# Mobile Web Services

## By

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# 1 Preface

This report on Mobile Web Services is prepared as part of my research work at the Department of Computer Science at the University of Helsinki, Finland. This report focuses on the application of web services technologies in the Mobile domain. It builds on an earlier report "World of Web Services – A Technology Map" [62], in which the main emphasis was on the evolution of the Web and development towards emergence of Web Services. A complete set of Web services technologies was discussed and how they fit together was addressed with the support of Web Services Technology Map. This report assumes that the reader is familiar about Web Services technologies and understands the Service Oriented architectures, as covered in the previous report [62].

The key objective of this report is to emphasize the relevance of Web Services in the Mobile domain, discuss the current developments and standards addressing the deployment of the Web Services technologies into the Mobile infrastructure. We discuss in this report the different players in the Mobile domain and the value assets they hold which can be turned into value added Web Service Interfaces. The different deployment models of web services in mobile domain have been discussed both from architectural and end user value proposition point of view. An overview of the various technologies and standards developing in the Mobile Web Services domain is provided in this report. This report is in no means an authoritative guide or tutorial towards Mobile Web Services. The main aim of this report is to provide an overview of the current state and discuss the key issues and gaps in the Mobile Web Services.

The interest to develop this report raised from the Seminar courses [59][27]carried out at the Department of Computer Science, University of Helsinki, Finland. In the preparation of this report and as well as in the course it was evident that there was no single source of information available to understand the various developments in the Web Services occurring in the Mobile Industry. There were several sources of information with clearly no link between the various developments. This led me to the interest to prepare this report to provide the current state of Web Services developments in the mobile domain.

Acknowledgements goes to all my peers and students of the course who have been very curious to understand the mobile web services developments and also contributed to my understanding of the subject due to their interest and discussions raised during the course work. Finally, I would like to thank my professor Kimmo Raatikainen to make it possible for me to work on this research report.

# 2 Executive Summary

Web Services are here today applied in the enterprise and internet space, enabling and solving the complex enterprise integration issues. The Web Services technologies are also used to expose one's services as an open interface for future and potential client software to integrate into its own logic. The solution provided by Web Services is agnostic to any specific platform, vendor tools, and development environment and at the same time it is built on top of the widely utilized basic Web Services technologies (XML, XML Schema, SOAP, WSDL, and UDDI). Web Services Architectures [62] builds on the success of the Web Architecture and applies the web services technologies to access web in a programmatic manner suitable and following the web Architectural principles [7]. The success and advantages of these technologies are felt and are heading towards deployment of these technologies into the mobile domain as Mobile Web Services.

The Mobile domain consists of a Smart computing mobile devices, A wireless cellular network infrastructure, which provides access and connected to the devices to the network, and a Service platform hosted by the Network operator and as well as a Internet Service provider. The Mobile Web Services differs from the main stream web services as the services and technologies are in this case are not just meant for business to Business integration but to provide services to the mobile end user and as well as enable mobile user to expose contextual data and personal data as services to the network/Internet Service providers.

The Mobile Web Services are being developed and deployed in the following different models:

- **Network hosted Mobile Services:** The operator and third party mobile services provider have valuable assets, the mobile network infrastructure and the various service enablers that they could be offered as web service interfaces to the developer and internet service providers. These services are best provided as WSI interfaces, considering the heterogeneous developer platform requirements available out there. The service Enablers such as Payment, Presence, SMS, MMS interfaces, Locations, Profile services are few of the services that could be provided as network/operator hosted Mobile Web Services.
- **Device hosted Web Services:** The mobile devices are getting computationally capable, such that they can host Web Services on the Mobile devices directly. This is the next big development in the mobile domain as smart mobile devices are getting capable to run Mini Web Servers on them [26]. At the same time also allowing great potential for

applications and services innovations that can be provided by individual mobile device owners by utilizing Mobile device as a:

- Web Services Client
- Web Services Provider
- Web Services Broker

- **Device Centric Peer 2 Peer Web Services:** The total mobile devices with the users have out numbered the number of PC's in the world [15], increasing the probability of mobile device closer to a human is a lot higher than a PC. These facts drive the need and possibility for the Peer-to-Peer mobile web services a reality in the future. Mobile services hosted on a device can communicate with another mobile device user leading new Communication or collaboration oriented mobile web services. This can also enable mobile user to provide services that can locally interact with services running on other non-mobile devices as well.

In this report we will discuss the current development in the Mobile Web Services world. Develop a basic understanding of how they differ from main stream web services technologies. Discuss the architectural implications and limitations when considering Mobile Web Services. A good discussion on potential research challenges in the Mobile services and application areas will be highlighted in this report.

# 3 Mobile Web Services Overview

The proliferation of the mobile device capabilities is opening up new opportunities for services providers in the mobile domain space. There are going to be about 3 Billion Mobile subscribers by 2008 [15] and the mobile subscribers growth has already overtaken the PC Industry. This makes it like one of every two individuals in the world can be accessible via a mobile device.

