Services:

A Critical Investigation

Uttam Kumar

Collaborating Organisation: Omitec Ltd, Coventry

A thesis submitted in partial fulfilment of the University's requirements for the degree of Master by Research in Software Engineering

December 2010

Coventry University

Acknowledgement

I would like to thank my Mother**, 'Adi Sakti'** for her support and inspiration for everything.

I would like to thank my Dad **Mr. Shio Narayan Prasad** who guided me and motivated me throughout my research. Without his guidance and motivation this work was simply impossible.

I would also like to thank my Director of Studies, **Dr. Anne James** and my second supervisor **Dr. Leonid Smalov**, from their help, guidance and advice. Dr. Anne and Dr. Leonid were always with me, whenever I needed them.

I also can't forget the contribution of all of them who contributed in my research work and would like to thank them all.

Abstract

The purpose of this research is to highlight the advantages of Web Services in distributed and interoperable environments. This research exposes the strengths, limitations and misconceptions of Web Services. It also highlights open areas for future developments and enhancement in this cutting edge technology.

During this research 214 IT professionals from 67 companies worldwide have been approached to discover the feasibility, importance and limitations of web services in the distributed environment. As part of this research, a prototype for remote vehicle diagnostics has also been created with the help of collaboration with Omitec Ltd. The purpose of developing the prototype was to give a good example of Web Services potential.

The final outcome of this research was the conclusion that although Web Services are a simple, easy and inexpensive option for a distributed solution, they are often not well understood and have issues with regard to interoperability and security. More development is needed in these areas as well as increased Web Services promotion and education throughout the global industry.

Table of Contents

List of Figures

List of Tables

1 - Introduction of Research

1.1 Problem Statement

Web Services represent a new platform on which developers can build distributed applications with interoperability as the highest priority. The Web Services platform represents the evolution of past distributed technology like Remote Procedure Call (RPC), ORPC (DCOM, CORBA, and Java RMI), messaging (MSMQ, MQ Series) and modern web applications, i.e. google.com. The main objective of Web Services is to provide a very simple framework for developing Web Services with maximum priority to interoperability.

Organisations are adopting Web Services because they can be used inside the firewall to allow application logic to be reused across the development groups and business partners with a reasonable amount of security.

Web Services are an example of a Service-Oriented Architecture (SOA) (Erl 2005), which is an increasingly popular way of building distributed systems. In a SOA, developers deal with services, which are relatively coarse-grained components that perform particular tasks (Alonso and Larrucea 2008). These components can be implemented in any appropriate manner - the SOA is concerned with what they do, not how they do it. Li and Karp (2007) stated that these services are usually distributed and can be located

anywhere on a network, mostly within the corporate firewall, but increasingly on the public Internet as well.

1.2 Relationship to previous work

Early studies have shown that the current Web Services are effective but although Web Services might solve some of the interoperability issues, many challenges remain (Vogels 2003). Synchronous interactions over Wide Area Networks are not scalable, for example, and large-scale versioning of procedure interfaces is extremely difficult. Because of common misconceptions the business industries and the developer communities feel hesitant in using Web Services for their distributed applications or B2B applications.

In 2003, the CTO of Amazon.com, Werner Vogels, produced an article which explained the common misconceptions about Web Services. In his research, Vogels analyzed existing Web Services technology with distributed objects i.e. COM, DCOM, RPC etc.

The hype surrounding Web services has generated many common misconceptions about the fundamentals of this emerging technology.

Web services are frequently described as the latest incarnation of distributed object technology. This misconception, perpetuated by

people from both industry and academia, seriously limits broader acceptance of the true Web services architecture (Booth et. al. 2004). Although the architects of many distributed and Internet systems have been vocal about the differences between Web Services and distributed objects, dispelling the myth that they are closely related appears difficult.

Many believe that Web Services are a distributed systems technology that relies on some form of distributed object technology (Vogels 2003). Vogels clearly highlights common misconceptions about this cutting-edge technology and provides an opportunity to make industry aware of these misconceptions and to make industry aware of what exactly a web service is, and what it can or cannot do. These misconceptions occurred because of a lack of understanding about Web Services and also because of confusion between two different technologies, namely Web Services and distributed object technology.

Web Services technology is changing the Internet, augmenting the eyeball web with capabilities to produce the transactional web. The eyeball web is dominated by program-to-user business-to-consumer (B2C) interactions. The transactional web will be dominated by program-to-program business-to-business (B2B) interactions. This transformation is being fuelled by the program-to-program communication model of Web services built on existing and

emerging standards such as HyperText Transfer Protocol (HTTP), Extensible Markup Language (XML), Simple Object Access Protocol (SOAP),WebServices Description Language (WSDL) (Christensen et al 2001), and the Universal Description, Discovery, and Integration (UDDI) project.

1.3 Aim & Objectives

The main aim of this research is to provide an exposition of Web Services in the context of how they are currently perceived by industry.

The objectives are:

- to collect information about the use of Web Services in a business context.
- to expose misconceptions about Web Services
- to expose the strengths/limitations of Web Services
- to design an application which highlights the power of Web Services
- to draw conclusions regarding the state-of-the art of Web Services and their suitability for current business scenarios

1.4 Organization of this thesis

Chapter 2 states and discusses the research issues that this thesis sets out to address. It also describes the research methods and materials used in order to address these issues.

Chapter 3 provides a basic background to Web Services and considers questions such as what is a Web Service, why do we need a Web Service, how do Web Services work and what are the supporting frameworks for Web Services. The chapter also considers a simple example of a working Web Service and its consumers. This chapter is logically divided into 3 parts: the first part of this chapter mainly spotlights the basic understanding about a Web Service and its use; the second part explains the architecture of a Web Service and attempts to correlate Web Services with Distributed Systems; the final part of this chapter provides information about the suitability of Web Services for both development and business communities and tries to highlight the common misconceptions about the Web Services. The chapter has been informed by extensive research, discussion and by interviewing various IT companies and various IT professions from well reputed IT companies. The chapter also highlights the

advantages of Web Services over ORCP (Object Remote Procedure Call).

Chapter 4 presents and analyses the results of the survey and interview components of the study.

Chapter 5 presents the application developed to highlight the use of Web Services in a current business scenario.

Chapter 6 discusses the main findings of the study and identifies their possible implications on the future of Web Services. Furthermore, it compares the result of the study against the results of other previous studies that have been carried out. This chapter also identifies the main contributions and achievements of the work that is presented in this thesis and discusses any future developments and areas of work.

1.5 Conclusion

This chapter has provided a general background to the research topic. It has outlined: a statement of the problem; the relationship to previous work; the aim and objectives of the work; and the overall organisation of the thesis.

2 - Research Materials & Methods

2.1 Introduction

This chapter states and discusses the research issues that this thesis sets out to address and describes the research methods and materials used in order to address these issues. To achieve the research goal there are some research questions. This chapter spotlights those questions.

This chapter also explains the research methodology, which has been used during entire research work. To relate this research to the real world, a questionnaire has been created and a survey has been carried out amongst the business community. In this context business is being used in its most general sense and encompasses various kinds of commercial enterprise. This chapter explains the approach that has been taken in conducting this survey.

To make this research even more practical and useful, a number of collaborating IT companies which are using Web Services, have been contacted to participate and to share their ideas and views about this topic.

2.2 Research Questions

The main research questions, which are addressed during the research, are as follows:

i. To what extent are Web Services being used in business?
ii. What environment is currently being used for Web Services?
iii. Are there any concerns about Web Services in business and if so what are they?
iv. To what extent are business users satisfied with Web Services technology?
v. What is the future of Web Services?

2.3 Types of Research Method

There are two well-known methodologies that exist for research investigations: qualitative and quantitative. In the former we use words to describe the outcomes and in the latter we use numbers (Miles and Huberman 1994). A third type of research philosophy has also been identified which is a combination of qualitative and quantitative and is referred to as a mixed research method.

2.3.1 Quantitative Research

Quantitative research methods were originally developed in the natural sciences to study natural phenomena. However examples of quantitative methods now well accepted in the social sciences and education. Quantitative research methods involve analysis of numerical data. The quantitative research is the research which can be quantified and which includes the following:

- surveys
- laboratory experiments
- formal methods such as econometrics
- numerical methods such as mathematical modelling.

Though a survey strategy is the most common quantitative strategy conducted by questionnaire and interviews, this method has some advantages and some limitations. As Easterby-Smith (1991) stated, the main advantages of quantitative research method, are as follows:

1. Quantitative methods can provide a wide coverage of the range of situations.
2. They are fast and economical, involving statistics aggregated from potentially large samples on

which basis they may be of considerable relevance for policy makers.

The main disadvantages are as follows:

1. The methods used tend to be rather inflexible and artificial.
2. They are not very effective in understanding processes or the significance that people attach to actions.
3. They are not very helpful as they make it hard for policy makers to infer what changes and actions should take place in the future.

However quantitative methods have been the main consideration with many studies involving social sciences (Cohen 1988) because of their efficiency and ability to help and generalise the data collected. Therefore many researchers consider data collected by quantitative methods more scientific and supporting (Hartmann 1988).

2.3.2 Qualitative Research

Qualitative research methods were developed in the social sciences to enable researchers to study social and cultural phenomenon. Qualitative research methods involve analysis of data such as words (e.g. from interviews), pictures (e.g. video), or objects (e.g. an artifact).

According to Gorman and Clayton (1997), qualitative research is defined as "…A process of enquiry that draws data from the context in which events occur, in an attempt to describe these occurrences, as a means of determining the process in which events are embedded and perspectives of those participating in the events, using induction to derive possible explanations based on observed phenomena."

Examples of qualitative methods include:

- action research which aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework;
- case study research - a case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context;

- ethnography- the ethnographer immerses her/himself in the life of people s/he studies and seeks to place the phenomena studied in its social and cultural context.

2.3.3 Comparison of Qualitative & Quantitative Research

Table 1 - Features of Qualitative & Quantitative Research

Qualitative	Quantitative
"All research ultimately has a qualitative grounding" (Miles and Huberman 1994)	"There's no such thing as qualitative data. Everything is either 1 or 0" (Miles and Huberman 1994)
The aim is a complete, detailed description.	The aim is to classify features, count them, and construct statistical models in an attempt to explain what is observed.
Researcher may only know roughly in advance what he/she is looking for.	Researcher knows clearly in advance what he/she is looking for.
Recommended during earlier phases of research projects.	Recommended during latter phases of research projects.
The design emerges as the study unfolds.	All aspects of the study are carefully designed before data is collected.
Researcher is the data gathering instrument.	Researcher uses tools, such as questionnaires or

	equipment to collect numerical data.
Data is in the form of words, pictures or objects.	Data is in the form of numbers and statistics.
Qualitative data is more 'rich', time consuming, and less able to be generalized.	Quantitative data is more efficient, able to test hypotheses, but may miss contextual detail.
Researcher tends to become subjectively immersed in the subject matter.	Researcher tends to remain objectively separated from the subject matter.

According to Spencer et al (2003) “Qualitative research aims to provide an in-depth understanding of people’s experience, perspectives and histories in the context of their personal circumstances or setting”. In contrast with the quantitative research approach, rather than being restricted in a relatively narrow band of behaviour, with the qualitative approach the researchers will find it more convenient to explore the phenomena in their natural environment (Rudestam and Newton 2001).

So in nutshell, the qualitative research type emphasises more on data as words than data as numbers. There is more emphasis on description and discovery and less emphasises to hypothesis testing and verification which means more weight is given to

exploratory concerns to enable better understanding of the research problem (Khushman 2010).

2.3.4 Mixed Research

Mixed methods research is a method for adopting a research strategy employing more than one type of research method together. The mixed methods approach might be a mixture of qualitative and quantitative methods. Mixed methods research also means working with different types of data (Miles and Hubermann 1994).

Keeping qualitative and quantitative methods in mind it is very unlikely that a research will fall under one category and most often a successful research uses a combination of both qualitative and quantitative methods. Saunders et at. (2000) emphasise that it is better to combine approaches within the same piece of research. In this context, Easterby-Smith (1991) also argued that the difference between a quantitative and qualitative approach is not always apparent. Some techniques could be used in both approaches, for example, the interview. Not only that but a single piece of data, for example an interview transcript, can be analysed in both ways. This clearly emphasises that there is no strict constraint defined which

enforces the use of a specific method in a specific circumstance and another for another circumstance.

The mixed research method has many advantages over any other research methods i.e. researchers can use combinations of different methods in one single study, either because of the research design or in order to corroborate results from different methods. According to Creswell (1998), the choice of utilising this multi-method approach would make the best of both methods and nullify the disadvantages of each one.

2.4 Methods Used In This Research

This research comes under the category of the mixed research method where quantitative and qualitative research methods have been used. During research following methods have been used:

- literature review
- survey
    - questionnaire
    - face to face and tele-conferencing interviews

- laboratory development as a means of experimentation
- collaboration in a case study development
- prototyping

The following is a brief description of the methods that have been used in this research:

2.4.1 Literature Review

A comprehensive survey of publications and an in-depth review of key works in the fields of interoperability and Web Services have been conducted.

The following sources of information and facilities have been used during research work:

Electronic Media - Electronic Media has played a very important role in the entire research process. It has been frequently used for searching the latest and updated information through the Internet and for conducting a survey through email. It has also been used for writing the thesis.

2.4.2 Survey

A survey has been carried out of a number of enterprises. The survey consisted of a questionnaire and in-depth interviews.

2.4.3 Questionnaire

A questionnaire has been created as part of the survey of business and engineering bodies. The questionnaire serves to answer some of the research questions.

2.4.4 Interviews

Face-to-face or teleconferencing interviews and discussions have been conducted with IT professionals from various IT companies to correlate the research work with the real world. The main objective of these interviews is to collect information about the level of understanding and possible misconceptions about the Web Services and to find out suitability, feasibility and other open issues in existing Web Services.

2.4.5 Laboratory Development

Computer Laboratory – To prove the practicality of this research a number of experiments have been undertaken. The

main objective of those experiments was to get a clear understanding about the subject matter and eventually to produce the prototype to demonstrate the advantages of Web Services.

2.4.6 Collaboration

To make this research more practical and to correlate it with the real world, collaboration has been established. This collaboration has yielded a case study and a business scenario to analyse and to execute. The main objective of establishing the collaboration was to obtain a real case study with which to work and to combine business aspects into the chosen research topic. Another object of the collaboration is to understand better how Web Services technology relates to the business requirements. The collaborating company was OMITEC Ltd, an automotive company.

2.4.7 Prototyping

As a result of technical collaboration a prototype Web Services based vehicle diagnostic system was developed. This prototype demonstrates the potential of Web Services for business and society. This component of the research was addressed partially at research question (v) (see section 2.2).

The table below summarises how each of the research questions were addressed by the above methods.

Table 2 - Addressing the Research Questions

Research Question	Method(s) Used
To what extent are Web Services being used in business?	Survey
What environment is currently being used for Web Services?	Survey
Are there any concerns about Web Services in business and if so what are they?	Literature Review Survey
To what extent are business users satisfied with Web Services technology?	Survey
What is the future of Web Services?	Literature Review Survey(Interviews) Collaboration Prototype Development

2.5 Employing the Methods

In order to employ the methods outlined earlier, a number of tasks have been done. These tasks have been carried out in three stages.

Stage 1 – Literature Review and Information Gathering

As a first step toward starting the research work, a number research papers and research journals have been studied. For digital and published research materials, the University's library has been used; for web-based information and to thoroughly understand the selected research topic, the Internet has been used, either at home or at work.

In order to garner further information regarding the current perceptions of industrial users a number of on-line groups were studied. These included Microsoft New Group, VBug and IBM newsletters. Attendance at industrial seminars and workshops mainly in Reading and Manchester provided further information in this regard.

Stage 2 – Survey (Questionnaire and Interviews

Stage 1 was a continuous process throughout the research. Thus Stage 2 was started in parallel. During Stage 2, the questionnaire was created as well as meeting plans for face-to-face discussion. A list of contact details was compiled of the professionals who were going to be approached. This list has been compiled from personal contacts, i.e. from work and ex-work colleagues, by the reference of work and ex-work colleagues and by approaching various companies from various sectors such as retail, IT consultancy,

finance, FMCG, automotive, banking and publication. The majority of the participating companies were the top-most blue-chip companies, including Microsoft, IBM, Oracle, Rover, Barclays, Phones 4u, Cognizant, TCS, Dell, HCL etc.

During the research, a total of 67 companies had been contacted. However only 29 companies actually participated in the research and 38 companies either did not respond or committed to give some time but never came back.

For the email based survey 214 people have been approached but only 168 people actually participated in the research work.

Out of 214 participants, 40 people have been approached for face-to-face discussions. 36 people have actually participated in face-to-face discussions.

Stage 3 – Collaboration and Prototype Development

To make the research more fruitful and more specific, a prototype has been developed for automotive industry after having collaboration with an automotive company called Omitec Ltd. The purpose of this development was to show how Web Services can be used to develop relevant and innovative systems to meet current business needs.

2.6 Conclusion

This chapter has presented the research questions which have been addressed and which have driven the entire research work. This chapter has also explained the methods of research and how those methods have been employed during entire research.

Literature Review

3 - An Introduction of Web Services

3.1 Introduction

In order to provide a clear understanding of Web Services, it is important to explain the terminology in detail first. Therefore this chapter starts with introducing the basic concepts of Web Services and then it explains various aspects of Web Services and also discusses the security model of Web Services.

This chapter also aims to provide information about the main benefits of using Web Services, for example why do we need a Web Service and how do Web Services work?

3.2 What is a Web Service?

It is quite difficult to provide a common definition of the term ***Web Services***. Much of the confusion comes from press and vendor hype, which lacks the technical depth needed to make people understand the real concepts. In 2003 the CTO of Amazon.com, Werner Vogels (Vogels 2003), commented that the political bickering among standards bodies such as WC3, OASIS, and WS-I McIntosh have not helped to clarify the simple, interoperable nature of Web Services (Vogels 2003). Since then, this research has shown that there is still misunderstanding about Web Services.

Some people use the term Web Services to describe applications that communicate with Simple Object Access Protocol (SOAP), some say Web Services is just RPC for the Internet, some say that Web Services is the application that communicates over the Internet, some view Web Services as anything accessible over the Web, some use the term to describe the software-as-a-service business model and others use the term to describe any Web-based application (Booth 2003).

We may conclude from the above that there was no official consensus within the industry. So let us consider what are the various definitions of Web Services provided by various software vendors who are providing this technology or using it in some form? Mainly two standards groups have been working on the definition of official Web Services standards: W3C (Austin 2004) and the Organization for the Advancement of Structured Information Standards (OASIS) (for example OASIS 2007a and OASIS 2007b). W3C focuses on core infrastructure specifications, and OASIS focuses on higher-level functionality. W3C initiated its Web Services standardization efforts with the launch of the XML Protocol Working Group (XMLP) in September 2000. In February 2002, W3C greatly expanded its Web Services effort with the formation of the W3C Web Services Activity. The goal of the W3C Web Services Activity is to “design a set of technologies in order to bring the development of

Web Services to its full potential.” The W3C Web Services Activity currently consists of three working groups and one coordination group (Manes 2002). OASIS, the other standards group, has more than 30 Technical Committees working on various XML-based standards, most of which apply to the Web Services Architecture.

The official definition of the term, as specified by the W3C, the World Wide Web Consortium (Jacobs 2001), a global organization that designs, develops, promotes, and encourages standardization of Web-related technologies, is as follows:

"A Web service is a software system identified by a URI, whose public interfaces and bindings are defined and described using XML. Its definition can be discovered by other software systems. These systems may then interact with the Web service in a manner prescribed by its definition, using XML based messages conveyed by Internet protocols." (Austin 2004)

According to OASIS who provides standards for Web Services, a Web Service is:

“A software component that is described via WSDL and is capable of being accessed via standard network protocols such as but not limited to SOAP over HTTP” (Broberg 2002).

These are fairly technical definitions, so let us analyze them to understand what they mean. To start with, let us look at some of the terminology that is used in these definitions:

URI (Uniform Resource Identifier) is the generic term for all types of names and addresses that refer to objects on the Web. A URI designates a specific resource on the Internet and also designates a method to access the resource. The familiar URL (Uniform Resource Locator) we use to reference a particular web page is one kind of URI.

XML (Extensible Markup Language) is a specification similar to HTML, but which goes beyond simple document presentation to capturing data in a meaningful and structured format so that it can be exchanged between applications that need that data. XML uses user-defined tags to describe data types, and also includes mechanisms to address and associate sets of data, referred to as resources. The XML specification comes from the same source, W3C, described earlier (Newcomer2002).

WSDL is an XML format for describing network services as a set of endpoints operating on messages containing either document-

oriented or procedure-oriented information. The operations and messages are described abstractly, and then bound to a concrete network protocol and message format to define an endpoint (Christensen et al 2001).

Related concrete endpoints are combined into abstract endpoints (services). WSDL is extensible to allow description of endpoints and their messages regardless of what message formats or network protocols are used to communicate (Christensen et al 2001).

The Hypertext Transfer Protocol (HTTP) is the set of rules for exchanging files i.e. text, graphic images, sound, video, and other multimedia files etc on the World Wide Web. It is relative to the TCP/IP suite of protocols (which are the basis for information exchange on the Internet). HTTP is an application protocol.

The Internet protocol in the Web Services definition refers primarily to SOAP (Simple Object Access Protocol). SOAP is a lightweight XML-based messaging protocol, independent of any operating system that encodes XML data as well as request and response messages before sending them over a network. Thus, while XML is used to tag the data to make it semantically meaningful, the actual process of transferring that data across a network is done using SOAP. In essence, SOAP is the glue that binds Web Services

together. Other core protocols include WSDL, a specification for describing a Web Service (the service methods, message types, etc.), and UDDI (Universal Description, Discovery and Integration), a mechanism to publish and discover Web Services.

Putting it all together and in simple terms, Web Services is a technology that integrates different Web-based applications from different sources by allowing them to directly communicate data, semantics, and processes with each other, independent of any specific operating system or programming language automatically, without human intervention (Agarwal 2007). The future trend in computing appears to be a move away from traditional desktop and client-server based applications towards applications that are fully developed and deployed over the Internet, that can also communicate with other Web-based applications dynamically in real-time to provide more integrated solutions to specific user tasks. Web Services is a crucial enabling technology for such applications, so we are likely to keep hearing a lot more about it in technology circles. Many of the leading high-tech companies offer development platforms and environments that support Web Services, including Microsoft with .NET, IBM with WebSphere, BEA Systems with WebLogic, and Sun Microsystems with the Sun Java Enterprise System. The IBM, BEA, and Sun products are all based on the Java platform.

In spite of various debates on the exact definition of Web Services, a Web Service can be defined as a piece of software that makes itself available over the Internet and uses a standardized XML messaging system.

XML is used to encode all communications to a Web Service. For example, a client invokes a Web Service by sending an XML message, and then waits for a corresponding XML response. Because all communication is in XML, Web Services are not tied to any one operating system or programming language--Java can talk with Perl; Windows applications can talk with UNIX applications.

Beyond this basic definition, a Web Service may also have two additional (and desirable) properties:

- First, a Web Service can have a public interface, defined in a common XML grammar. The interface describes all the methods available to clients and specifies the signature for each method. Currently, interface definition is accomplished via the Web Service Description Language (WSDL).
- Second, if you create a Web Service, there should be some relatively simple mechanism for you to publish this fact. Likewise, there should be some simple mechanism for interested parties to locate the service and locate its public interface. The most prominent directory of Web Services is

currently available via UDDI, or Universal Description, Discovery, and Integration.

3.3 Definitive Characteristics

A Web Service exhibits the following definitive characteristics:

- A Web Service is accessible over the Web. Web Services communicate using platform-independent and language-natural Web protocols. These Web protocols ensure easy integration of heterogeneous networks.

- A Web Service provides an interface—a Web *API*—that can be called from another program. This application-to-application programming interface can be invoked from any type of application. The Web *API* provides access to the application logic that implements the service.

- A Web Service is registered and can be located through a Web Service Registry. The registry enables service consumers to find services that match their needs.

- Web Services support loosely coupled communications between systems. Web Services communicate by passing

messages to each other. The Web Service interface adds a layer of abstraction to the environment that makes the connections flexible and adaptable.

3.4 Why Web Services?

Web Services is an ideal choice for the current business and engineering scenario because of its enormous advantages and its flexibility. It can be used for Business-to-Business, Application-to-Application, and Application-to-Services and Service-to-Service integration. A number of software professionals think that it is an ideal choice for Distributed Computing and a boon for Grid Computing; other thinks it is a future framework for Internet application development.

Almost any product can be sold on the Web and many services can actually be performed on the Web, remotely and without human intervention (Agarwal et al. 2007). Computing and data storage services are good examples. Web site use analysis, medical diagnosis on the basic of given appropriate input devices and data, insurance needs analysis, and stock trading are other examples. In brief any service that you now provide by mail or by in-person service may often be offered to remote users.

Many of these services can already be found on the Web, often built at considerable expense. Web Services includes the computing

platforms, standard data formats specified by industry or in general, ways of exchanging data, and ways of posting the availability of services to the world that will make building these services faster, cheaper and safer.

The best example of the growth of Web Services is eBay. eBay the flagship company for online auction has been frequently developing its Web Services platform by extending application programming interfaces that essentially turn its Web site into a platform. The auction site's developer section gives plenty of information about deploying its eBay API. With the eBay API, one can communicate directly with the eBay database in XML format. By using the API, an application can provide a custom interface, functionality and specialized operations not otherwise afforded by the eBay interface. Since 1999, eBay has offered APIs and now offers more than 100 Web Services calls available to developers to build applications that can connect to those services. They include pricing information, buy-it-now features, and payment options through its PayPal subsidiary. The growth and use of APIs across the Web illustrate how rapidly Web services are spreading, even as standards bodies work out technical issues such as security and authentication.

The above information has been provided by eBay in order to provide development support.

Online retailing giant Amazon.com is another example. Companies such as Microsoft and Sun Microsystems have been helping developers build and deploy Web Services and clients for a number of years now. Sun's J2EE platform, for example, is what developers build on in order to provide access to Amazon.com's selling platform.

One of the main reasons for deploying Web Services is that Web Services mitigate the application integration crisis. They help you integrate applications, and they do so at a significantly lower price point than any other integration technology.

Web Services represent a new form of middleware based on *XML* and the Web. *XML* and the Web help solve the challenges associated with traditional application-to-application integration which were as follows:

- Traditional middleware doesn't support heterogeneous network architecture.
- Traditional middleware doesn't work across the Internet.
- Traditional middleware is not persistent.
- Traditional middleware is hard to use.
- Traditional middleware is expensive.

- Traditional middleware maintenance is really costly.
- Traditional middleware connections are hard to reuse.
- Traditional middleware connections are fragile.

Web Services address these issues. Web Services are platform and language independent. A Web Service can be developed using any language, and can be deployed on any platform. In addition Web Services can also be accessed by any other application, regardless of either's language or platform. Web Services communicate using *XML* and Web protocols, which are pervasive, work both internally and across the Internet, and support heterogeneous interoperability.

Web Services simplify the process of making applications talk to each other. Simplification results in lower development cost, faster time to market, easier maintenance, and reduced total cost of ownership. The bottom line is: Web Services allow you to integrate your applications at a fraction of the cost of traditional middleware.

Traditional *RPC*-style middleware, such as *RPC*, *CORBA*, *RMI*, and *DCOM*, rely on tightly coupled connections. A tightly coupled connection is very brittle, and it can break if you make any modification to the application. Tightly coupled connections are the source of many a maintenance nightmare. In contrast, Web Services support loosely coupled connections. Loose coupling

minimizes the impact of changes to your applications. A Web Service interface provides a layer of abstraction between the client and server. A change in one does not necessarily force a change in the other. The abstract interface also makes it easier to reuse a service in another application. Loose coupling reduces the cost of maintenance and increases reusability.

3.5 Main Strengths of Web Services

As mentioned above, Web Services are actually just applications; they fundamentally do the same thing that a normal application does. However, the way they do things is different. Let us consider three scenarios in which Web Services are exceptionally good:

3.5.1 Integration

Today, application integration continues to be one of information technology's most important challenges. Business spends millions of pounds on it every year. Web Services based application integration offers the next big step in application-to-application communication. It attacks the three problems identified above, cost, complexity, and solution inflexibility, with a new model that is lower cost, easier

to learn and deploy, and more adaptable to changing business needs. The result is a faster, easier application-to-application communication, allowing companies to connect many more applications within their company, and opening the door for better portals and Business-to-Business (B2B) solutions. Now many, rather than only the most critical, applications can talk to each other, presenting enormous opportunities for improved business performance.

3.5.2 Service Re-Use

For years it has been known that reusing code, or parts of applications, rather than rewriting them for a new application increases productivity. One of the most powerful features of Web Services is the ability to re-use a service (e.g. a business function application) many times rather than creating a new service for the same function over and over to meet the requirements of the receiving application. This is possible by isolating the packaging or delivery requirements of the service from the business function. Putting only the 'business logic' in each service and maintaining the packaging or delivery information outside of the service, allows the service to be used again and again, without changing, whenever a receiving application requires that business logic. Service re-use can increase your organizations' productivity, allowing your people to

develop new services around new business functions rather than rewriting services to meet the requirements of new client applications.

3.5.3 Business Flexibility

The third area where Web Services shine is in providing increased business flexibility. Historically, business applications are rather rigid. Updating them with new functionality to meet changing business requirements has traditionally been expensive, complex, and time consuming. However, Web Services provides a substantial step forward, allowing you to build new Web Services based integration solutions quickly, at a reasonable cost, so you can adapt to changing or time-sensitive business requirements more easily. And, since it is easier to reuse services for multiple clients in the Web Service environment, you achieve additional business flexibility. As an example, you might want to build a dashboard to view orders, shipping, and billing information for your customers. Using a Web Services based integration, you could rather easily integrate information from your order-entry, shipping, and billing systems to build the new view. You could quickly build a 'Customer Dashboard' that provides a complete history of all the orders, shipments, and billing activities for a customer over time.

Corporate dashboards are becoming increasingly important. Often legal requirements drive the need for certain dashboards, particularly in company financials. Using Web Services can reduce the development time substantially. It is fundamental to the promise of Web Services that you can connect applications for internal use, portals, or B2B opportunities and efficiencies - quickly, at reasonable cost - that allow you to adapt to changing business needs.

3.6 How do Web Services Work?

Web Services allow client applications to access business logic through Internet protocols, which means that any business can interact with any other business (B2B) without encountering problems related to company-specific protocols.

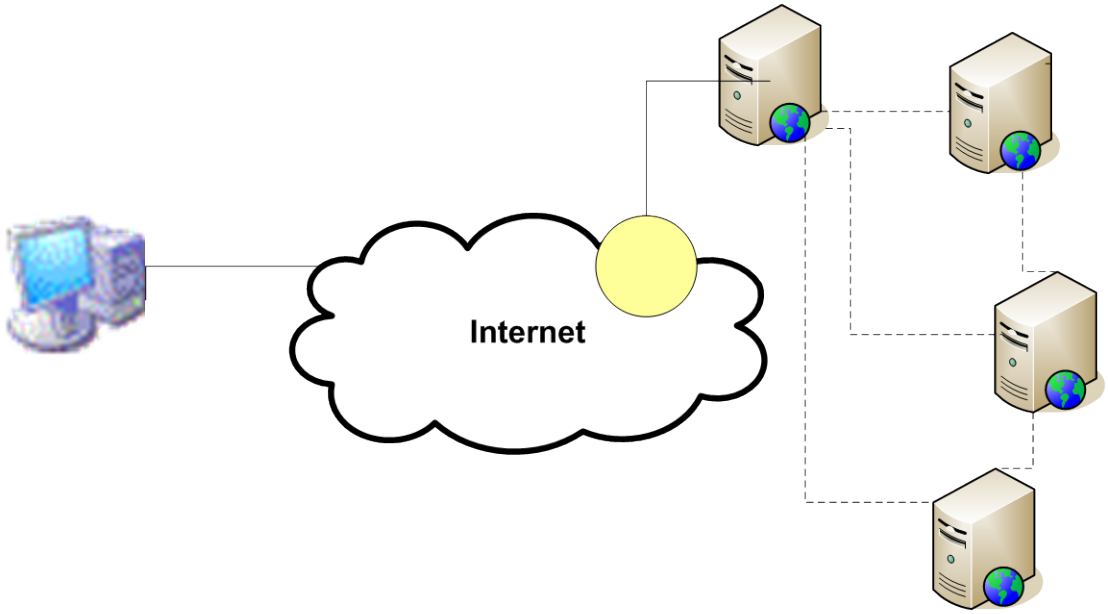

Figure 1 - Integration of Applications over the Internet

The client machine needs to use a Web Service; it uses a process called Discovery to find out what services are available from a specific company over the Internet. To provide this flexible approach, the Web Services in a Discovery document must provide certain details.

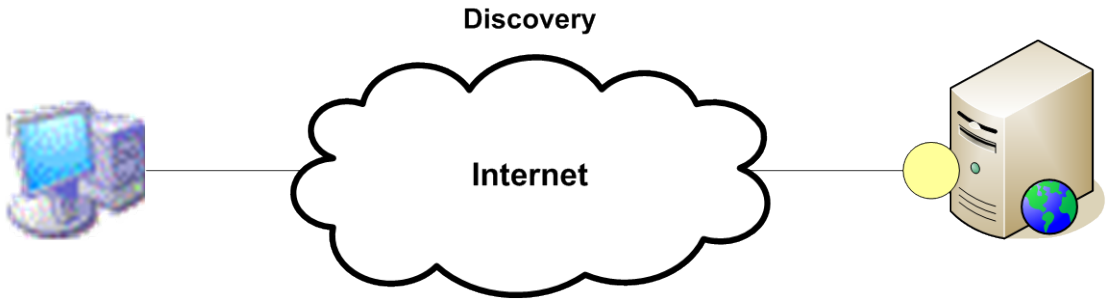

Figure 2 - Discovery over the Internet

A Discovery document contains information in XML format about one or more Web sites that provide Web Services. The document contains URL links to descriptive documents or contracts for a specific Web Service.

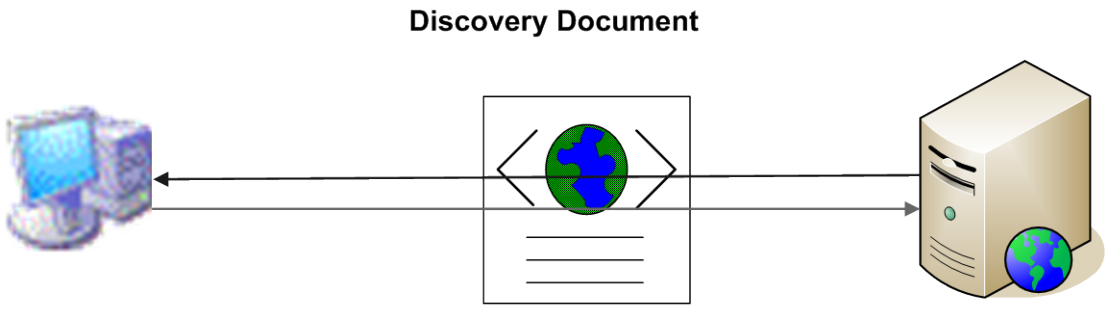

Figure 3 - Discovery Document Layout

Many languages which support Web Service development automatically create Discovery documents to locate individual services and contract agreement information.

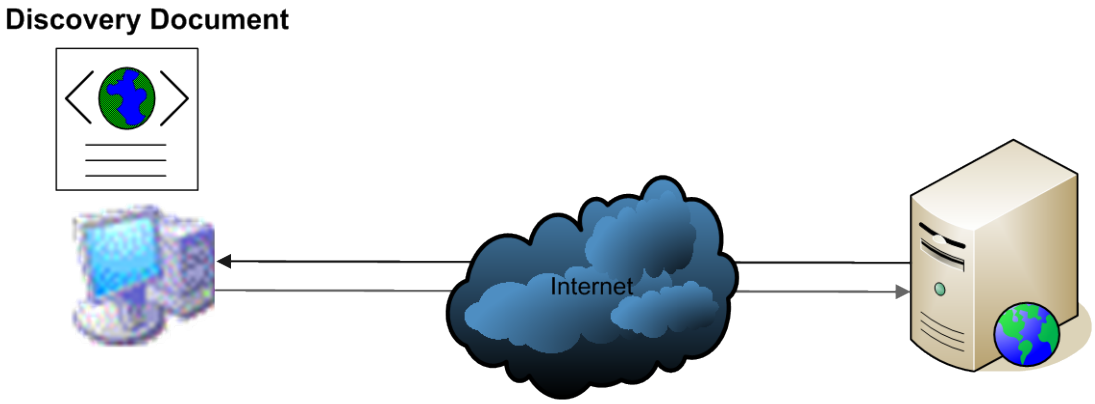

Figure 4 - Communication through WSDL

With this information, the client can explore the contract documents to find the requirements of the Web Service methods. These contracts are also in XML format, but they follow specific standards that have been established to describe the methods, arguments and return values of a Web Service.

To describe the methods and services available to the client in a specialized way it uses ASP and WSDL (Web Services Description Language). WSDL documents describe the details of each method for three different protocols: HTTP-Get, HTTP-Post and the Simple Object Access Protocol (SOAP). For these requirements, the client automatically constructs a proxy class to ease communication between the developer's client code and the Web Service. It may use the SOAP method descriptions when creating this proxy. The beauty of using SOAP is that it can use some enhanced features such as call by reference parameters and the ability to pass objects, structures and specialized datasets i.e. ADO.NET.

The client application calls the proxy class as if it were talking directly to the real service. In fact, the proxy hides all the network communications and gives a feel that the client is using the Web Service locally rather than remotely. The proxy then makes requests to the Web Service, passing the desired parameters across the Internet as SOAP messages. The Web Service processes the

incoming request and performs the required action. If values need to be sent back to the client, the Web Service creates these values and returns them as SOAP messages. The message is received by the proxy and converted into client's base type with which the client can work. This layer of abstraction allows developers to work with a Web Service as it were a component running locally to the client.

So in brief the client sends an XML document in a format called the Simple Object Access Protocol (SOAP) over HTTP. The server has a listener waiting for a SOAP packet. When it receives one, it opens it up, and if everything is in order, it executes the native code. It then takes the results from that code, packages it into another SOAP packet, and returns it to the client. SOAP supports platform and language interoperability through XML.