The most widely and rapidly growing platform for service innovation today is the internet based Web platform. Web based technologies have started to be deployed into the Mobile space, as the availability of Mobile Web browsers can be found in most smart phone devices and as well normal mobile phones where Mobile devices are used to browse and access the web pages. The Mobile Web experiences are moving along with the web platform evolution from the static only browsing experiences into more Programmatic access by leveraging the development in the Web Services technologies [39]. This development though being true the usage model and design of the web services client and infrastructure is not similar or can not be similar to that of the PC centric world. The Web has traditionally shaped to support Personal computers centric platforms and hence the usage of the Web Services protocols assumes the computing

power and display capabilities of the PC world. Hence direct utilization of Web Services technologies is not suitable for mobile device. This is not just based on the platform computing but several other reasons such as:

- Mobile user has limited patience and willingness to read and use any information and services which requires considerable amount of concentration.
- Services are built from the fact that the devices are always on and connected and available over the network. This is not fully compatible with the mobile device and its available infrastructure.
- The computational capabilities are limited due to the size and form of the mobile devices to render and compute rich data which demand high computing capabilities unlike the PCs and Laptops.
- The user interface available on the Mobile is a single screen and also smaller compared to the PC world typically to which most web based information sites are shaped towards, though the Mobile browser can render similar data, not all the data accessible on the devices are relevant.

Mobile device users access information and services over short bursts of time and mostly limited to focused needs. Users do not browse for general information as they do so in the context of PC based usage of web content. The need is usually related to some context in physical world needs where they are assumed to be mobile. The Mobile usage is primarily for voice and messaging applications when communication oriented usage is considered, the remaining purposes is in Personal Information Management. Gaming and Browsing is only now gaining momentum as the access technologies have started to provide higher bandwidth and in turn leading to better experiences. It is still noted that the Messaging or Asynchronous interaction (push/pull) based applications will be more acceptable as it will not demand constant attention from the Mobile users. Applications such as Instant Messaging and Push Email are increasingly in demand as the devices and access networks are getting more stable.

As Web Platform is getting richer with ubiquitous access, the mobile infrastructure is also continuing to develop into an excellent platform to hold user contextual information to the applications and services of what really matters to the user. This information when leveraged to adapt the service it will provide a highly personalized service to a single user in question. An open and platform neutral application communication (i.e. XML based) interfaces over the web provides potential opportunities for a mobile solution providers to leverage the innovation and exploit the web of services available over the Web based platforms. This will enable developers immensely benefit from the services and the support to provide value added features with rich native interfaces to the web platform in the mobile device environment.

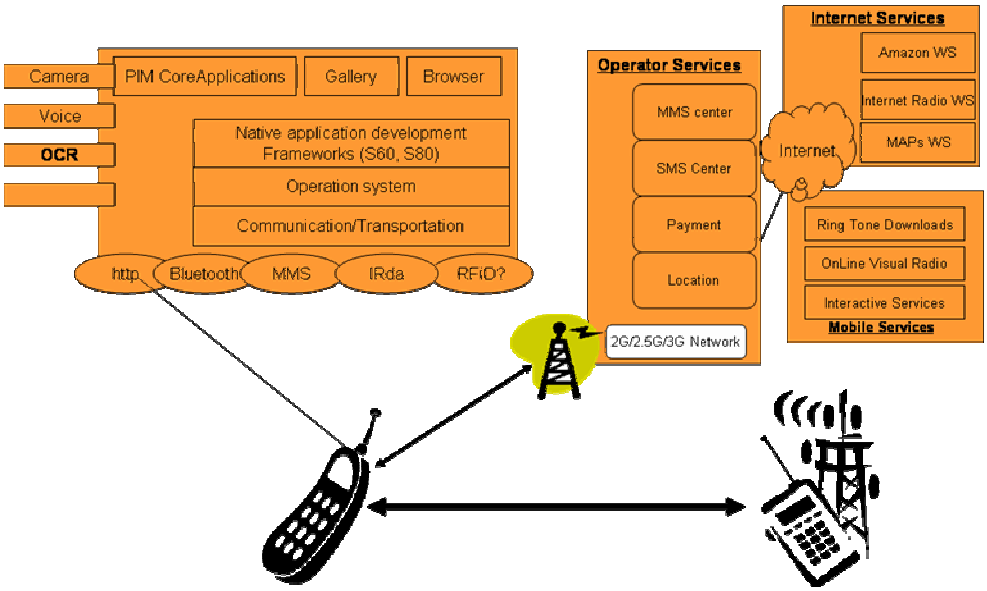


**Figure 1: Mobile Service Infrastructure**

In the Figure 1 we see the current Mobile Services Infrastructure which highlights three main players of the mobile solution: End user, Infrastructure provider and the service provider. In the case of End user, the user has a device which can contain rich core application data containing personal information, business data and value added application data, a network connectivity and enablers to capture and create electronic data on the move; Network infrastructure provider, who can provide essential communication, administrative and transactional infrastructure and services to both the end user and the service providers. The Service provider provides internet centric or mobile aware services to the mobile device owners.