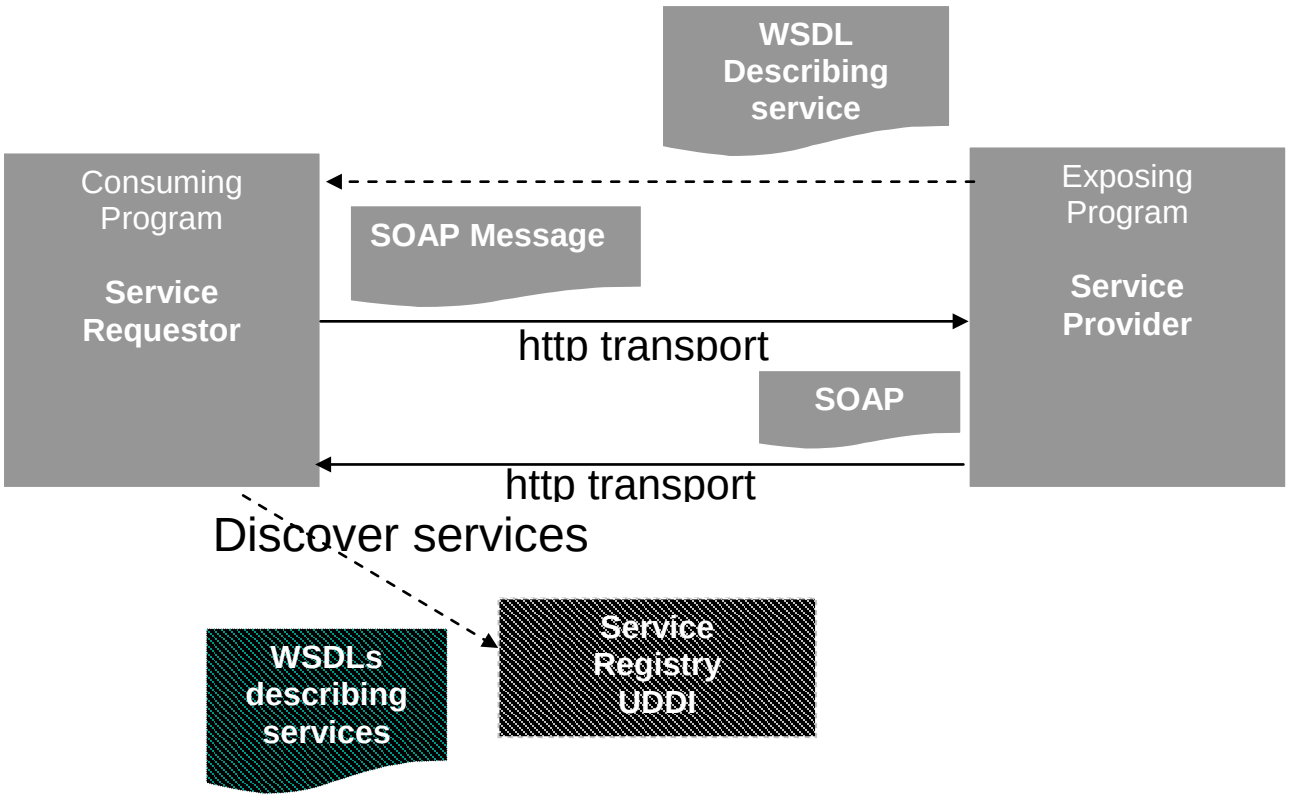

Figure 5 - Working Architecture of Web Service

The client application does the following to access a Web Service:

- Uses the discovery process to find out what services are available.
- Uses the WSDL to define methods to call the address of the SOAP endpoint, schemas for SOAP messages and responses, and the data types returned.
- Creates a proxy client class.

3.7 The Web Services Model

The architecture of a Web Service is based on the interaction between main three roles, which are as follows:

- Service Provider
- Service Registry
- Service Requester

The interaction between these three roles involves the main three operations:

- Publish
- Find
- Bind

These three roles and its operations are tightly integrated with each other. They act together to develop, discover and to use a Web Service (Booth 2004).

In a common scenario, a service that is an application component (an executable code) is hosted by a service provider on an

internet/intranet as a network-accessible software module, which is technically known as an implementation of a Web Service. The service provider defines a service description for the Web Service and publishes it to a service requestor or service registry. The service requestor uses a “find” operation to retrieve the service description to bind with the service provider and invoke or interact with the Web Service implementation. The service provider and service requestor roles are logical constructs and a service can exhibit characteristics of both. Figure 6 illustrates these operations, the providing them and their interactions (Kreger 2001).

Fig 6 has been removed due to third party copyright. The unabridged version of the thesis can be viewed at the Lanchester Library, Coventry University

Figure 6 - Web Services Roles, Operations and Artefacts (Kreger 2001)

3.8 The Web Services Security Model

Security is one of the biggest concerns in the eCommerce and distributed application and that is why security models and security standards are the back bone of Web Services technology. The security mechanism of Web Services protects the confidentiality and integrity of data and information in transit during data and messages exchanged between a client and a Web Service. Not only this, information protection requires consideration not only simple two way client and server communication but also extend to highly

complex communications and interactions, i.e. business to business interactions and communication through multiple Web Services. The need for providing end-to-end security through distributed and heterogeneous security mechanisms called for the development of standards for Web Services security with the ultimate goal of making interoperable different implementations of the same security functions (Anderson 2006).

The Web Services security model is based on a number of Web Services security standards which are developed as a part of comprehensive framework with the following underpinning criteria:

- Web Services security standards have to be independent of specific underlying technologies.
- Web Services standards need to be extensible and should be capable of dealing with new requirements and technologies.
- Web Services standards should be organised in layers so that the upper layer standards could use and extend standards at a lower level (DeLooze 2008).

- Web Services security standards must be composable.

The existing and current Web Services security standards are as follows:

“Near the wire” security standards

This is a basic level of security which exists at the communication layer. SSL (Secure Socket Layer) and TLS (Transport Layer Security) are the well known security standards which are being used to ensure transport level security for web applications (Dierks and Rescorla 2006).

SSL and TLS are a protocol layer located between a connection oriented network layer protocol, i.e. TCP and the application protocol e.g. HTTP. It also enables point-to-point secure sessions by providing server authentication to the client, optional client authentication to the server, data message authentication, data confidentiality and data integrity (Dierks and Rescorla, E. 2006).

SSL / TLS provides for:

- Confidentiality, by the use of symmetric cryptography for data encryption i.e. DES, RC4 (Askarov et al 2008).
- Data integrity by the use of a Messaging Authentication Code (MAC) generated through a secure has function which is called MD5
- Authentication using certificate and public keys.

Although SSL / TLS are quite secure for point to point communications, it does not provide end to end communication protection which is needed in a Web Services setting. The other issue of SSL / TLS is that it does not allow one to selectively encrypt parts of data to be transmitted (Dierks and Rescorla 2006).

XML Data Security

Securing XML data to maintain integrity, confidentiality and authenticity is considered as one of the most important requirements of Web Services. In Web Services these security options are being achieved using encryption mechanisms and digital signatures. Integrity and confidentiality are achieved

by using encryption mechanisms. The digital signature technique is also being used to enforce authenticity in Web Services. XML encryption (Eastlake and Reagle 2002) and XML signature standards specify how to represent and how to convey encrypted data and digital signature in an XML document in a standard way (Baker et al 2005).

Security Assertions Markup Language (SAML)

Security Assertion Markup Language (SAML) is an XML-based standard for exchanging authentication and authorization data between security domains (Anderson and Lockhart 2005).

SAML is a product of the OASIS Security Services Technical Committee and was approved in March 2005.

SAML mainly addresses the Web Browser Single Sign-On (SSO) problem, a problem also addressed by the more widely-used OpenID standard. Single sign-on solutions are abundant at the intranet level (using cookies, for example) but extending these solutions beyond the intranet has been problematic and has led to the proliferation of non-interoperable proprietary technologies (Cahill and Hughes 2005).

SAML assumes the principal has enrolled with at least one identity provider. This identity provider is expected to provide local authentication services to the principal. However, SAML does not specify the implementation of these local services; indeed, SAML does not care how local authentication services are implemented (Gross 2003).

Thus a service provider relies on the identity provider to identify the principal. At the principal's request, the identity provider passes a SAML assertion to the service provider. On the basis of this assertion, the service provider makes an access control decision.

SOAP Message Security

In Web Services the main mode of communication is SOAP messaging. As SOAP messages can communicate with multiple applications which may be one or many SOAP intermediaries and multiple trust domains within and between business entities, there is a need to provide an end-to-end protection over multiple hops to assure SOAP message integrity and confidentiality as well as the requester’s identity. This can be achieved by using XML encryption and XML

signatures but it is also necessary to standardize the representation to prevent the following types of attacks:

- Message modification, code injection and information theft by attackers.
- Well formatted messages sent by a hacker that lack appropriate security claims to warrant processing.
- Alteration by an attacker of a message sent to the Web Services (Eastlake and Reagle 2002).

The main building blocks for SOAP message security are as follows:

- **WS-Security** – A de facto standard for securing SOAP messages which has been started in 2001 and approved as an OASIS standard in June 2002 (Nadalin et al 2004).
- **WS-Secure Conversations –** This is an OASIS standard which enables two channels to establish and manage a session at the SOAP message level (Anderson, S. et al. 2005)
- **WS-Reliability –** It defines a messaging protocol to manage the reliable the reliable delivery of messages

between exactly two parties, a source and a destination referred to as the Reliable Messaging Source and RM Destination.

- **WS-Trust –** This is another OASIS standard which defines extensions to WS-Security that provide a framework for requesting and issuing security tokens for assessing the presence of trust relationships and the brokering trust relationships (OASIS 2007b).

3.9 Emerging Directions of Web Services Security

An emerging direction in Web Services security is in the area of business processing and security support for business workflow. A work flow may consist of a number of tasks, each represented by a Web Service or set of Web Services. The question of authorisation to carry out those tasks within a business process arises. To address this scenario, role-based-access control has been proposed (Konshutanski and Massacci 2003 and 2005, Bertino et al 2010). Role-based access control has been a well-understood approach in information systems for some time (Sandhu et al 1996, Bertino 1999, Al-Kahtani and Sandhu 2003) but applying the concept to Web services is an

emerging field. A similarly new direction is that of “security as a service”. In software terms, this idea is to provide security functions as software functions that exist outside applications but which can be shared by applications. This approach can avoid code duplication and also allow for clearer security management as all security policies could concievably be maintained in one place. A standard has emerged which separates access control from applications XACML (OASIS 2009). Web Services could be the vehicle to implement this new approach

3.10 Conclusion

This chapter has provided an exposition of Web Services pointing out the features that distinguish them from older distributed object technology. The main distinguishing features are discoverability, loose coupling, web messaging infrastructure and the support for new application composition. Older technologies i.e. RPC, DCOM etc did not have these features.

This chapter also has explained the current security model of Web Services, highlighting the current standards. Some

words have also been provided on some emerging security trends which are relevant to Web Services.

Project Outcome

4 - Survey

4.1 Introduction

This chapter presents the results of the survey, which consisted of an email survey through a questionnaire and interviews for which the same questionnaire formed the basis. The survey was carried out to discover current professional opinion and relevance of Web Services to the current business scenario. In this chapter the results of the survey is described and the results are presented. Some limitations of the survey are also discussed.

4.2. Purpose of the Survey and Subject Types

The main objective of doing the survey was to find out the suitability and to justify the need of Web Services in the current and next generation applications. The survey targets various professionals so that we can analysis Web Services from different dimensions.

The survey was conducted among the following types of professional:

- Directors and owners of companies that uses Web Services.

- Resourcing executives who are involved in recruitment processes or trying to find resources on Web Services technology.
- New Business Development Managers who are responsible for generating new business.
- IT managers / Leaders who can justify the suitability of Web Services for new applications and old / legacy applications.
- IT Consultants / IT professionals / IT Developers and implementers who can explain the technical parts of the Web Services.

4.3 Questionnaire

A questionnaire was created and distributed among professionals to gather relevant information about the suitability and acceptance of the undertaken research topic in the existing business and the engineering scenario. This questionnaire also aimed to gather information about common problems and open issues in the existing technology. The survey questionnaire form is shown below:

1. Are you using Web Services?

2. When did you start using Web Services?

3. For what kind of development works do you use Web Services?

_____

4. Which OS you are using as a development platform?

- Microsoft
- O2
- Solarise
- Unix/Linux
- Others

5. What is your development environment?

_____

6. Do you use a Web Services Toolkit?

If Yes, please specify toolkit name, purpose of using that toolkit and name of the toolkit provider:

_____

7. Where do you host your Web Services?

_____

8. Are you using a third party Web Service?

If Yes, please specify Web Service name, purpose of and provider name:_____

9. Do you think Web Services are:

(a) a good choice for distributed applications in terms of simplicity?

(b) a good choice for distributed applications in terms of cost effectiveness?

(c) a direct replacement of distributed objects?

(d) an effective and suitable technology for distributed applications

10. Are you satisfied with the current security model of Web Services?

If No, please explain why:

_____

11. Do you think Web Services completely fulfil the promises of interoperability?

If No, please explain why:

_____

12. Do you find any issue or limitation in the existing Web Services?

If Yes, please explain:

_____

13. Do you think the versioning process is simple enough in Web Services?

If No, please explain:

_____

14. Do you find any limitation or issue in the building process of a proxy for a Web Services client?

If Yes, please explain:

_____

15. Do you find any issue in deploying a Web Service?

If Yes, please explain:

_____

16. Do you find any limitation or issue in WSDL?

If Yes, please explain:

_____

17. Do you find any limitation or issue in the discovery process of Web Services? If Yes, please explain: _____
18. Can you suggest any idea to improve the way Web Services, WSDL and the discovery process works?
19. Can you suggest any idea to improve the versioning and deployment process of a Web Service?

4.4 Mapping of Survey Questions with Research Questions

The survey questions contributed in part to answering the research questions as shown in table 3 below:

Table 3 - Mapping of Research questions and Survey questions

Research Question	Survey Question
To what extent are Web Services being used in business?	1, 2, 3,
What environment is currently being used for Web Services?	4, 5, 6, 7, 8
Are there any concerns about Web Services in business?	16, 17, 18, 19
To what extent are business users satisfied with Web Services technology?	9, 10, 11, 12, 13 14, 15
What is the future of Web Services?	All questions contribute to some extent to this research question

4.5 Survey Results

In spite of busy schedules making contact difficult, a large number of IT professionals from various countries agreed to participate in this research. These professionals were mainly from USA, UK and India. A number of big software companies were involved, including Microsoft, IBM, Barclays, Citi Bank, HCL, Xerox, Phones 4u, Accenture, Oracle, Rover, Cognizant, TCS, Dell, HCL Lloyd TSB, Carphone warehouse, Jaguar, Atos Origin, Infosys, and Satyam. The survey was conducted among various professional role types. These included Worldwide Directors, Engineering Directors, Associate Directors, Resource Managers, Release Managers, Team Leaders, IT integrators and developers. This survey also has been conducted among various industries i.e. Automotive Industry, Retail Industry, Telecom Industry, Service Industry, Consultancy, Banking Industry, Finance Industry, FMCG.

During research, a total of 67 companies had been contacted. However only 29 (44%) of the companies actually participated in the research. 21 (31%) companies did not respond and 17 (25%) companies committed to give some time but in the end were unable to participate.

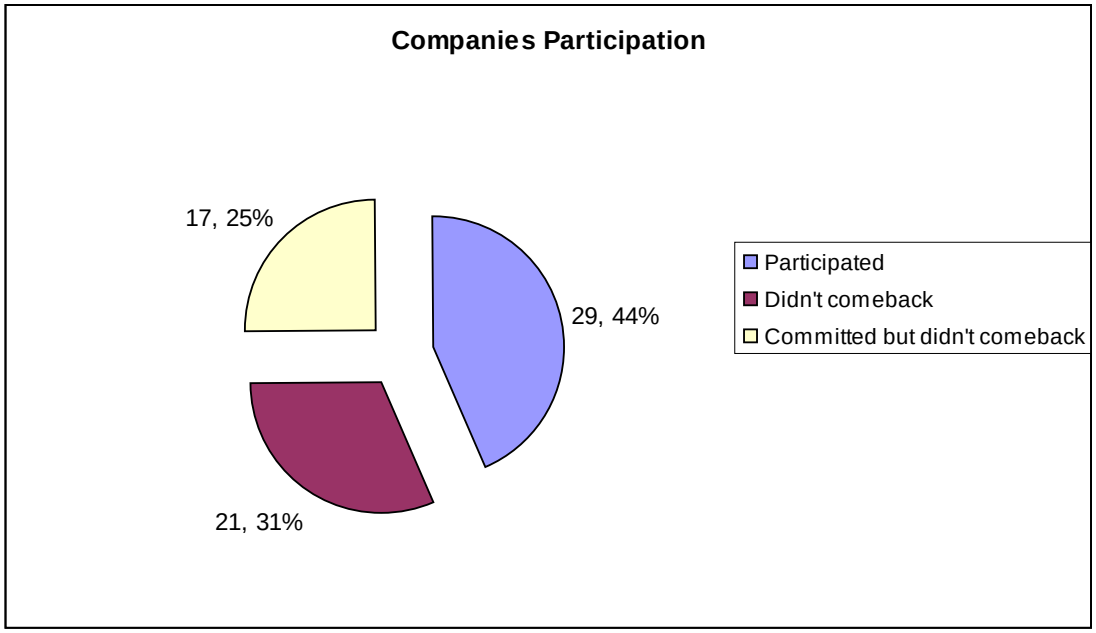

Figure 7 - Graph for Companies Participation in the Research

For the email based survey, 214 IT professionals were approached but only 132 (62%) of those people actually participated in the research work. Fifteen (7%) responded to the email and promised to complete the survey soon but never responded further. Thirty seven (17%) replied that they do not have direct interaction with the subject chosen and 30 (14%) people did not respond to the email at all.

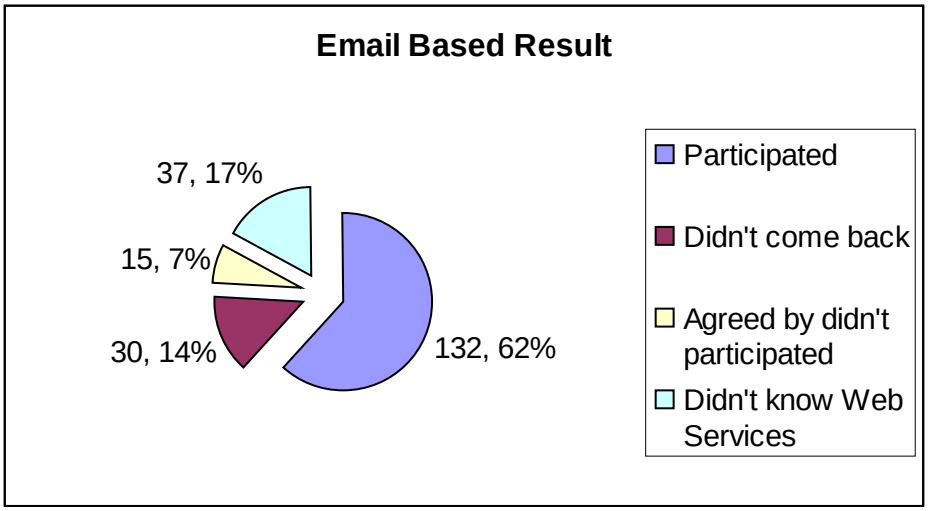

Figure 8 - Email Based Survey Result

For the face-to-face discussions and interviews, 40 people were approached and out of 40 people, 36 (90%) people actually participated in the research. Three (7.5%) people refused and 1 (2.5%) person committed but did not give time even after several attempts to engage.

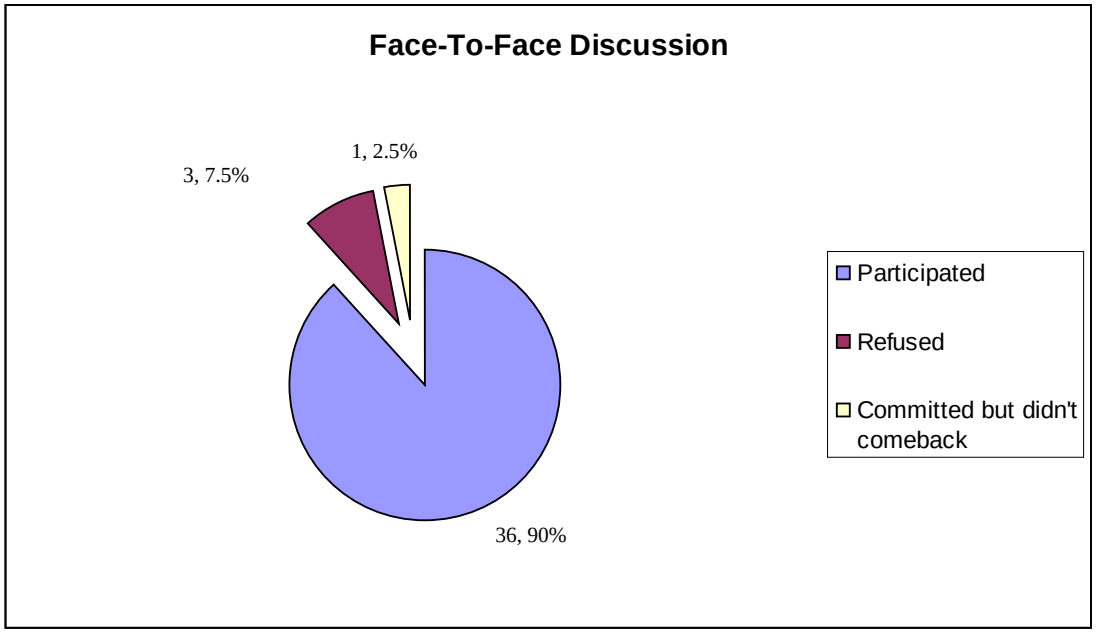

Figure 9 - Face-To-Face Discussion Result

So in summary, this survey has been conducted by involving 29 companies, 132 survey participants and 36 face-to-face discussions from professionals based around the world. It was found to be really difficult to talk to IT directors or managers. People tried to avoid any face-to-face interview and found it difficult to participate in the questionnaire survey. It was also noticed that a large majority of IT developers are aware of this cutting edge technology but they are hesitant about it. Nevertheless they showed huge interest to know more about this technology, especially developers who are not yet using this technology.

Thirty six people agreed for a face to face interview and gave a 20-30 minutes slot for interview. Due to geographical differences, many people preferred either telephonic discussion or sent their view through email i.e. 16% preferred telephonic discussion whereas 46% preferred email response. A small number of professionals (21%) either declined the request or did not respond. The same survey questions were used as a basis for face-to-face, telephonic and email interactions. However the richness of data gathering varied according to the method used, the face-to-face interviews allowing for further information to be gathered and explanations of survey questions to be given where necessary. This was also possible in the telephonic exchanges but to a lesser extent as the telephonic discussion is usually characterised by less engagement than a face-to-face interview. The opportunity for explanation and further information extraction was even less in the email interactions as primarily these took the form of the questionnaire being sent out, completed by the participant and then returned. However even in email interactions some further exchanges occurred.

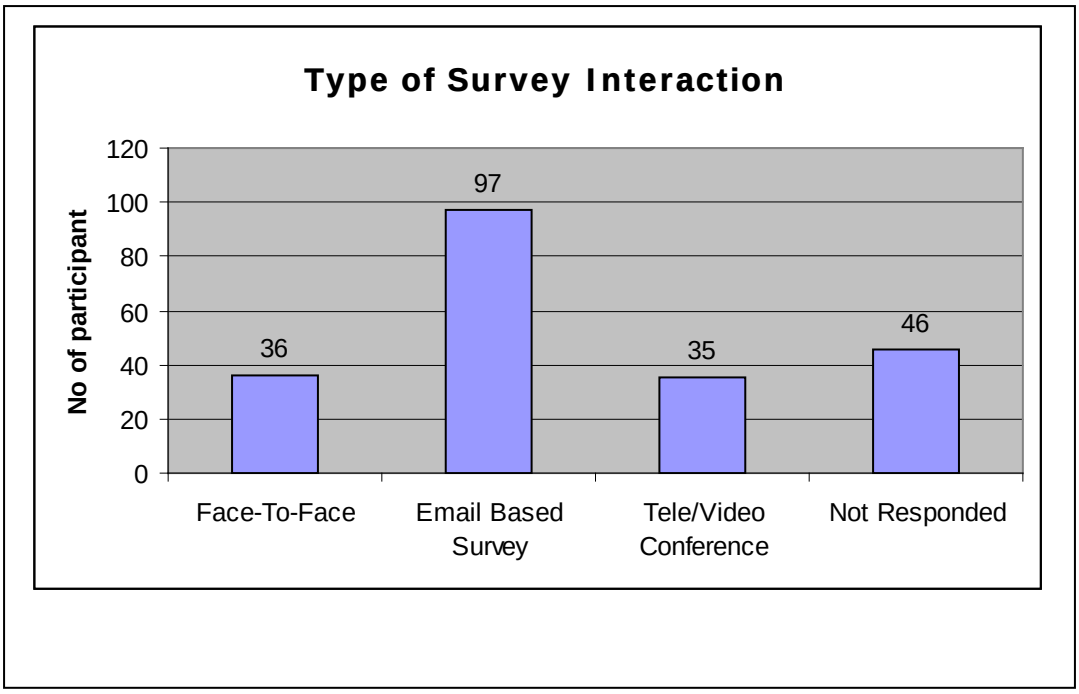

Figure 10 - Type of Survey Interaction

The survey questions have been intentionally kept open so that professions and specialists of this area would be given more chance and scope to express their views in depth.

The survey conducted face-to-face had a very positive result as 75% participants answered and discussed open questions in detail whereas 25% refused to comment on the open questions (question 16 to 19 have been considered as main open questions).

Survey Question - 1 (Extent of use)

The main aim of asking survey question 1 was to find out the popularity of Web Services in the existing industry or, in other words, to what extent are Web Services being used at present. In response to survey question 1, in which it was asked of 214 professionals whether they are using Web Services or ever used Web Services, 168 (78.50%) participants answered “yes” whereas 46 (21.49%) participants admitted that they never used Web Services in their organisation.

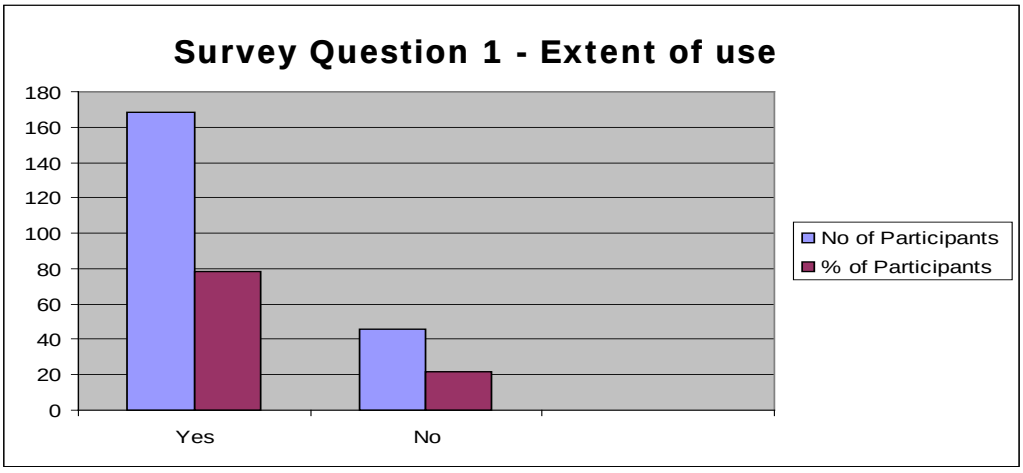

Figure 11 - Extent of use

The 46 participants who said they were not using Web Services at present were contacted with further questions either through email or via telephone. Those who said that they do not use Web Services were also asked further questions about the reasons for

non-use of Web Services in their computing environment. The outcome of the additional questions asked was as follows:

- They are not using because of technological differences i.e. their legacy solutions are not very suitable for the Web Services.
- There was lack of either awareness or thorough awareness about Web Services technologies.
- There were concerns about security features offered by Web Services.

These additional questions helped in populating or in answering the research question of whether there are any concerns about Web Services in business.

Survey Question – 2 (Length of use)

A total 168 people have participated in response to survey question 2. This question has been aimed at answering the first research question which was to what extent are Web Services being used in business. Out of 168 participants, a majority 73 (43.45%) participants have been using Web Services for the last 2-5 years, 52 participants (30.95%) have been using Web Services for the last 5-10 years, 34 (20.24%) participants started using Web Services

recently and 9 participants (5.36%) have more than 10 years of experience in Web Services. This result clearly shows that although Web Services are popular and increasingly in demand, they are not in a very mature state. Few people have used Web Services for more than 10 years. It was also noticed that people who have been using Web Services for more than 10 years are developing Web Services under the Unix environment and using Java based technologies. It has also been noticed that the open questions have been attempted by all the participants who had more than 10 years experience in Web Services. Another interesting finding has been noted that people who are using Web Services for more than 10 years have also good experience and wide exposure of RPC and distributed computing.

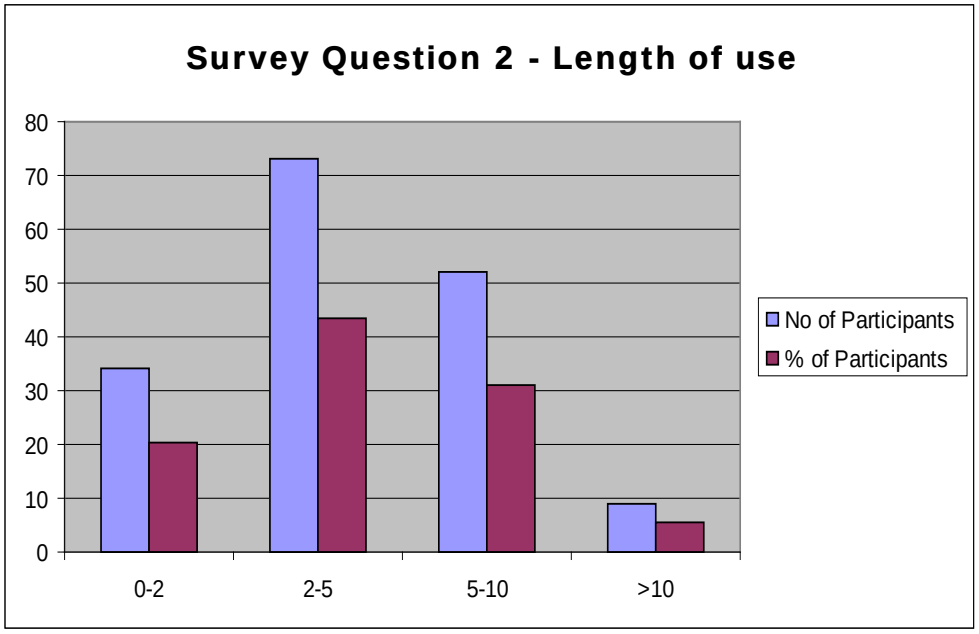

Figure 12 - Length of Use

Question – 3 (Web Services Uses)

Survey question 3 was also created to answer research question 1 which was, to what extent are Web Services being used in business. This research question also populates a picture in which domain Web Services are most and least used. The survey result for question 3, in which all together 168 IT professionals have participated, was as follows:

134 participants (79.76%) were using Web Services in more than one domain. 100% Web Services user were using Web Services for eCommerce / intranet applications. After eCommerce the second highest uses of Web Services is distributed computing which was 79 (47.02%) in total. The third most popular use of Web Services was Transaction Processing Systems. Twenty four (24.28%) participants reported using Web Services for TPS. Nineteen (11.30%) participants were using Web Services in their financial applications.

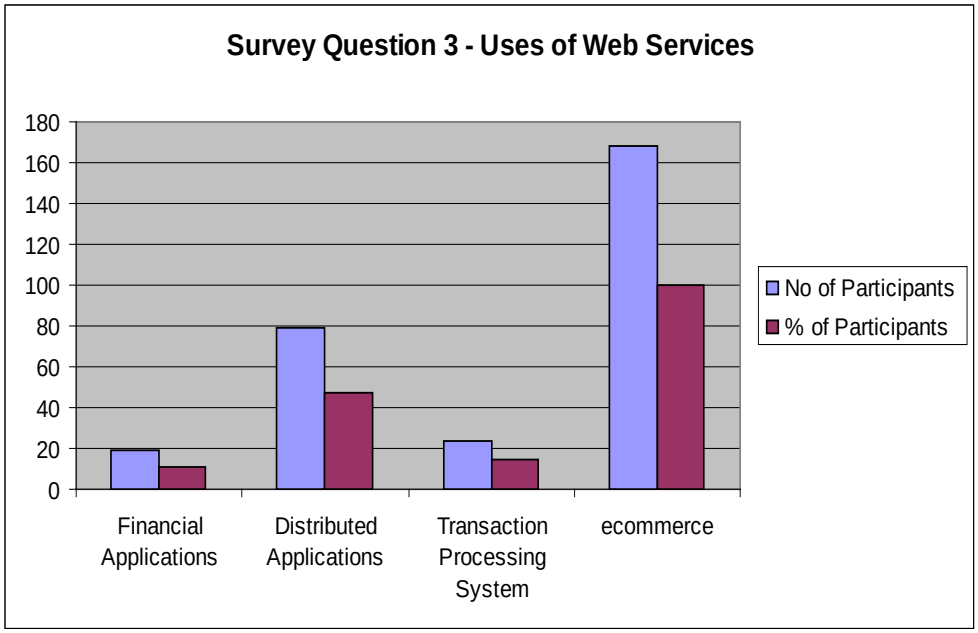

Figure 13 - Uses of Web Services

When the question was raised to the financial and transaction processing systems users of why they do not use Web Services in their business domain, they responded that either their legacy systems and existing infrastructure preventing them in using Web Services or they were still doubtful about Web Services' security and scalability. However they still thought that Web Services are the future and they will be using Web Services in the up-coming projects.

Survey Question – 4 (Development Platform)

The main aim of survey question 4 was to answer the second research question what was about what environments are currently

being used for Web Services. For question 4 (Which OS is being used to develop Web Services) the response was divided. However the majority of participants (89 out of 168 or 52.97%) are developing Web Services under the Unix / Linux environment. 75 participants (44.64%) are developing Web Services under Microsoft Operation Systems. Two participants (1.94%) use Solaris as their preferred operating system and 2 participants (1.94%) were not sure about the operating system being used by their development environments. None of the participants voted in favour of OS 2. The results show that Unix / Linux is the most popular operating system among the eCommerce industries followed by Microsoft.

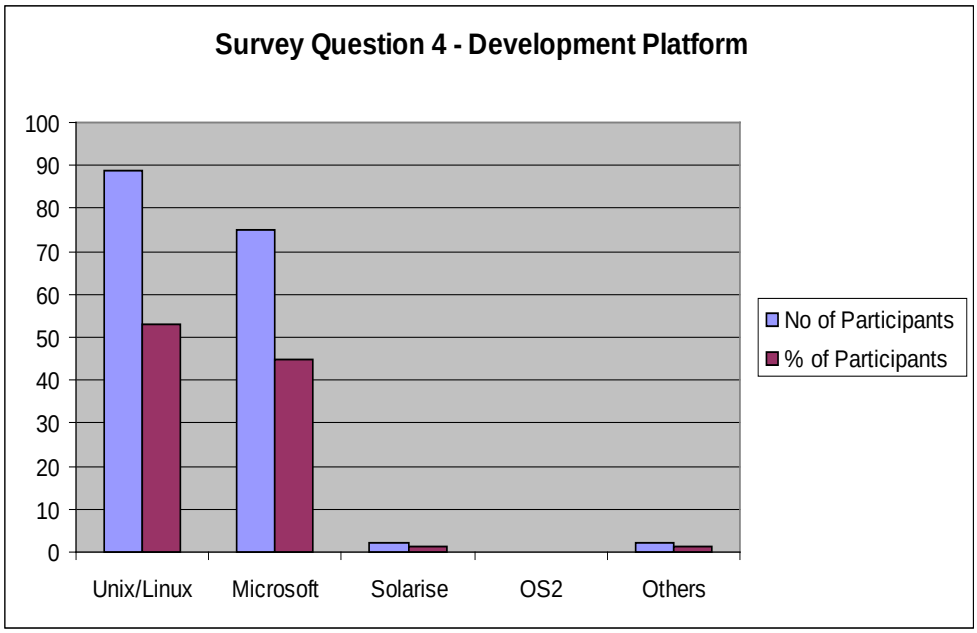

Figure 14 - Development Platform

Survey Question – 5 (Development Tool)

In response to question 5 the survey result indicates that although Web Services are quite frequently developed under the Microsoft environment, large percentages of the participants have indicated that they are developing Web Services either using JAVA or J2EE. After Java and J2EE, the Microsoft .Net framework was the preferred development environment chosen by the participants. A small number of participants also indicated that they are using developing Web Services in PHP. This survey question was aimed at answering the second research question which was about the environment currently being used for Web Services.