## *3.1 Players in the Mobile Web Services*

Web Services in mobile domain are enabled by three main players. We will discuss these three players value and the assets they offer to enable Mobile Web Services.

**End User:** Mobile devices can be assumed to be with users when mobile. Considering data intensive applications available in the devices it can bring with it very rich contextual information about the environment, user's preferences, sensorial data such as location, region and historical data. This information can play a big role when services need to be personalized and adaptive to user needs.

As the technologies mature in the devices such as mass storage along with computing capabilities is rapidly increasing, this enables Mobile devices today to house and become a large source of data (be it personal or business data) and services. As most of the user's personal and

business related data can be carried in the device, this makes the mobile potentially a personal roaming portal of services along with the user where and when the user is. Personal Information such as: Business contacts, Personal Schedule, Image gallery, Music, Business Documents, Customer information start to become the end user assets if they can turn into Services. These services can also have potentially customers or end users such as: family members, Friends, customers and Enterprises as end users if they can be packaged and delivered with sufficient security and trust model put into place. The devices have a huge potential to be a tool for social and business communication platform in the future. As the number of domains and the platform under which the device can be utilized can not be controlled the most suitable platform under which service and communications capabilities can be developed is open XML based protocols. This approach though is not the most efficient protocols respecting the network bandwidth requirement and economical aspects still serves a wide spectrum of deployments and usage.

**Infrastructure Provider:** Mobile Infrastructure provider, namely the mobile operator has the key mobile assets, namely: the infrastructure and the mobile subscribers. The infrastructure provider owns the subscriber base, which is currently close to 3 Billion mobile users, and as well maintains a well established Customer relationship related services such as Billing, service access technologies in some cases also own the devices. The Mobile infrastructure providers can even provide sufficient information related to the location (at a CELLLID level) as contextual information when a mobile subscriber requests and access mobile web based internet services (if of course sufficient end user permissions are obtained). This enables the mobile infrastructure providers to package and provide access to such contextual data as value added service back to the mobile subscriber or then to the Services infrastructure. This sort of services will in turn enable more personalized experience to the Mobile users when accessing services. The Mobile operators are the most trusted player in the mobile industry by the subscriber and they play a major role in exposing or controlling the access to the mobile subscriber information.

The Mobile infrastructure itself provides already global roaming while still enabling user to continue interacting with his/her favorite mobile services. This roaming functionality can be extended to all internet services in future, adding a huge potential benefits to mobile subscribers to access such services relevant to the location, time and place. The service providers can also leverage this key value of reaching and providing services to the mobile subscriber where and when it is actually needed.

**Service Provider:** The Service providers in the mobile domain can provide services to the mobile users basic mobile infrastructure related services or advanced services. Today the basic services are the most

popular mobile centric services (IMS, Push-Email, SMS, Voice, Gaming and PIM) provided by the mobile infrastructure provider, such as the mobile operators. The advanced services are the ones which can complement the mobile infrastructure connecting the mobile to more rich and enhanced and traditional platforms (such as Enterprises, Entertainments, Media or Civil Services). The internet as a service platform and the innovation potentials of the web services are not yet fully exploited in the mobile space. This can be due to the fact that the mobile devices and technologies were not mature. These devices are turning towards supporting web architectures and markup technologies enabling mobile services providers to leverage the open internet centric innovation platforms or even cost efficient to innovate here on. The technology barrier so far has been the proprietary or platform specific means to develop and deploy services.

The Mobile devices' being fit with Multi-Radio enables them to access services from multiple channels (over WLAN, via PC and also over 3G networks) and Flat rate models will ensure usage of the internet platform for service deployment making it low cost. The emergence web based technologies into the device environment provide necessary incentives to the service developer to develop open and platform neutral solution further lowering the technology barrier. This development also opens up new opportunities with the internet and web based services to be accessible. Looking further into more advanced case an internet services can also be provided by Mobile subscribers who is on the move and has contextual information to add to real physical world, such as in the cases of Mobile enabling Citizen Journalism [11].

## *3.2 Roles of Mobile in Web Services*

Mobile devices enabled with web services can be equal participants in the web services architectures. The services must take into account the actually needs for such service nodes considering the act of mobility. The mobile specific needs and purposes for the different web services roles in mobile space, particularly when accessed from smart phone enabled devices are discussed further here:

- **Web Services Client** (WSC): Access web based services which can help interact with the mobile users at the point of urgency. The user wishes to address and communicate with the services at the very instance of time. Such as: User wants to share a picture of real event via the phone camera to a web based news service or a family album. Mobile user wants to access customer data when the user is in front of the customer (traveling sales/work force).
- **Web Services Provider** (WSP): Provide services to other devices (mobile users) in local environments or to remote mobile users. The mobile nature of the service makes it very promising to enable

mobile Commerce or multimedia collaboration services available. Services such as Personal calendar/Gallery services or business services for small and medium services are crucial.