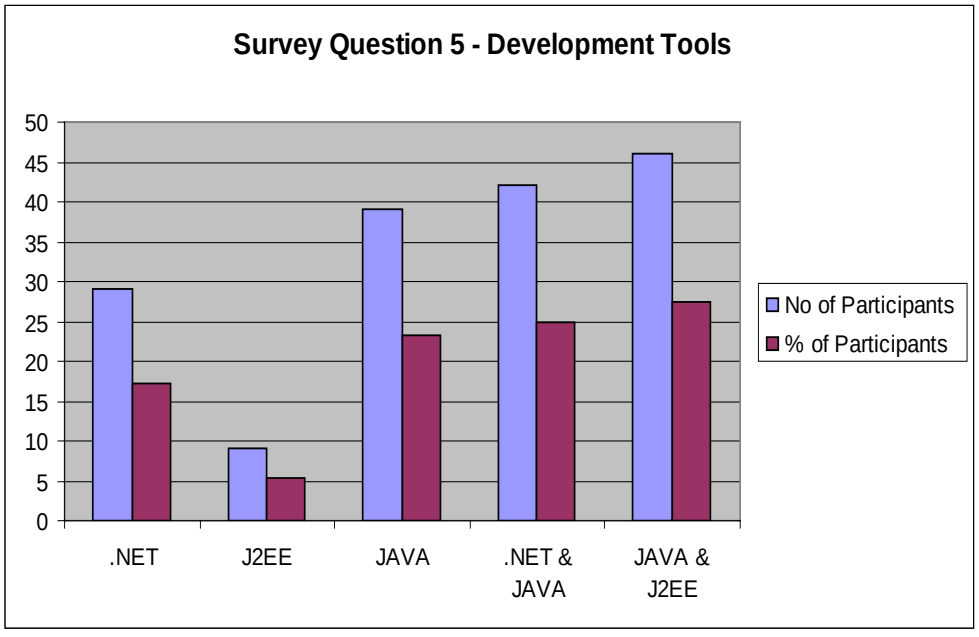

Figure 15 - Development Tools for Web Services

The above graph indicates that out of 168 participants 46 participants (27.38%) are using J2EE and Java together, 42

participants (25%) are using both .NET and Java, 39 (23.21%) participants are only using Java, 29 (17.26%) participants are only using .NET for developing Web Services. Nine (5.36%) participants have indicated J2EE as their development tool for developing Web Services and only 3 participants (1.79%) in total have developed Web Services using PHP and Java together.

This survey also projects a very interesting picture that the most popular development environment is not single. Different types of environment are often used within the same company.

Survey Question – 6 (Testing Tools)

Survey question 6 was also focused to answer research question 2 which was about what environments are currently being used for Web Services. In response to the question asked for tools used during Web Services development the responses were mixed. The survey result indicates that the SoapUI tool is quite popular for Web Services testing. After SoapUI many professionals indicated that they are testing their Web Services functionalities through a test driven framework. It has also been noticed that a large number of participants admitted that that they are still writing personalised test harnesses for Web Services testing.

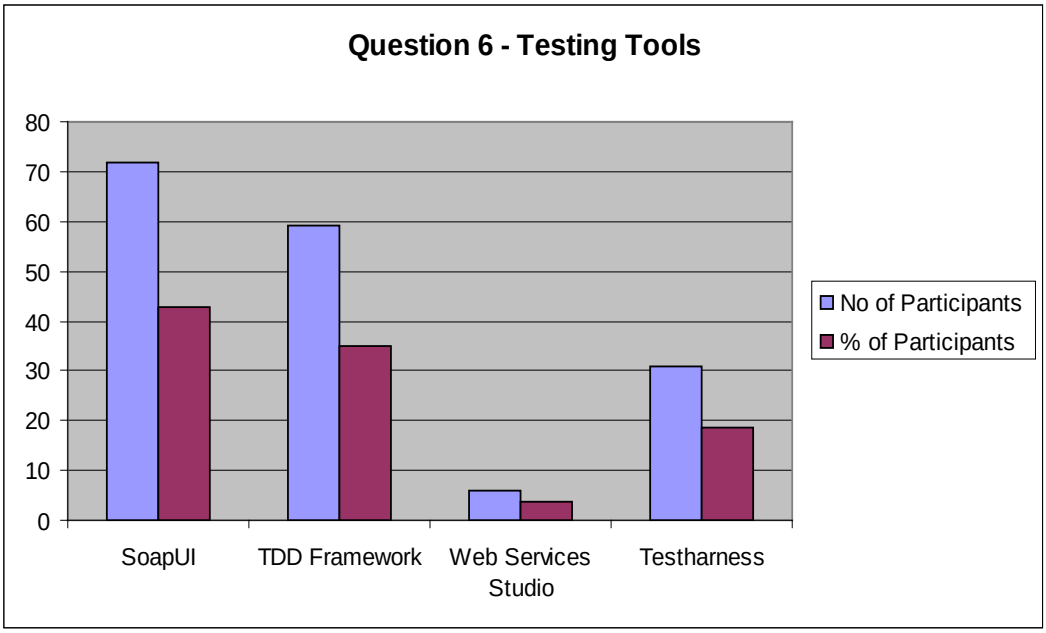

Figure 16 - Web Services Testing Tools

Survey Question – 7 (Hosting)

In response to question 7 which was about Web Services hosting, all of the participants stated that they host their Web Services on their internal web servers. Three participants indicated additionally that they are using Web Services on the local application servers and the services are being consumed through self contained applications. However for distributed applications they also use their own internal web servers for hosting their web services. This survey question was aimed to answer the second research question which was about what environments are currently being used for Web Services.

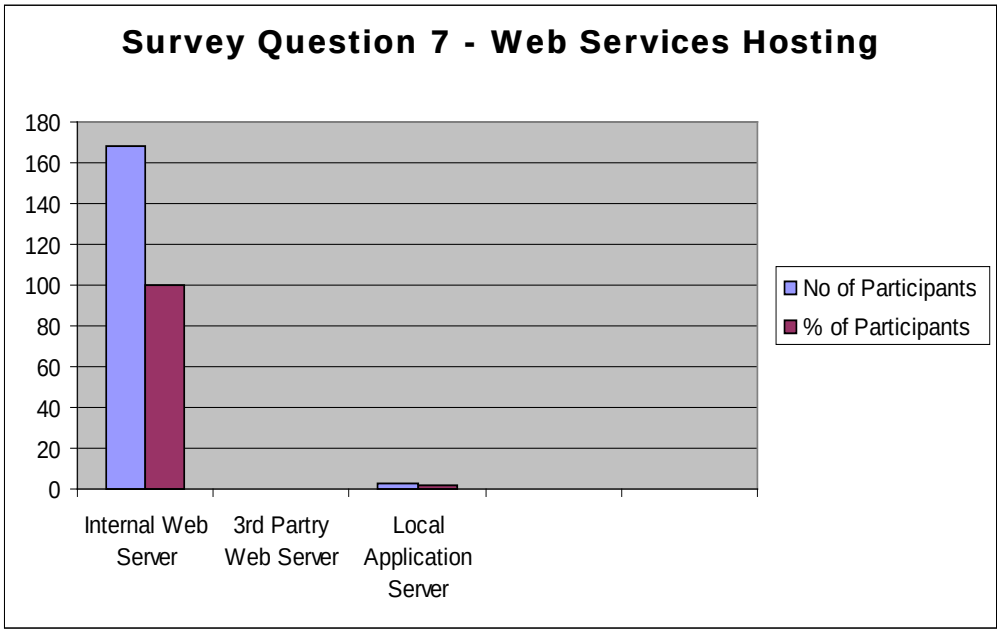

Figure 17 - Web Services Hosting

Survey Question - 8 (Uses of 3rd Party)

Survey question 8 also contributed in answering research question 2 which was about what environments are being used for Web Services. Question 8 has projected a very interesting picture. The result clearly shows that large companies and medium size companies are using many third party Web Services and they indicated that third party Web Services are the backbone of their business. However small scale companies do not tend to use Web Services and if they use them (the survey showed just 7% of small

companies using Web Services) then they indicated that they use third party web services for a specialised and specific reason and the uses of third party Web Services are very restricted and minimal.

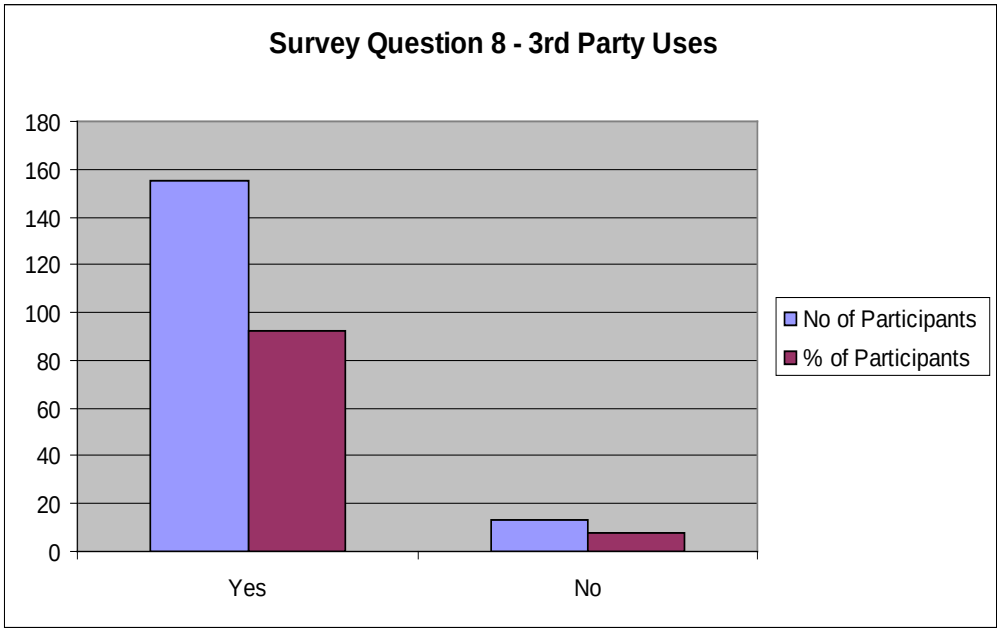

Figure 18 - 3rd Party Web Services uses

Survey Question - 9 (Suitability in distributed environment)

The main objective of question 9 was to find out how suitable Web Services are in a distributed environment. Survey question 9 is directly linked to research question 4 which is about the extent to which business users are satisfied with Web Services technology. In response to this question all 168 participants agreed that Web Services are a good, cost effective, easy and effective solution for

distributed applications. However many 103 participants (60.75%) also admitted that Web Services are not a true replacement of distributed objects as Web Services only work on the HTTP protocol. However this is not completely true because the latest technologies i.e. Windows Communication Framework also support TPC, MSMQ and others.

The overall survey results are as follows:

Cost Effectiveness – Out of 168 participants, 134 (79.76%) participants believe that Web Services are a cost effective solution for distributed applications whereas 34 (20.24%) did not. Some concerns about cost effectiveness were about additional overheads such as maintaining a web server, having security experts and implementing security features.

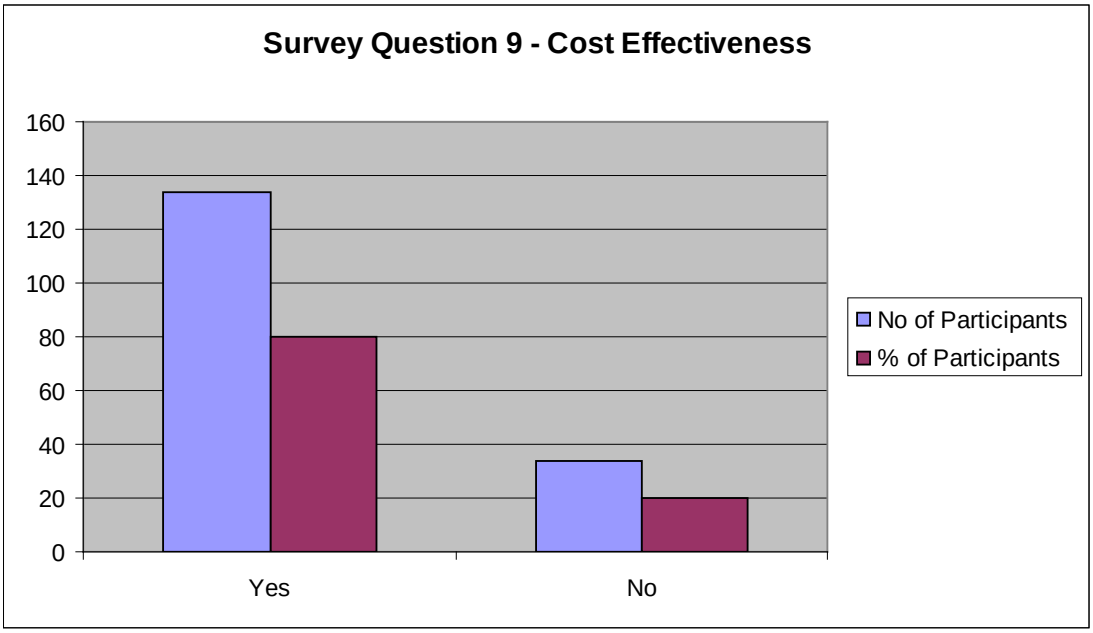

Figure 19 - Cost Effectiveness

Simplicity- All 168 participants did agree that Web Services are much easier and less complex than previous technologies used for distributed computing.

Replacement of Distributed Objects - Out of 168 participants, 103 (60.75%) participants considered that Web Services are not a true replacement of distributed objects.

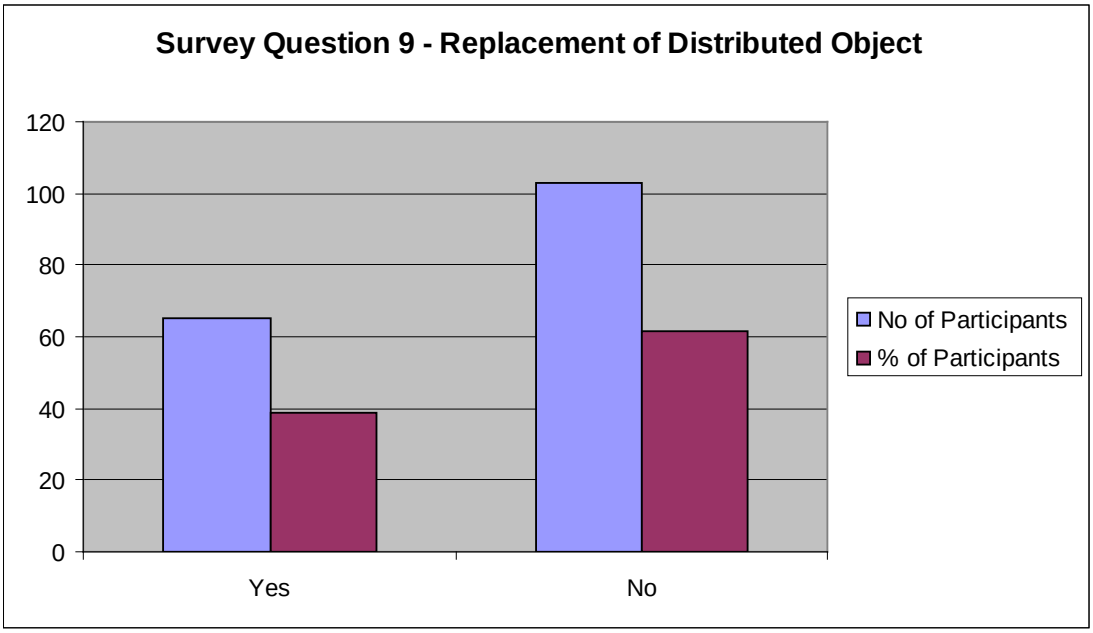

Figure 20 - Web Services vs. Distributed Objects

Suitability in Distributed Application - Out of 168 participants all 100% participants admitted that Web Services are effective and suitable technology for distributed applications.

Survey Question – 10 (Satisfaction of Web Services Security Model)

Question 10 was about the existing security model of Web Services. This survey question has been included in the survey questionnaire to address research question 4 which was about the extent to which business users are satisfied with Web Services technology. This survey question also answers and maps with research question 3 which was about concerns related to Web Services in business. All participants who participated in this survey found this question

really hard to answer. All the participants tried to avoid giving a clean sheet to the current security model of the Web Services. They also found this question as a very open question which could involve lots of discussion and lots of investigation. The overall survey outcome for this question was as follows:

Only 30 participants (18.40%) considered that Web Services are fully secure and could not find any need for security model enhancement. 132 participants (62%) believed that although Web Services are secure enough for their needs, they could not give a clean sheet to the Web Services security model and suggested that future improvement is highly recommended. 40 participants (24.54%) could not comment on the security model. On further investigation, all 40 participants who could not comment about the security model admitted that the existing Web Services security model is meeting their expectations. However because of lack of in-depth knowledge of the security model of Web Services and because security is itself a very wide and open area, they chose not to comment on the security model of the Web Services.

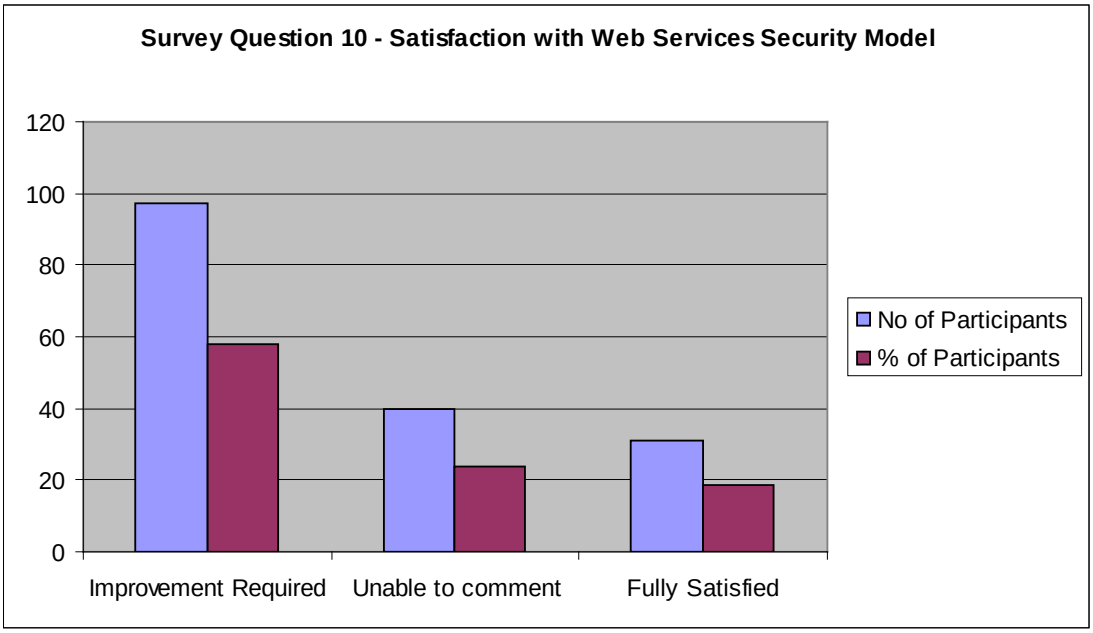

Figure 21 – Satisfaction with Web Services Security Model

Survey Question – 11 (Satisfaction with Interoperability Model)

In response to question 11, which was aimed at the interoperability model of Web Services, the majority of 104 participants (61.90%) reported that they are fully satisfied with the interoperability model of Web Services. 138 participants (82.14%) admitted that they do not know about the Web Services interoperability model. There was a large overlap between those satisfied with the interoperability model and those who did not know about it. 30 participants (17.85%) suggested that there is still improvement required in the interoperability model of Web Services. People who suggested improvements in the Web Services interoperability model commented mainly around standardising the implementation of

Web Services and the need for guidelines for using and implementing interoperability in Web Services.

This survey question was included in the survey questionnaire to address research question 4 which was about to the extent to which business users are satisfied with Web Services technology. The same question also answers research question 3 which was about concerns about Web Services in the business.

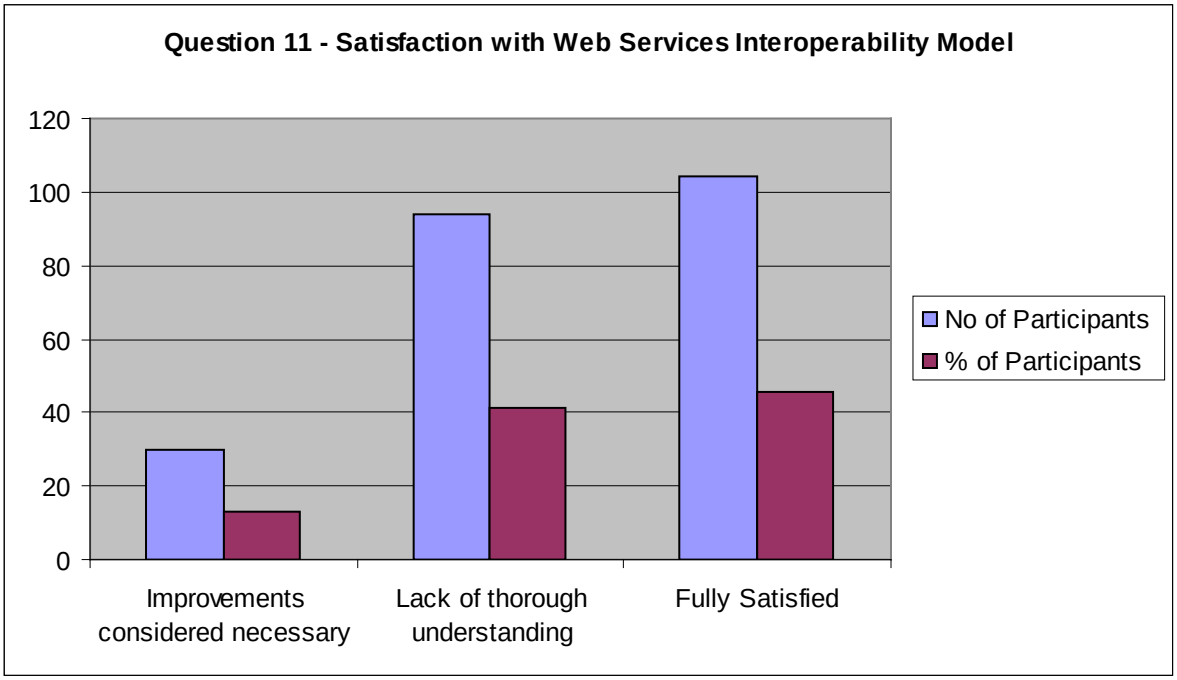

Figure 22 – Interoperability Model of Web Services

Survey Question – 12 (Limitation of Web Services)

The main objective of asking question 12 was to find out limitations in the existing Web Services technology. During the survey it was noticed that people found this question the most difficult question to answer. It was also noticed that none of the participants who had participated through email answered this question. Out of 168 participants only 2 participants answered this question and the others left it blank. The identified limitations by these two participants were as follows:

1) Lack of common implementation in interoperable environment.
2) Only supported on HTTP protocol.
3) Lack of standard guidelines about usability of Web Services.

This survey question initially answers the research question 4 which was about the extent to which business users are satisfied with Web Services technology and eventually also addresses the research question 3 which is about the concerns about Web Services in business. However it must be taken into consideration that only two people were answered this question. One could interpret this as meaning those who did not answer did not find any limitation with Web Services or it could be that the majority of applicants did

not feel they understood the technology enough to make a sensible answer

Survey Question – 13 (Versioning Model of Web Services)

Interestingly none of the participants reported that that versioning model is not adequate or required any improvements. In fact many participants were overly satisfied with the versioning model of the Web Services. The survey result shows that 140 participants (83.33%) were satisfied with the versioning model and, 28 participants (16.67%) said that they can not comment on the versioning model. None of the participants said anything against the versioning model of the Web Services.

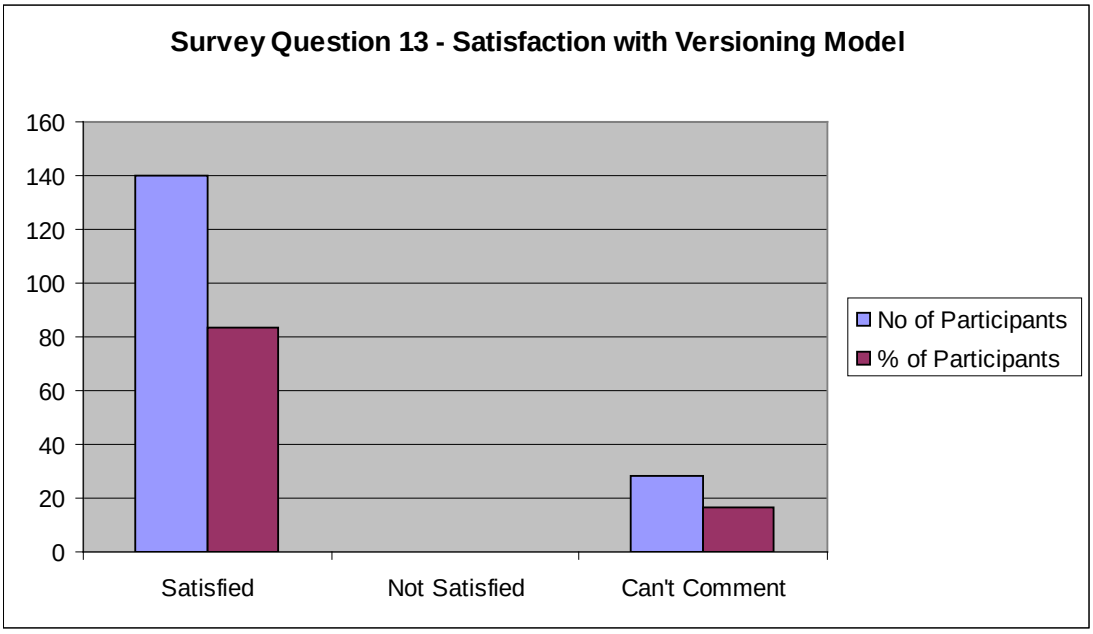

Figure 23 – Versioning Model of Web Services

Survey Question – 14 (Satisfaction with Proxy Model of Web Services)

Question 14 was asked to find out any limitations in proxy generation and mock object implementation in Web Services. Out of 168 participants, 79 (47.02%) reported that they are not experiencing any issues with the way Web Services proxy objects work, whereas 89 participants (52.98%) could not comment on this question. None of the participants could suggest any improvements or limitations of the proxy generation model of Web Services.

Since 89 participants (52.98%) could not answer this question, it indicates that perhaps they did not understand the question. This survey question was intended to be linked with the research question 4 which is about the extent to which business users are satisfied with Web Services technology.

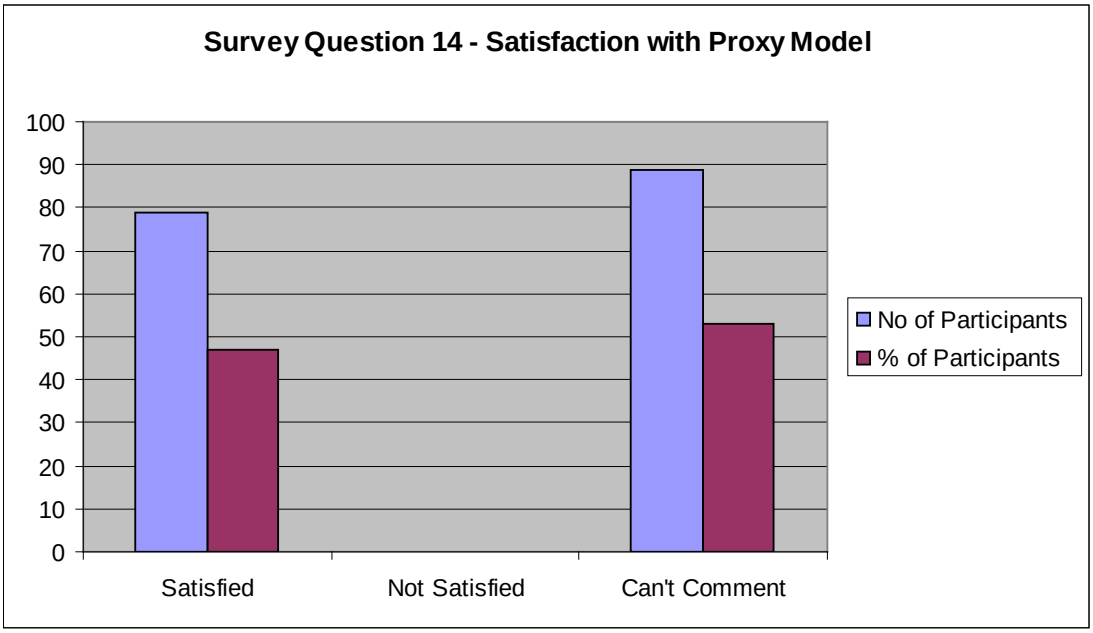

Figure 24 – Satisfaction with Proxy Model of Web Services

Survey Question – 15 **(Satisfaction with Deployment Model of Web Services)**

Question 15 was mainly focused around deployment mechanisms and deployment methodologies/methods of the Web Services. The main objective of asking this question is to establish how easy and acceptable deployment mechanisms are.

The final outcome of this question states that all 168 who participated in the survey admitted that they do not find any issue with the deployment mechanism and deployment methods. In addition to this many of the participants also stated that the deployment mechanism of Web Services is better than the previous technologies deployment methods.

During face-to-face and teleconferencing discussion many participants suggested that sometimes they are finding difficulties in configuring the Web Services server. However it has also been accepted that this is a different area to that of deployment methods.

This survey question clearly contributes towards research question 4 which is about to the extent to which business users are satisfied with Web Services technology.

Survey Question – 16 To 19 (Limitations and Improvements)

Question number 16, 17, 18 and 19 were included in the survey to find out the limitations and areas of improvements of Web Services. These questions were intentionally kept open and mainly designed for subject matter experts of Web Services. Unfortunately these questions were not answered at all by any participants who participated through email. Out of the total 168 participants only 21 (12.5%) participants participated in these questions and these were the participants who were in the sets of those who were interviewed face-to-face or who took part via teleconferencing. Out of the 21 participants who answered these questions, 13 participants (7.73%) participated in the survey face to face and 8 (4.76%) participants participated in the survey though teleconferencing.

All 21 participants agreed that they are happy with the WSDL and discovery process of the Web Services. Questions 16 and 17 map onto research question 3 which covers concerns about Web Services in business.

Questions 18 and 19 map onto research question 3 which covers concerns about Web Services in business. No suggestions were made on how to improve the way the WSDL and Discovery process works

During face-to-face interviews it has been pointed out that Web Services are suffering from standard implementation problem: lack of understanding about the security model of Web Services and lack of a well defined common mechanism for implementing security features in the Web Services. It has also been pointed out that Web Services only supports HTTP protocols and SOAP messaging works on the "fire and forget" principal which means there is no default message delivery notification possible in the SOAP messages.

4.6 Summary of Survey Results

78% of people surveyed are using Web Services right now but 22% are not using either because of technological limitations or because they are not aware of this technology.

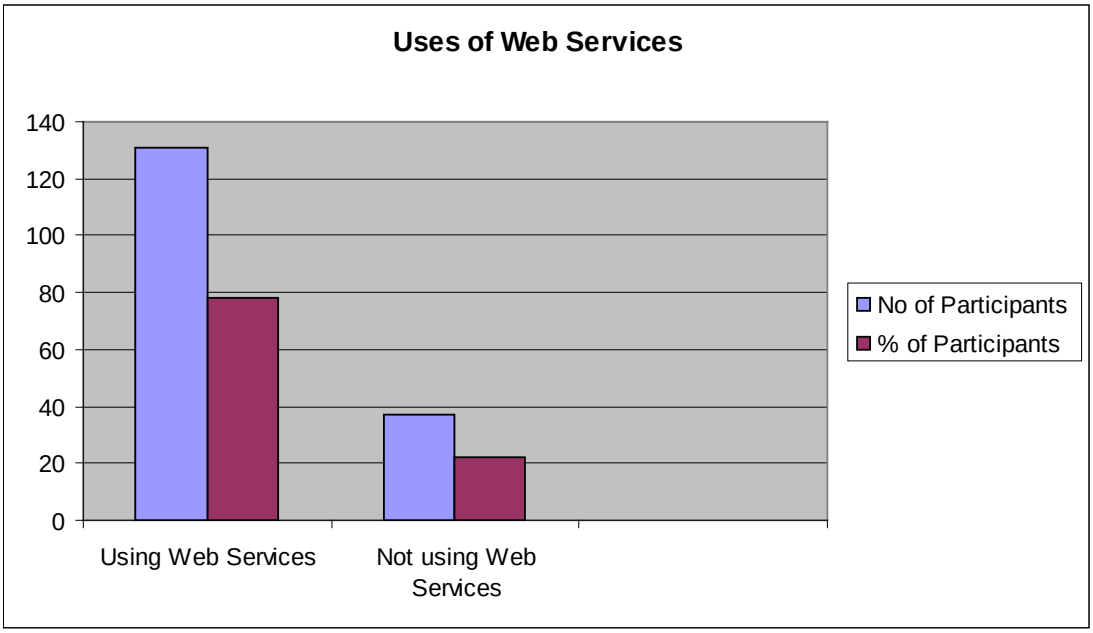

Figure 25 – Uses of Web Services

Out of 78% of professionals who are using Web Services 43% think that it is a high risk to use Web Services in the current business scenario whereas 56% categorises Web Services as a medium risk solution. People who have voted the Web Services solution as a high or medium risk were mainly concerned about security and scalability of the Web Services.

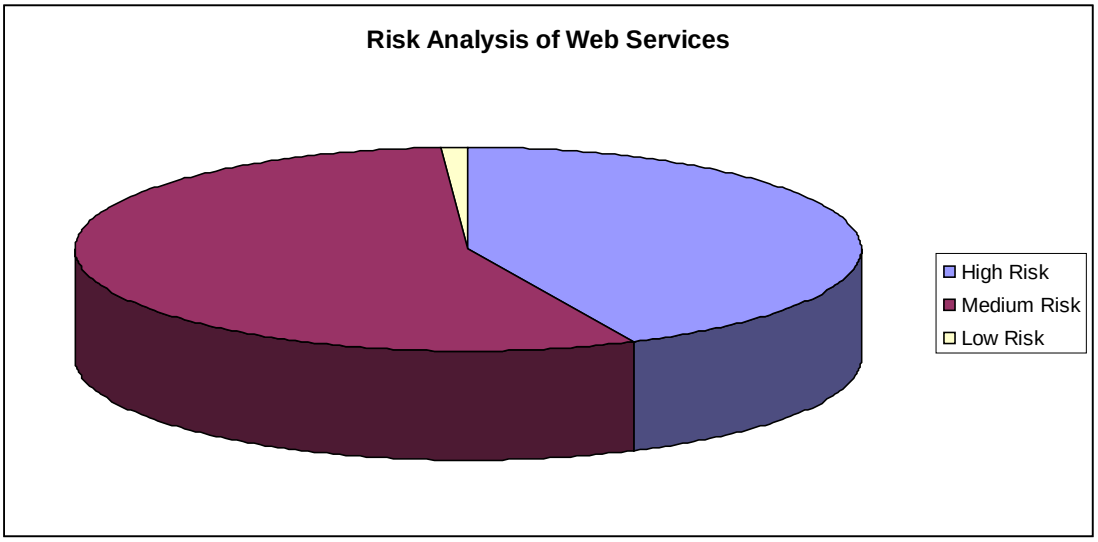

Figure 26 – Risk analysis of Web Services

The survey also indicated that people who are in a higher level management role skills feel high risk in using Web Services whereas the IT implementer or technical professionals find it a medium risk solution.

The survey shows that almost all users use Web Services for distributed solutions and host them on their own Web Server. Figure 27 summarises the important results that have emerged from the survey. The figure shows the environments where Web Services are developed and deployed. 70% of the users were not very clear as to whether UNIX or Windows is their main platform for developing Web Services but this suggests that as a result of their facility for interoperability Web Services are used in mixed environments. The study shows that 76% of Web Service users are

dealing with 3rd Party Web Services whereas 23% users are using Web Services for their internal use only.

Figure 27 also shows user satisfaction with interoperability and security. Regarding security, 81% of user thinks that the security model Web Services is offering now is good enough for their needs; however they do accept that there are lots can be done to improve the existing Web Services Security model. The interviews revealed that the majority of the users have a very high expectation from Web Services and need more and more security features added because they still do not trust the security model of the Web Services. However when asked to propose or highlight the limitations they struggled to suggest some. This indicates that the majority of the users still have a lack of understanding or misconception about Web Services. On the other hand some users commented that Web Services rely on a transport protocol, i.e. HTTP, which does not guarantee whether the message will be delivered to the destination or not. Another limitation picked-up by a security specialist was that SOAP is a default messaging standard for Web Services which, does not support many security features. Some of the Web Services-enabled applications also require role-based security features, which expose different functionalities, depending on user credentials. Underlying technologies used by Web Services currently do not support these features.

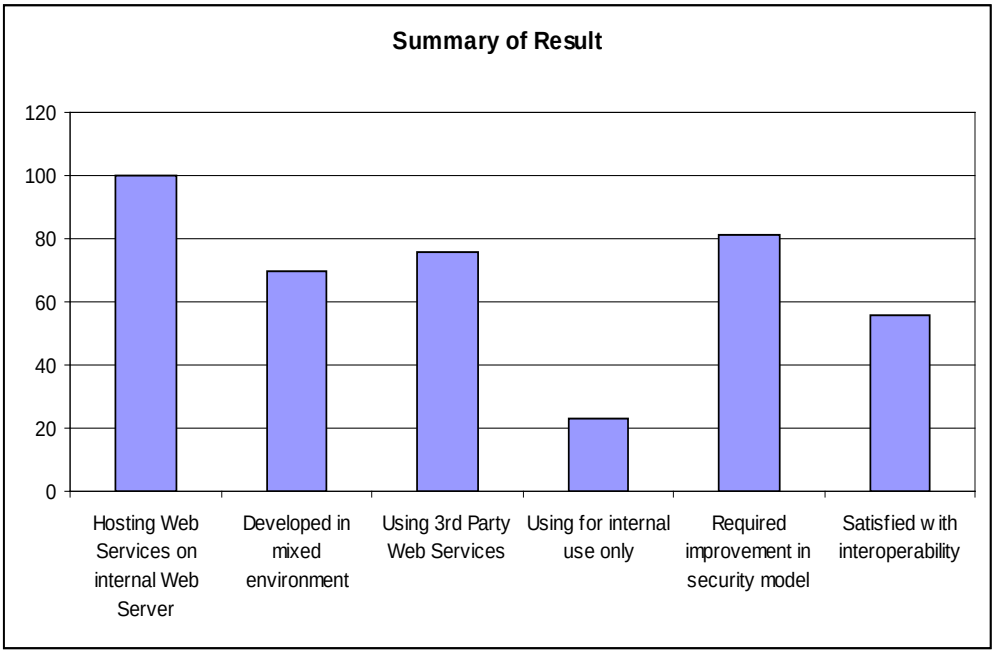

Figure 27 - Summary of Results

Figure 27 also shows satisfaction with interoperability. For a large number of users interoperability is still a kind of black box but the survey result also shows that 56% of users are using interoperability and they believe that Web Services fulfil the promises of interoperability successfully. This information has been captured by survey question 11. On further investigation it was revealed that many professionals were just using Web Services by going through manuals or by analysing the WSDL but that they do not fully understand the architecture or how the Web Service will be interoperable. An important observation made through the survey was that the majority of the Web Services specifications are defined under standards bodies. As these activities are under way, there is

a delay in the implementations. Vendors have to partly implement the specification in their products due to the competitive nature of this market. This results in poor interoperability.