- **Web Services Broker** (WSB): A mobile device can contain a list of web services and a registry of services which can be made available to other mobile Service Clients. The mobile users (client) would like to know which services a particular mobile client has been using (Service List: Personal favorites, subscribed services, etc) or then the mobile provides more location and navigational data to find a particular service available only in a particular location. As end users share and recommend services, this sort of solution will enable social networking based service distribution in areas where there is not necessarily cellular network coverage available.

# 4 Mobile Web Services Architecture

The Mobile infrastructure provides an eco-system for new and innovative Mobile Web services platform to be realized once the basic web services capabilities are introduced into the Mobile devices and the MSP's platform. The key value assets of the both the mobile and the MSP can be leveraged and embedded into Open Internet based Web platform which is currently emerging from the Converging industries.

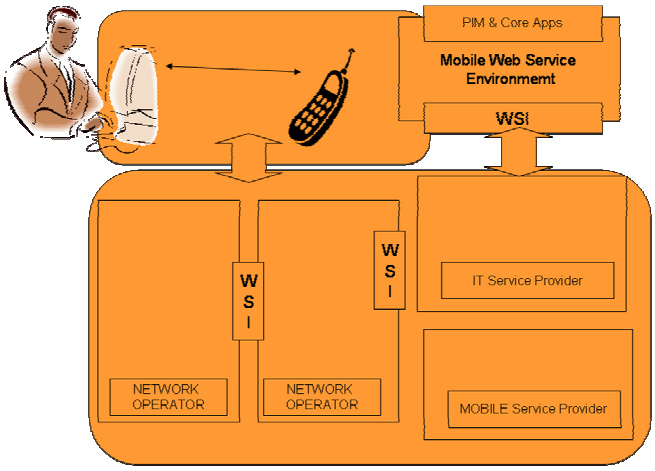


**Figure 2: Mobile Web Services Architecture**

The Figure 2 depicts the high level architecture of the different parts of the mobile infrastructure and how web services fit into this architecture. The Mobile device, the MSP (operators) and the user (end user or service developer) directly interact with the web services. The Mobile Web Service Environment as depicted in the Figure 2 is the device environment which exposes communication to an environment using Web Services Protocols (Local proximity or remote

communication services).This interface can be exposed directly to another mobile device, to the MSP or even the Internet Service provider (ISP). The mobile device mentioned here is primarily a Smart phone but this can as well be any other mobile device, such as: a tablet device, a PC, a Vending Machine or Point of Sale at a retail stores.

The Network Operator (MSP) can benefit from Web Services by tapping into the web based innovation platform to provide new value added services appealing the mobile users. The users utilizing these services via their PC environment can benefit the value the mobile device can bring as the users will be able to be connected to the same service while mobile. In addition to this the MSP's can provide a rich development platform for service developers to reach out mobile clients. The Web Services for mobile infrastructure have also seen its place for inter-operator interoperability and in Enterprise integration solutions. As the Mobile web service interfaces can be standardized the operators can benefit from a unified interface to communicate and manage different mobile platforms in one common and unified manner. This will enable Mobile Network operator new services opportunities to provide to non-cellular mobile devices (such as WIFI/WLAN enabled devices such as PDA, etc.)

## *4.1 Mobile Web Service Components*

In this section we will discuss the key components of the Mobile Web Services Architectures, i.e. the Mobile Device, the Network Operator and the Service Provider. In each of these we will look at key enablers available in each of them; the reason why web services technologies will provide a value and services which can potentially be exposed as Mobile Web Services.

### 4.1.1 Mobile device

Mobile devices as of today are close to 3 billion devices which are being used in the world with the characteristics that the are handheld enabled with voice call and messaging data services (SMS and optionally MMS and IM ). This number is constantly increasing and in the near future (2-3 year by) they could increase at least a billion more mobile devices. This makes it a very attractive platform for new innovations and services made available to as most people can be accessed via mobile devices where ever they are. In addition to traditional Mobile phones there are all sorts of mobile devices that are emerging which can be accessed over a network infrastructure (Cellular or over Local Wireless networks). Devices such as: Music Players, Navigation Systems, Sensors collecting environment statistics such as temperature/motion sensors, Web cameras and numerous such network enabled devices are emerging.