Overall the survey indicates that professionals think that although Web Services are meeting expectations on delivery, there are improvements that need to be done to the existing technology. For example the way Web Services are developed and implemented in one environment differs in another environment which makes implementation and integration a bit tricky. The main problem and potential area of improvement has been found to be inconsistency among various technologies and among various vendors. Ideally industry should devise a common protocol which should be consistent in all languages and in all environments. Security also needs improvement and should be a part of core foundation not an optional extra that users need to build in.

The following results can be provided by this research based on the survey:

a) Web Services are a common technology in web-based development but still not well understood.
b) Web Services are being more and more popular for interoperable solutions.

c) Web Services are a cost-effective and simple option for distributed applications.

d) Web Services are frequently used, developed and consumed without knowing or having complete understanding about architecture of the Web Services and its building blocks.

e) Web Services have a number of issues which need to be addressed and improved in the future standards.

4.7 Limitations of the Survey

The survey was conducted through an email, face-to-face interviews and teleconferencing. The same questionnaire was used as a basis for investigation in all three survey modes of interaction. Questionnaires can have problems if questions are not clear and therefore not well understood. It is very important to construct a questionnaire carefully so that the information givers and information gatherers have a common understanding of the semantics of each question. It might be impossible to prove this in the case for any particular questionnaire and hence this may be is a limitation of this method. The problem can be mitigated by ensuring the language used is precise and clear and also by pilot testing. In the case of this research, the questionnaire was piloted amongst students before being released to the professionals. However, on reflection, that this might not have been the best

group on which to trial the questionnaire as they may differ in knowledge and culture from that of the eventual information givers, i.e. the professionals.

Another potential problem in this case is the range of professional included in the survey. All participants had some knowledge of the use of Web Services but some had far more detailed knowledge than others. For instance a developer would normally have far more detailed knowledge of the technology than a company director. In the case of this research it did appear that there might have been a lack of understanding of some questions (questions 16-19) as some were not answered by the email participants. The problem was less so in the case of the teleconferencing and face-to-face interviews as there was an opportunity in those for the interviewer to explain what was meant by each question. Also it is likely those who volunteered for interviews were subjects who were particularly interested in the technology or the research or who were professionals who at that point in time had more time to participate. The interview methods of information garnering provided much richer data than the email survey.

A lesson to learn in survey design is that one must ensure that any questionnaire reflects the culture, understanding and vocabulary of the targeted information givers. In the case of this research the set of targeted information givers was wide ranging and some may

not have understood all of the questions or even if they understood the questions did not have the knowledge to answer them in a meaningful way. The lack of answering of questions 16-19 did however give an indication that there may be lack of understanding of the detail of Web Services in enterprises and this in itself was a useful result.

4.8 Conclusion

In summary Web Services are widely used and trusted as a best solution for distributed computing, however because of lack of awareness professionals still hesitate in using this cutting edge technology.

Based on the survey among IT professionals we can conclude:

- Web Services are delivering well but still there are many improvements that be done to existing technology.
- The main problem and area of improvement has been found to be inconsistency among various technologies and among various vendors.
- Security also needs improvement and should be a part of the foundation of the technology rather then an add-on

5 - Proposal for a Remote Diagnostics System

5.1 Introduction

This chapter demonstrates the feasibility of Web Services in a modern distributed computing scenario. To achieve the above mentioned goal a prototype has been developed based on the collaboration with an automotive company which is involved in developing various diagnostics tools for automotive industries. This chapter describes the prototype and indicates benefits that ensue for a variety of users

5.2 Problem Statement

From the research process and literature review the following outcome/result has been noticed:

Web Services are a suitable, cost effective and commonly used technology in distributed applications, however there is not enough awareness in the industry to promote Web Services further and because of that a large user group is hesitant in using Web Services. Furthermore misconceptions make users hesitate.

The idea of developing this prototype was to demonstrate the potential of Web Services.

5.3 The Prototype

Through collaboration with the automotive company, Omitec Ltd, a prototype ***Remote Diagnostics Platform*** for automotive industries was conceived. The design deliberately includes all major aspects of Web Services and Distributed Computing as its purpose is to serve as a demonstrator of the potential of Web Services for current business scenarios.

In the wireless world where people are adopting many wireless devices, i.e. wireless headphone, wireless keyboard, wireless mouse, WiFi etc. , let us consider a model where a car can be examined or even can be fixed wirelessly on a motorway. It is possible in this scenario to do remote vehicle diagnostics without going to a service centre.

5.4 Target Audience

This research would benefit the following user groups:

- Automotive Manufactures
- Automotive Service Centres
- Automotive Technicians
- Automotive Research Group

- Automotive Students
- Automobile Users

5.5 The Prototype

A prototype for the Remote Vehicle Diagnostics System is proposed

Let us assume the following scenarios:

- You are travelling on a motorway or even in a remote area and your car has broken down and you want to get it examined as soon as possible, what would you do?
- You are abroad and your car has broken down, you do not trust the local service centre and want to fix your car in a proper way or in a prescribed way, what would you do?
- If you want to setup your service centre in cyber space what would you do?

This prototype provides a solution to the above scenarios.

- The Remote Vehicle Diagnostics Platform will enable automotive users (i.e. Automotive Manufactures, Automotive Service Centres, Automotive Technicians, Automotive

Research Group, Automotive Students, Automobile users etc) to:

- Subscribe to a service for vehicle diagnostics - Any individual vehicle owner would be able to take advantage from this service by subscribing a remote diagnostics service for his vehicle.
- PAYG service for vehicle diagnostics – Automotive manufactures, web traders and automotive service centres would be benefited through this service. They would also be able to offer one time (PAYG) service to their clients.
- Add remote service stations on Web – Automotive manufactures, web traders and automotive service centres would be benefited through this service. Using this service it would be possible to open service centres on the web to do MOT or simple diagnostics.
- Diagnose the vehicle anywhere and anytime worldwide – Any individual vehicle owner would be able to take advantage from this service. As long as they have got a smart phone and a subscription of the remote diagnostics service, they would be able to

diagnose their vehicle remotely from anywhere anytime.

5.6 How will it work?

The entire prototype can be divided into following parts:

5.6.1The Framework

There will be a framework which will provide various types of APIs to automate the business and to communicate with the various parts/components of the business.

5.6.2 The Presentation Layer

A Web interface needs to be created which would enable user to do the following tasks:

- User can create a new web shop.
- User can administrate the existing web shop.
- User can use a service directly from the provider.
- User can use a service from a third party via the common interface.
- A customer can subscribe a service from the provider.

- A customer can access a service on demand from the provider.
- A customer can subscribe a service from the third party.
- A customer can access a service on demand from the third party.

5.6.3 The Service Layer

The Service layer hosts / implements a number of services to incorporate various functionalities, or in summary this layer can include a number of service catalogues and each service catalogue can have a number of services.

5.6.4 Framework Organisation

The overall high level framework organisation is as follows:

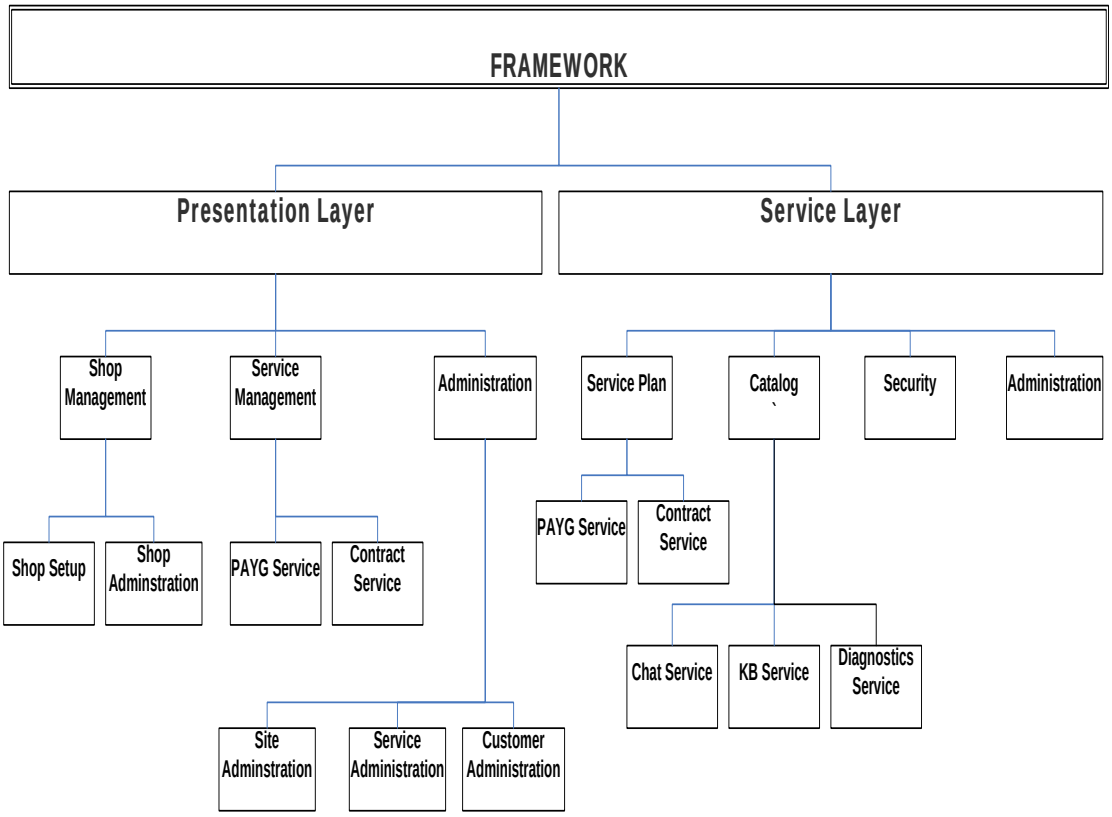

Figure 28 – Framework Organisation

5.6.5 High Level Diagram

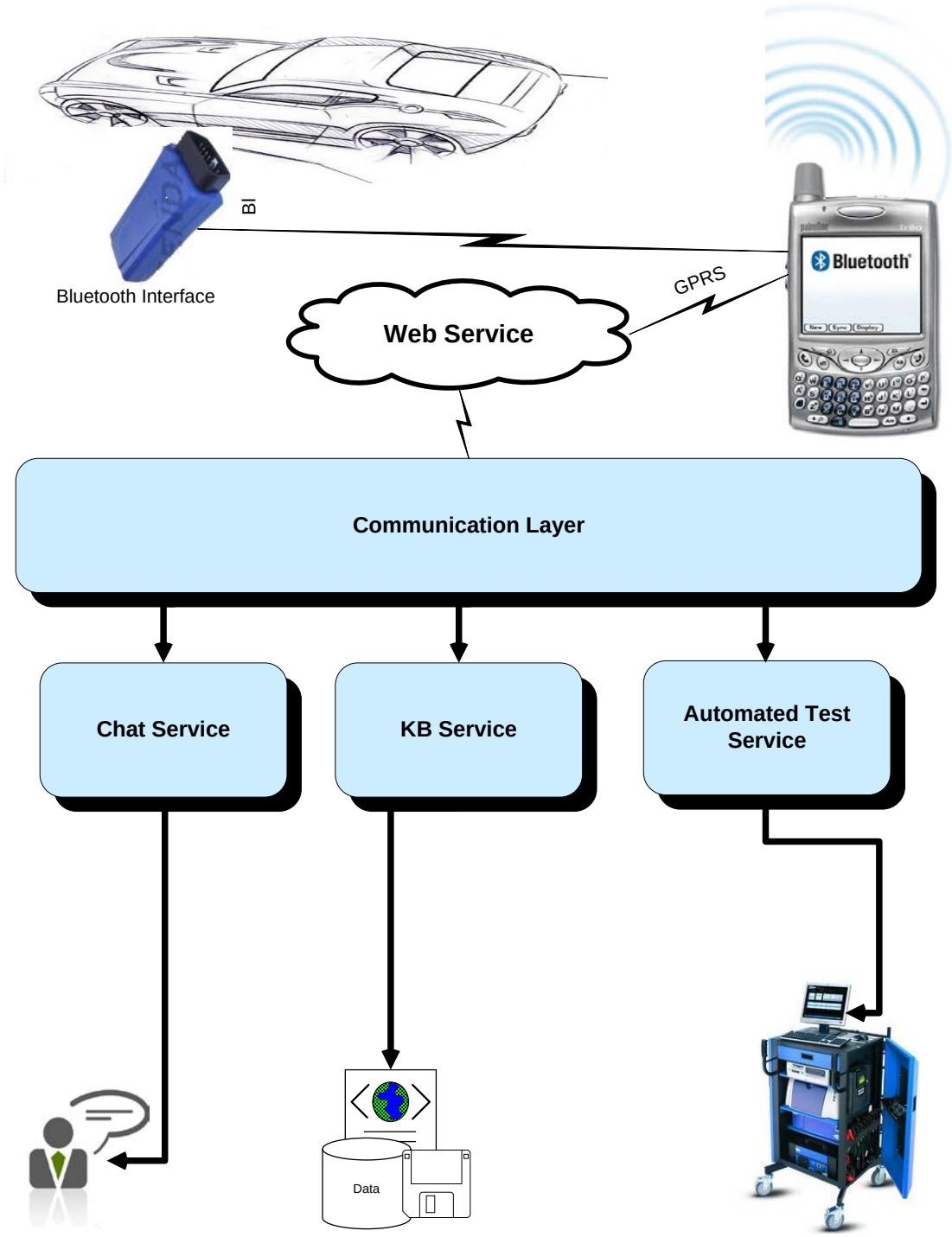

Figure 29 – High Level Diagram

5.7 A functional walkthrough

Once the solution is fully developed, the solution can be used by a number of users which are as follows:

- Automotive Manufacturers
- Automotive Service Centres & Automotive Technicians
- Vehicle Owner
- Road side assistance and breakdown service.

To explain even further let us consider a case study for each of the potential users.

Case Study 1 (Automotive Manufactures) - ABC Ltd is a car manufacturing company. ABC Ltd is going to launch a new range of cars. The company decided to make the vehicle diagnostics easy and less expensive. The board discussed their intention with the technical team and told them to propose a design.

The proposed design was as follows:

a) Every vehicle would have a Bluetooth enabled ECU (Electronic Control Unit) installed in the car. The vehicle is also having a diagnostic device installed in the vehicle which is connected through ECU.
b) ABC Ltd should instruct their customers that if they have got a smart phone they can download a vehicle diagnostic application from the website free of charge on to their smart phone.
c) Whenever user finds a fault in his car, he should launch the vehicle diagnostic application from his smart phone.
d) The smart phone connects the diagnostic device through Bluetooth and runs some tests on the car.
e) The test results are sent to the ABC Ltd's central server.
f) Central Server receives the result and checks for the solution in its knowledge base.
g) If the knowledge base has an appropriate match or an appropriate solution, it is sent to the user. If user is satisfied with the result, he terminates the program otherwise runs another test.
h) If the knowledge base does not have a match for the data sent by the user, the central server forwards that data to the technical server. The technical server receives the test data and runs some automated test on the simulators and sends

the suggestions or result to the central server. The central server then redirects the output to the client.

To provide this service ABC Ltd has launched a web portal from where a customer can register for a PAYG, monthly, yearly or lifetime vehicle diagnostic subscription. ABC Ltd also exposes Web Services for the same kind of services. By consuming those services any automotive garage or service centre can set up an independent web shop (as you can do on eBay) and could offer the same service to their customers.

Case Study 2 (For Service Centres, Road side assistance, Auto Technicians) – JMD Automobiles is a service centre which provides complete automotive diagnostics including repair, servicing and MOT; because of their encouraging yearly turn over, the company decided to invest more money to improve customer's experience and the company's revenue. JMD Automobiles had taken consultancy and the outcome was as follows:

a) The company decided to offer their clients a new service called DIY. This service will only be available to those clients who will be subscribing a 24 months complete care plan with

the company which would include the car insurance, breakdown assistance, MOT, and servicing.

b) Whoever signs the contract for 2 years would get a diagnostics kit installed in his vehicle, a two years remote diagnostics subscription and top of that complete vehicle care for 2 years.
c) Company is also going to provide short term vehicle insurance for car rental companies and any individual who wants short term PAYG insurance and provides same short of features to their clients.

5.8 A Technical Walkthrough

The above case study explains where and how the proposed prototype fits in the current automotive domain. This section explains how the prototype would be the reality and what are the tools, technologies and infrastructures required to implement the prototype.

In order to convert this prototype to implementation the following tools, technology and devices required:

a) A high performance Web Server which runs Web interfaces and Web APIs on it.
b) An information server which contains catalogue information, knowledge base and service information.
c) An application server which runs automated test.
d) Vehicle simulator which simulates the test which is actually run on the vehicle.
e) A smart phone with mobile Internet connection.
f) A vehicle fully equipped with Electronic Control Unit (ECU) on board diagnostics kit.

The following diagram explains how all the above components hang together:

Figure 30 - Infrastructure Diagram

The following UML activity diagram demonstrates how the overall solution works and what would be the functional flow of the overall solution:

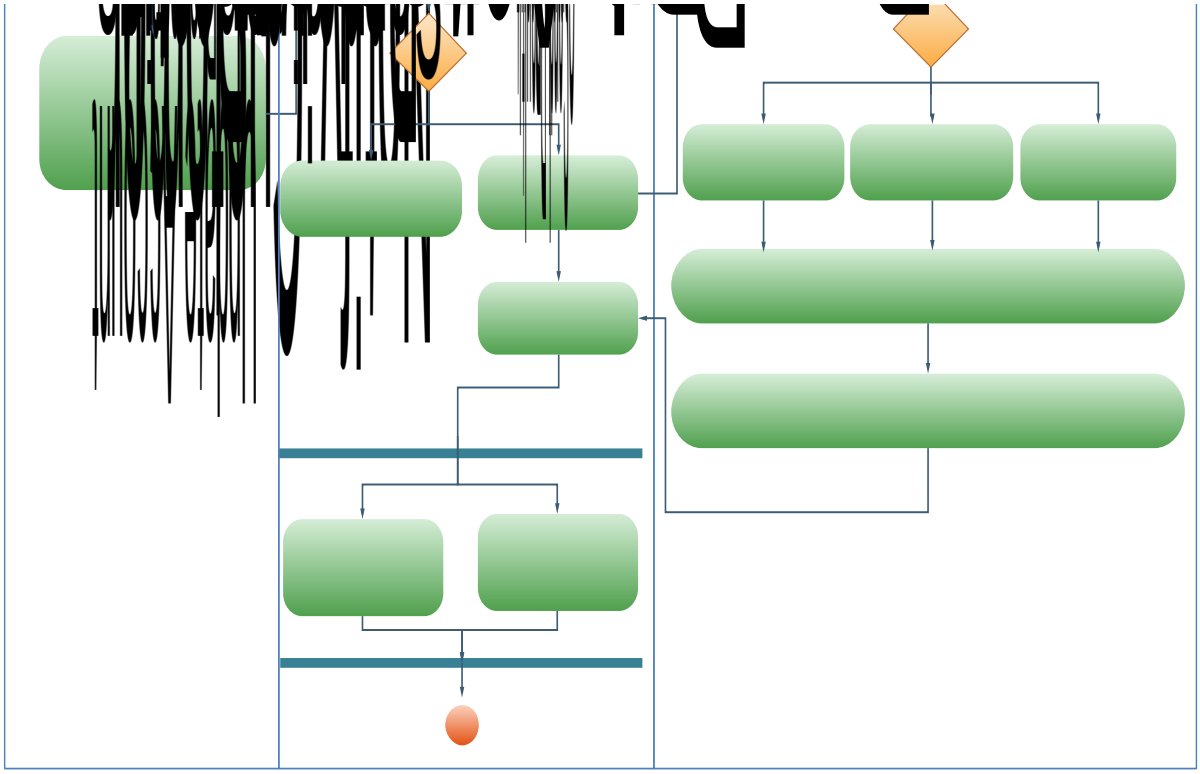

Figure 31 – Vehicle Diagnostics Activity Diagram

5.9 Discussion of the Prototype

So in nutshell the above case study and prototype explains the strength of the Web Services and tries to give a new dimension to any business. In fact this prototype itself communicates a message

to every business that there is a time to re-architect their business and re-define their marketing strategy.