A special class of these mobile devices called the Smart-Phones is one of the most potential to exploit the Web Services technologies in mobile environment to the fullest. To limit the focus of this report we will focus on the Smart phone class of devices. The lower class of devices are also very important but for the focus of this report we will discuss about Smart phones only, as this device class is capable to play a equal role as other internet based Web Service nodes[62], as it can access, host and provide web services based on the platform capabilities. Smart Phone device is a mobile phone (including voice and messaging) with a rich internet based data communication capabilities over a multi-radio high bandwidth access. Smart phones also are programmable and have at least 200 MHz of computing powers (Similar to PC in mid 90s). Currently most of the smart phones supports the following different internet based applications or services, such as:

- Internet access and Web browsing, and fax
- Instant messaging
- Internet
- Personal information management applications
- Data Connectivity
- Optionally Graffiti style data entry capabilities
- Data Synchronization with PC or a network based services
- Remotely control computers, home or business electronic systems
- Interactivity with multiple messaging systems, Wireless e-mailing

The key properties of these smart phones are that they are Personal and are always carried while Mobile. There is a very high probability that a user can be reachable via mobile devices than any other means while remotely or physically trying to reach the user. These devices also posses few salient features such as near Displays (close to a person) that enables the content available via this display suitable mostly for personal consumption in public places. Users prefer to store a lot of personal information such as: Images, contacts, personal messages.

When considering building applications or services for the mobile phone users (applicable to smart phones also) close consideration needs to be taken at the limiting factors in the role of mobility. Such as:

- Users are able to only focus on the content or information for a short period of time
- End users require information and services which support their mobility, but yet allow them to fulfill and allow them to carryout tasks which will help them avoid traveling and manage the task remotely.
- The Network availability may not be ubiquitous and user's can face intermittent breaks (in Train, Airplanes, out of network coverage zones (theaters, undergrounds in some cases, etc.))
- The devices do have reasonable Battery Life, but are limited certainly based the demand for computations cycles

- The does have sufficient computation capability to address the basic needs of mobility

These above limiting factors calls for any service or solution to take into account the following key aspects: Intuitive user interface, efficient protocols, capability to adjust to intermittent connections, demand less computational requirement, Support offline functionality, support for local networking and ad-hoc networking.

Smart phones today support multiple development environments and platforms. The major devices support C++ variants which are available in a platform specific APIs enabled in these devices. The major mobile runtime platforms available today as: Symbian C++, Windows Mobile .Net, Linux / C-C++, Java a common runtime on Mobile devices (JDK1.x, Java Micro edition i.e. MIDP-CDC/CLDC)

It is equally important to understand the main Mobile end user needs when building web services in the mobile environment as the environment is primarily available to ensure end user communication and collaboration needs while on the move. Here a few user needs that need to be kept into account while considering services in mobile devices:

- The user interface should make service transparent to what the underlying technologies are used
- Use of a service both from Mobile and PC should be functionally alike with device specific user interfaces (Image Sharing experience over Flicker[14], Access internet/mobile mail gMail[16])
- Use communication services between several devices PC/Laptop, Mobile device and other devices (for example messaging, IM, voice calls, Contacts, Collaboration applications such as file sharing)
- Access services which can adapt to the mobility context and provide access to relevant service experience

### 4.1.2 Mobile Infrastructure Service provider (MSP)

Network operators and infrastructure providers are changing the world by connecting everyone no matter where and when it is needed. This connectivity is made in real-time over a highly scalable cellular radio network infrastructure, across the globe. Voice and Messaging are the two main applications in use today, but this is spanning also to other ICT based rich communication services as well. The mobile infrastructure has scaled so far very well supporting a well standardized network infrastructure such as 3G networks by standard bodies such as 3GPP [3]. The support for mobile device has also centered on mobile domain centered industry consortium and standards bodies. The mobile industry is converging with the internet industry. The internet is a platform consisting of heterogeneous platforms and hence applying a standardized approach to address scalable systems will be a major challenge to bridge communication across different platforms. A solution which can inter-work in a platform neutral format is very much required and relevant.

Web services have been a standardized approach to solve inter-operability across heterogeneous platforms. In order for mobile devices to exploit a web services platform a support for WS technologies within the infrastructure components is essential. The MSP can play a major role by enabling web services technologies within the mobile infrastructure. This can help provide an open Services deployment model in the mobile domain. MSP have also in the past attempted to host and develop services and applications of their own. There are many popular services which are successful from the mobile industry domain. The Web based Services platform provides a rapid application development environment enabling roll out of new innovative services with a very low cost and high speeds in the internet. The convergence will enable mobile service deployment happen with a similar ease as of Web Services development for PC centric platform.

#### 4.1.2.1 Needs of the MSP

MSP's play a primary role of making available a stable and reliable network infrastructures for the mobile subscribers and services providers to reach out to the mobile users. There are several core services provided by MSP's few key and crucial ones are:

- Charging and Billing
- Instant Messaging
- Network and Internet Access services
- Short Message services
- Multi-media Message services
- Voice and Video communication services
- Local and Global Roaming services (in partnership with other operators)
- Personal Information Management

The MSP also enable internet service providers or mobile application and service providers a good customer base and infrastructure using which solutions and services can be delivered to mobile subscribers. The interfaces that a MSP can provide to an internet or web service provider can utilize for building solutions are not fully standardized and vary between different vendors and services providers.

The key needs for MSP are to:

- Provide an open interfaces for service innovation
- Leverage unused assets to provide new enablers for service creation
- Integrate mobile systems with and inter-operate with existing systems
- Enable end users provide services to other mobile users

### 4.1.3 Internet Service Providers

Internet based services are noticing two main changes. Firstly the Mobile Service providers have utilized the Web as a platform for providing services. The end users today utilizing the web based services are the PC users, but this is changing over a short period as the mobile experience to access services over

the Web is improving drastically. And secondly the main access mode for the web centric information and data is via browsing user interface paradigm. The Internet services are changing this as push based solutions are maturing (Push Email). Pull based services are also making the usage of web technologies suitable for application or service specific interactions (Services such as Mobile RSS readers by Reuters [45] or Pull based Emails such as one made by gMail). These two developments are specifically suitable for the mobile usage as Browsing is not the main mode of mobile application usage (the main communication modes are asynchronous and messaging based). A suitable open protocol for application level communication is important for mobile web services space.

The main needs for services providers in the mobile domain for Web services are the following:

- Open platform neutral and standard protocol format to expose services to mobile and receive mobile data in an open data formats.
- Access contextual data from the mobile subscriber or about the mobile subscriber so as to deliver Personalized Services
- Enable provide a common service which can be seamlessly consumed across various devices.
- Ability to integrate Services with mobile infrastructure or other devices with which mobile can interact with.
- Enable Enterprise backend Integration so as to mobilize business applications and business processes
- Management of mobile business terminals

The MSP provides a platform for mobile service/application developer community and the needs of these users are:

- Develop mobile extensions and re-use existing services and applications available for PC centric solutions.
- Build services for Mobile Consumption.
- Build services for consuming Mobile application Data over open protocols so as to integrate the media collected to media or data Portals (for example: YouTube[69])

## *4.2 Key Players in Mobile Web Services*

The technologies and enablers required by Mobile Web services are mainly being developed by the key technology vendors, device manufacturers and enterprise services providers. The operators and the network infrastructure providers are specifying the several service interfaces which are required to expose the network and services over the standard Web Services technologies. The key mobile technology developers in the mobile device space are today mainly Nokia for S60, Symbian and Linux Tablets devices, while Microsoft is developing them as part of their XML & Web services libraries in the Windows Mobile editions. Sun Microsystems is involved in ensuring that Java available on these devices can support Web Services protocols in a standard manner. The

operators and infrastructure providers have specified a set of service interfaces that are essential for Network hosted Mobile Web Services via Parlay-X Web Services. There are a few open source technologies and libraries also available to enable web services on these devices. This will be covered in more detail in the later sections.

Here are a few of the key Mobile web services activities and technologies that be found from the various vendors of technologies and industry consortiums.

- Nokia Mobile Web Services [34]
- Microsoft Mobile Web Services [23]
- Sun Microsystems's J2ME Web Services[51]
- IBM: Web Services Tool Kit for Mobile Devices[18]
- Parlay X Web Services [43]

## *4.3 Standardization activities in Mobile*

Standardization bodies play a major role in making the technologies and architecture deployable and realizable. In addition to this, these bodies also ensure that the developed technologies inter-operate with each other. The several bodies addressing Web Services technologies for Mobile devices and services are:

**OMA [38]:** Open Mobile Alliance is specifying an overall architecture and guidelines for web services deployment in the mobile domain. Ensuring that best practices are used to specify and deploy Mobile Web Services via its MWS Working Group
**Liberty Alliance [21]:** Is specifying an Identity Web Services architecture and framework for a single Sign on and security protocols to enable shared identity among a group of services and end user over Mobile and internet infrastructure enabled services.
**Java [19]:** Java Community process – Has developed a Mobile Web Services Java APIs for devices with limited capability such as: Java 2 Micro Edition. The specification addresses the needs of the mobile computing platforms and provides ability to target Web Services clients on Mobile devices with different native platforms (Symbian, Windows Mobile, and Linux)
**Parlay:** Parlay X Web Services [43], This is consortium in which telecom and IT partners jointly specified a set of Mobile web services for operators and IT solution providers to utilize to make their services available over Web Services Protocols

We will discuss in more details each of the standard bodies most relevant to the Mobile Web Services in the Section 6.

## *4.4 Dominant Mobile Web Services Platforms*

There are two dominant Mobile Web Services Platform providers currently in the mobile and IT industry are the leading Mobile device manufacturer, Nokia and leading IT platform and solutions provider Microsoft.

### 4.4.1 Nokia Web Services Framework

Nokia provides a Mobile Web Services Framework(MWSF) [34][29] enabling the Mobile phone end user to access Web Services running on the Internet and for the Mobile application provider to utilize this framework to provide an enhanced user experience in using Web Service. The MWSF is a middleware framework providing access to transportation protocols and higher level abstracted APIS to handle SOAP based messages so that the application provider can focus on the application level functionalities.