Web Services provide the backbone technology for the prototype described here. The essential characteristics of Web Services which enables the development of such a prototype are: autonomy of service, meaning services can be independently hosted and geographically dispersed; and composition of services meaning larger services can be developed from underlying smaller services giving rise to no end of possibility for application development.

5.9 Conclusion

This chapter shows the feasibility of Web Services in the distributed computing scenario by proposing a prototype for a relevant business application. The prototype has been developed in collaboration with an automotive development company, Omitec Ltd. The prototype shows how new businesses can be built by harnessing the power of Web Services and also how new services can be developed for customers which have a notable impact on daily life. The prototype can be used as a model which can be implemented to expand the existing business.

6 - Conclusion & Future Work

6.1 Introduction

This chapter provides the overall conclusion of this research work which is based on the literature review, survey and collaboration with an automotive development company. It also highlights the scope of future work required in the highly demanding technology of Web Services.

6.2 Overall Conclusion

Based on the research conducted through literature review, survey, face-to-face and collaboration, the final outcome can be concluded as follows:

a) Web Services are a common but not well understood technology in Web based development.
b) Web Services are being more and more popular for interoperable solutions.
c) Web Services are a simple, easy and inexpensive option for distributed applications.
d) Web Services are frequently used, developed and consumed without knowing or having complete understanding about architecture of the Web Services and its building blocks.

e) Web Services have a number of issues which need to be addressed and improved in the future releases.

f) The potential of Web Services are not yet fully harnessed and many powerful applications are still to be built as demonstrated by the prototype development in chapter 5.

The work also revealed the following limitations of Web Services and also suggests the scope for future work. Limitations of the Web Services are as follows:

a) Inconsistency - the ways Web Services are developed and implemented in one environment differs in another environment which makes implementation and integration quite tricky i.e. a Web Service developed in .net would be very different in a Web Service developed or implemented in Java .
b) Performance - The Web Service performance depends on various things, i.e. application logic, network and on messaging and transport protocols e.g. SOAP and HTTP. The SOAP protocol is still not in a matured state and still provides room to accommodate a lot of performance and scalability problems. The SOAP protocol uses a multi-step process to complete a communication cycle. For example the SOAP

request begins with the business logic of your application learning the method and parameter to call from a Web Services Description Language (WSDL) document. This whole process is time-consuming, which requires various levels of XML parsing and XML validation which affects the performance of the Web Service.

c) Reliability – Current Web Services relies on transport protocols such as HTTP, which does not guarantee whether the message will be delivered to the destination.

d) Integrity - Data Integrity is one of the key things in order to incorporate proper functioning of any object and must be assured, otherwise it may corrupt a the program and it could be nightmare to trace the error. Web Services transactions tend to be asynchronous and long running in nature. Transaction integrity is just one of several QoS (Quality of Service) elements, including security and process orchestration, which are missing from the first incarnations of Web Services standards of SOAP, UDDI, and WSDL (Verma 2005).

e) Accessibility – Building scalable systems are expensive, and this may cause smaller companies to defer their requirement. In addition it also creates an infrastructure issue for companies that deploy Web Services within their enterprise.

f) Availability – In a real time scenario, building fault-tolerant systems for highly available Web Services is expensive. As companies roll out Web Services, the ability to manage this diverse, dynamic, distributed environment becomes critical because it raises questions about availability and performance and loads on the Web Services.

g) Interoperability – Mostly Web Services specifications are defined under standards bodies. As these activities are under way, there seems to be a delay in the implementations. Vendors partly implement the specification in their products due to the competitive nature of this market. This results in poor interoperability.

h) Security - SOAP is in fact a messaging standard for Web Services which does not support many security features. Some of the Web Services-enabled applications also require role-based security features, which expose different functionalities, depending on user credentials. Underlying technologies used by Web Services currently do not support these features.

This research has shown that Web Services have a secure future with increasing numbers of companies taking up or showing interest in the technology. Future developments will include increasing numbers of innovative mobile and distributed

applications development such as the one described in chapter 5. Furthermore future developments will include solutions to the limitations mentioned above.

6.3 Future Work

After completing and concluding this thesis, the final result or outcome raises some questions which define the scope for further work and demands for future work and further studies. The further studies and future work needed could be divided into the following parts:

a) Awareness and Education – This research has highlighted that although Web Services has enormous power and is completely capable of supporting re-architecture of the entire enterprise information infrastructure, there are many of misunderstandings/misconceptions about this cutting edge technology. Therefore it is highly recommended that people should be well informed and should be fully aware about this fantastic technology. It would be good if this technology could be introduced in the business-driven curriculum and education. It is also recommended that every business studies course should have a module related to IT which should have a dedicated section which emphasises how a business can be automated and executed globally. If this type of study were

introduced, people would be forced to think about distributed computing and non-geographical business models enabled through the internet or intranet. Similarly both Government and NGOs should help small and medium scale industry by arranging workshops and short courses on these types of technologies so that such industries would become more aware and more comfortable about this technology and would start thinking out of the box about expanding their business.

b) Working on the theory that critics and criticism is the key of success, although Web Services are an excellent and very powerful technology, they are still in a very initial stage and require much improvement and enhancement in the functional, operational and security areas for example. Web Services have been developed for mainly distributed computing and heavily targeted interoperability but it is also a fact that the ways in which Web Services are developed and implemented in one environment differs in another environment which makes implementation and integration quite tricky, i.e. a Web Service developed in .net would be very different in a Web Service developed or implemented in Java. It would really be good if industry came up with a common idea as they did for XML for both development and integration.

Web Services use the SOAP protocol which is still not in a matured state and still provides room to accommodate a lot of performance and scalability problems. The SOAP protocol uses a multi-step process to complete a communication cycle. For example the SOAP request begins with the business logic of your application, learning the methods and parameters to call from a Web Services Description Language (WSDL) document. This whole process is time-consuming, which requires various levels of XML parsing and XML validation which affects the performance of the Web Services. It would be good if industry considers writing a new protocol for Web Services which can skip the XML parsing and XML validation process because by doing this the application performance will be improved drastically.

Another fact is that current Web Services rely on transport protocols such as HTTP, which does not guarantee whether the message will be delivered to the destination. This highlights the need to develop a mechanism to enable Web Services to guarantee message delivery.

Although Web Services are not a costly solution, building scalable systems are expensive, and this may cause smaller companies to defer their requirement. In addition it also creates an infrastructure issue for companies that deploy Web

Services within their enterprise which means there is a need to enhance the technology so that it would be more powerful and more cost effective.

And finally security is the backbone of any business and organisation. SOAP is in fact a messaging standard for Web Services which does not support many security features. Some of the Web Services-enabled applications also require role-based security features, which expose different functionalities, depending on user credentials. Underlying technologies used by Web Services currently do not support these features. There are quite a few security models in place to secure the Web Service but they are not an integral part of this technology. Such models should not be optional and should be integrated and should work. There is also a need to embed the security model with development and integration so that the developer and implementer would be forced to secure the service. This is not the case at present.

6.4 Conclusion

Web Services are commonly used in web applications and gaining massive popularity among distributed and interoperable solutions. As an overall conclusion this research highlights that although Web Services are a simple, easy and inexpensive option for a distributed

solution, they are often not well understood and have issues with regard to interoperability and security. More development is needed in these areas as well as increased Web Services promotion and education throughout the global industry.

References

References

Agrawal, A., Amend, M., Das, M., Ford, M., Keller, C., Kloppmann, M., König, D., Leymann, F., Müller, R., Pfau, G., Plösser, K., Rangaswamy, R., Rickayzen, A., Rowley, M., Schmidt, P., Trickovic, I., Yiu, A., and Zeller, M. (2007) 'Web Services Human Task (WS-Human Task), Version 1.0.' [online] available from <http://incubator.apache.org/hise/WS-HumanTask_v1.pdf> [29 January 2009]

Al-Kahtani, M.A. and Sandhu, R. (2003) 'Induced Role Hierarchies with Attribute-Based RBAC.' In *Proceedings of the 9th ACM Symposium on Access Control Models and Technologies*, New York: ACM Press: 142-148

Alonso, G., Casati, F., Kuno, H., and Machiraju, V. (2004) *Web Services: Concepts, Architectures, and Applications*. Springer-Verlag, Berlin

Alonso, R., and Larrucea, X. (2008) 'ISOAS: Through an Independent SOA Security Specification.' In *Proceedings of the 7th*

International Conference on Composition-Based Software Systems, Washington DC: IEEE Computer Society: 92-100

Anderson, S., Bohren, J., Boubez, T., Chanliau, M., Della-Libera, G., Dixon, B., Garg, P., Gudgin, M., Hada, S., Hallam-Baker, P., Hondo, M., Kaler, C., Lockhart, H., Martherus, R., Maruyama, H., Nadalin, A., Nagaratnam, N., Nash, N., Philpott, R., Platt, D., Prafullchandra, H., Sahu, M., Shewchuk, J., Simon, D., Srinivas, D., Waingold, Waite, D., Walter, D., and Zolfonoon, R. (2005) *Web Services Secure Conversation Language (WS-SecureConversation*) [online] available from <http://download.boulder.ibm.com/ibmdl/pub/software/dw/specs/ws-secon/ws-secureconversation.pdf> [15 August 2010]

Anderson, A., and Lockhart, H. (2005) *SAML 2.0 Profile of XACML v2.0. OASIS* [online] available from <http://docs.oasis-open.org/xacml/2.0/access_control-xacml-2.0-saml-profile-spec-os.pdf> [24 September 2010]

Anderson, A. (2006) 'Web Services Policies.' *Security and Privacy* 4, (3) 84-87

Askarov, A., Hedin, D., and Sabelfeld, A. (2008) 'Cryptographically-masked flows.' *Journal of Theoretical Computer Science* 402, (2-3) 82-101

Austin, D., Barbir, A., Ferris, C., and Garg, S. (2004) *Web Services Architecture Requirements - W3C Working Group Note 11 February 2004* [online] available from <http://www.w3.org/TR/wsa-reqs/> [29 December 2005]

Baker, P., and Shivaram, H. (2005) *XML Key Management Specification (XKMS 2.0*) [online] available from <http://www.w3.org/TR/xkms2/> [27 March 2008]

Bertino, E., Atluri, V., and Ferrari, E. (1999) 'The Specification and Enforcement of Authorization Constraints in Workflow Management Systems.' In ACM Transactions on Information and System Security, 2, (1) 65-104

Bertino, E., Martino, L., Paci, F., and Sqicciarinni, A. (2010) *Security for Web Services and Service-Oriented Architectures.* Springer : 159-173

Booth, D., Haas, H., McCabe, F., Newcomer, E., Champion, M., Ferris, C., and Orchard, D. (2003) *Web Services Architecture* [online] available from <http://www.w3.org/TR/2003/WD-ws-arch-20030808/#id2608472> [21 October, 2006]

Booth, D., Haas, H., McCabe, F., Newcomer, E., Champion, M., Ferris, C., and Orchard, D. (2004) *Web Services Architecture* [online] available from <http://www.w3.org/TR/2004/NOTE-ws-arch-20040211/#wsstecno> [21 September 2009]

Boyer, J., Eastlake, D., and Reagle, J. (2002) *Exclusive XML Canonicalization Version 1.0* [online] available from <http://www.w3.org/TR/xml-exc-c14n/> [10 January 2010]

Broberg, J. C (2002) *Glossary for the OASIS Web Service Interactive Applications (WSIA/WSRP)* [online] available from <http://www.oasis-open.org/committees/wsia/glossary/wsia-draft-glossary-03.htm > [29 December 2005]

Cahill, C.P., and Hughes, J. (2005) *Security Assertion Markup Language (SAML) v2.0* [online] available from <http://docs.oasis-open.org/security/saml/v2.0/saml-core-2.0-os.pdf> [19 July 2009]

Chinnici, R., Moreau, J., Ryman, A., and Weerawarana, S. (2007) *Web Services Description Language (WSDL), v2.0* [online] available from <http://www.w3.org/TR/wsdl20/> [24 September 2010]

Christensen, E., Curbera, F., Meredith, G., and Weerawarana, S. (2001) *Web Services Description Language (WSDL) 1.1 - W3C Note 15 March 2001* [online] available from <http://www.w3.org/TR/wsdl> [30 December 2005]

Cohen, E. (1988) 'Traditions in the qualitative Sociology of Tourism.' *Annals of Tourism Research* 15, (1) 29-46

Creswell, J. W. (1998) *Qualitative Inquiry and Research Design: Choosing Among Five Traditions.* Thousand Oaks, CA: Sage

DeLooze, L. (2008) 'Providing Web Services Security in a Federated Environment.' *IEEE Security and Privacy* 5, (1) 73-75

Dierks, T. and Rescorla, E. (2006) *The Transport Layer Security (TLS) Protocol Version 1.1*[online] available from <http://www.ietf.org/rfc/rfc4346.txt> [23 September 2010]

Easterby-Smith, M., Thorpe, R. and Lowe, A. (2000) *Management Research: An Introduction*. London: Sage

Eastlake, D. and Reagle, E. (2002) *XML Encryption System and Processing W3C* Recommendation [online] available from <http://www.w3.org/TR/xmlenc-core/> [27 March 2008]

Erl, T. (2005) *Service-Oriented Architecture*. Delhi, India: Dorling Kindersley (India) Pvt. Ltd.

Gorman, G.E. and Clayton, P. (1997) *Qualitative research for information professional: A practical handbook.* London: The Library Association

Gross, T. (2003) 'Security Analysis of the SAML Single Sign-on Browser/Artifact Profile.' In *Proceedings of the 19th Annual Computer Security Applications Conference*, Washington, DC: IEEE Computer Society: 298

Hartmann, R. (1988) 'Combining Field Methods in Tourism Research.' *Annals of Tourism Research* 15, (1) 88-105

Hu, V.C., Martin, E., Hwang, J., and Xie, T. (2007) ' Conference Checking of Access Control Policies Specified in XACML.' In

Proceedings of the 31st Annual International Computer Software and Applications Conference Vol. 02. Washington, DC: IEEE Computer Society: 275-280

Jacobs, I. (2001) 'World Wide Web Consortium Process Document' [online] available from <http://www.w3.org/Consortium/Process-20010719/> [27 March 2008]

Khushman, S. (2010) *The Relationship between Culture and E-Business Acceptance (A Comparative Study of Arab And UK Cultures).* Unpublished PhD. thesis, Coventry University

Koshutanski, H., and Massacci, F. (2005) 'Interactive Credential Negotiation for Stateful Business Processes.' In *Proceedings of 3rd International Conference on Trust Management (iTrust 2005)*. Roquencourt, France, May 2005: Springer LNCS 3477: 256-272

Koshutanski, H., and Massacci, F. (2003) An Access Control Framework for Business Processes for Web Services, In *Proceedings of ACM Workshop on XML Security*. George Mason University, Fairfax, VA, USA, October, 2003: ACM Press: 15-24

Kreger, H. (2001) *Web Service Conceptual Architecture (WSCA 1.0)* [online] available from <http://www.cs.uoi.gr/~zarras/mdw-ws/WebServicesConceptualArchitectu2.pdf > [23 June 2009]

Li, J., and Karp, A. H. (2007) 'Access Control for the Service Oriented Architecture.' In *Proceedings of the 2007 ACM Workshop on Secure Web Services*, New York: ACM

McIntosh, M., Gudgin, M., Morrison, K.S., and Barbir, B. (2007) *Basic Security Profile Version 1.0 Final Material* [online] available from <http://wsi.org/profiles/basicsecurityprofile-1.0.html> [24 September 2010]

Miles, M.B., and Huberman, A.M.(1994) *Qualitative Data Analysis: An Expanded Sourcebook*. 2nd edn. Sage Publications, Newbury Park, CA: Sage Publications

Nadalin, A., Kaler, C., Phillips, H. B., and Monzillo, R. (2004) *Web Services Security, SOAP Messaging Security 1.1* [online] available from <http://docs.oasis-open.org/wss/v1.1/wss-v1.1-spec-pr-SOAPMessageSecurity-01.pdf> [10 June 2009]

Newcomer, E. (2002) *Understanding Web Services: XML, WSDL, WSDL, SOAP, and UDDI*. Reading, MA: Addison-Wesley Professional

OASIS (2007a) *Web Services Business Process Execution Language Version 2.0 OASIS Standards* [online] available from <http://docs.oasis-open.org/wsbpel/2.0/OS/wsbpel-v2.0-OS.pdf> [18 March 2009]

OASIS (2007b) *WS-Trust 1.3 OASIS Standard* [online] available from <http://docs.oasis-open.org/ws-sx/ws-trust/200512/ws-trust-1.3-os.html> [16 November, 2009]

OASIS (2009) *XACML v3.0 Hierarchical Resource Profile Version 1.0* [online] available from <http://docs.oasis-

open.org/xacml/3.0/xacml-3.0-hierarchical-v1-spec-cd-1-en.pdf> [20 February 2011]

Papazoglou, M.P., and Van den Heuvel, W.-J. (2007) 'Services Oriented Architectures: Approaches, Technologies, and Research Issues.' *The VLDB Journal* 16, (3) 389-41

Rudestam, K. E., and Newton, R. R. (2001) *Surviving your Dissertation.* Thousand Oaks, CA: Sage

Saunders, M., Lewis, P., and Thornhill, A. (2003) *Research Methods for Business Students.* Essex: Pearson Education

Sandhu, R., Coyne, E., Feinstein, H., and Youman, C. (1996) Role-based Access Control Models, *IEEE Computer* 29, (2): 38-47

Verma, M. (2005) *Web Services Transactions*. Armonk, NY: IBM Publications

Vogels, W. (2003) *Web Services are not Distributed Objects: Common Misconceptions about Service Oriented Architectures* [online] available from <http://weblogs.cs.cornell.edu/AllThingsDistributed/archives/000120.html> [31 October 2005]