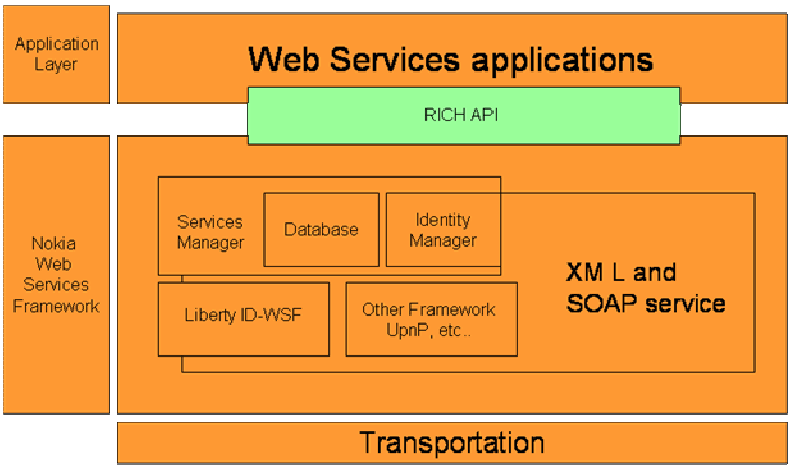


**Figure 3: Nokia Web Services Framework – Overview**

The Figure 3 shows the basic middleware components available in Nokia's Mobile Web Services Framework. As mobile computing devices contain very sensitive data about mobile users and are considered device of trust, the security features are strongly considered by extending support for enabling Liberty Alliance specified Mobile Web Services Security framework (will discuss this in more detail in a later Section). The MWSF contains basic SOAP and XML libraries to interact with Web Services, A Service Manager which contains data related to invoking services and several higher level APIs for web services application developers as tools to support development. The MWSF provides tools to generate a Web Service Stub client provided a Web Service Interface description (WSDL) is fed into the tool.

### 4.4.2 Microsoft's vision developed towards Mobile Web Services in collaboration with Vodafone

Microsoft and Vodafone have released a high level vision of a Technical Roadmap for Mobile Web Services. The aim of this is to expose the mobile Security and Payment Services to wider developer communities and exploit the Location, Messaging and several value added services of the operator infrastructure to both the PC / Mobile environments.

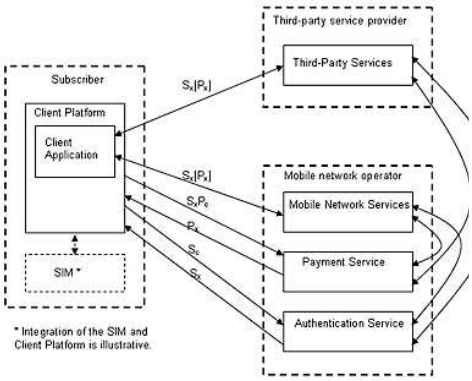

**Figure 4: Microsoft and Vodafone's Joint Mobile Web Service Vision, Source [30]**

The Figure 4: Microsoft and Vodafone's Joint Mobile Web Service Vision, Source [30]Figure 4 depicts the overall vision on how Mobile client (PC or Smart phone) talking to web or internet services over Web Services protocols. It is envisioned that the Web Services can be hosted by either the operator or any 3rd party service providers. The mobile can interact with both the hosted Web service providers. The 3rd party web services provider can interact with the operator Web Services interfaces.

The key benefits of providing Web Services Interfaces for Mobile domain as depicted by Microsoft and Vodafone are [30]:

**End users:** Users benefit from this as they can seamlessly access services across both the wired and wireless networks i.e. in PC and mobile devices respectively. The developers of these services would immensely benefit as:

- Application developer use open and standard interfaces.
- Have a rich development environments across PC and mobile environments.
- Applications can access mobile network services from both mobile network terminals and PCs.
- Innovate on top of the existing network services: Messaging, Location, Authentication and Billing into new applications

**Mobile operators:** Can utilize these technology developments to:

- Extend their businesses by making their network services available to the broadest audience of developers and software users
- Enable a new breed of value-added services for their users spanning PC and mobile devices

We will in the next section discuss and look into the details of the web services related technologies, the current related Web technologies and suitable for the mobile devices

# 5 Mobile Web Service Technologies

As we discussed in the previous sections the two main domains in which Web Services specific to Mobile technologies are in the Network and Mobile device environments. The Network centric Mobile web services do not demand any new mobile specific Web Services Technologies, the current technologies available in the Web Services technology map [62] are sufficient for enabling Network hosted MWS. The device end of the Web Services calls for technologies to be made suitable for the device environments. The mobile devices representing a WS Client or a WS provider requires corresponding extensions to the Web Services technologies to make a light weight implementations of the standard technologies, as existing technologies may not be directly suitable for porting

over into the Mobile environment. We will in the next sections elaborate a bit more on each of these domains for MWS.

## *5.1 Mobile Infrastructure Environment and Services*

The Mobile operator infrastructure environment for application and services unlike the radio and networking level (standards based inter-operable technology enablers) has been built using proprietary technologies, open and non-web based technologies, such as n-Tier Enterprise application platforms (J2EE, .NET, CORBA, DCOM). The infrastructures was developed using distributed computing platforms often a tightly coupled distributed systems. Mobile Specific technologies have been used to enable application Integration (protocols) and this has usually been developed based on Vendor specific manner making it hard for systems to inter-operate in a loosely coupled manner.

The Mobile operators are opening up interfaces to internet based services available to mobile subscribers to experience and access both entertainment and business oriented services from mobile terminals. Web Services will play a major role in fueling and making open IT solutions available in Mobile Environments. Operators can leverage *Service Composition [62] to reuse its existing legacy systems and Services to building higher level services for internal deployment and expose it as services to enable new innovations on existing assets.*

The currently available Web Services interfaces made available by future looking mobile operators are services such as:

- Delivery : Enables deliver digital content to Mobile devices
- Notification: Enables notification to the Web Services clients in mobile devices
- Payment / Billing / charging: Enable billing and payment based transactions with the mobile operator infrastructure, this is meant for both the end user services and operator's partner interfaces.
- Presence: Enable relay presence information of the mobile subscribers for mobile /internet services and applications.
- SMS WSI: Web Service interface to send and receive SMS Messages intended mainly for service providers
- MMS WSI: WSI for sending and receiving MMS messages
- Locations : To query and receive information about the Mobile subscriber location
- Profile: Allow maintain user profile data, can contain information about users preferences and user account details
- Call Handling: Enable call handling utilizing Web Service Interfaces
- User Management: Manage user subscription via WSI
- Group management: Manage user group

The Mobile industry has two major bodies which aim to enable web services for mobile domain. Namely:

- OMA: Open Mobile Alliance has specified “OMA Web Services Enabler (OWSER) Release 1.0”[36]
- Parlay X Web Services 2.0: Which has released a set of Web Services for mobile operators[36]

## *5.2 Mobile Device Environment*

Mobile devices particularly the smart phones already have XML based technologies available since long as the browsers utilize them for rendering web content. There are several other Open XML Technologies supporting the Web Model which are seen in mobile set of XML technologies such as: WML, cHTML, xHTML, SMIL. The XML technologies so far employed in Mobile devices have been earlier used for applications (Browser, MMS client) where the content can be directly rendered for End user consumption. The Web Services takes this towards application level interfaces, where applications can utilize XML for communication, application or business logic and means to invoke and communicate with distributed web based services in a more programmable manner. It hence moves the focus from end user towards the service and application developer’s point of view.

This application level functionality requires a local runtime and application development model to guide and host mobile device based Web Services. There are several aspects a device manufacturer or software platform development should take into consideration to enable mobile centric Web Services capability. The key aspects important to consider enabling Mobile Web Services in a resource constraint and mobile environments are:

- Provide a secure communication mechanism when applications utilize SOAP and XML based communication with a service side. Ensure that the application communicating outside the device passes the basic trust and security models put in place to avoid any malicious code
- Provide a light weight and an enhanced performance over non-verbose protocol deployment. Web Services technologies as such which are textual and verbose are not directly usable in the context of the mobile usage without adapting it relevant to the mobile context.
- A Framework which can link the middleware level protocols to the application user interface level communication modules
- Ability to communication to native system level platform and communicate over proximity technologies (Bluetooth, radio or Messaging infrastructure)
- An Open architecture maintaining compliance to the basic Web architectural principles[7]
- Enable different modes of user interaction, user initiated(Pull) or system initiated or automated communication(push)

- Elegant and less resource demanding solution.
- Support Device Centric Communications over local networks in a peer to peer fashion.

In addition the Web services platform enablers or framework should provide easy and rich application interfaces so as to include the exchanged web services data into the corresponding device user interfaces, which the end user can consume. This will provide a capability for mobile devices to run local services and end users to interact with such services.

Mobile devices provide an environment to support WS Client software and a more advanced environment to even host Web Services. Web Services technologies can be made available in Mobile device either as a native platform support provided by the original device manufacturers or as an application framework supporting a particular developer platform environment. We will take a look at few Web services technologies available currently for the smart phone device categories.

### 5.2.1 J2ME Web Services: JSR-172

Java Micro Edition Web Services is a Specification made by Java community process [19] making Web services deployment suitable for java environments available in J2ME capable devices. The support for mobile java spans across multiple device operating devices which support Mobile Java on them. This specification provides support for two parts of web services communication.

- Java API for XML processing (JAXP) : Enabling software modules to process XML messages
- Java API for XML based Remote procedure calls (JAX-RPC) : Enables make remote method calls across service nodes. Basically helps in processing SOAP Messages and transportation and exchange of these messages between the different Service Nodes.

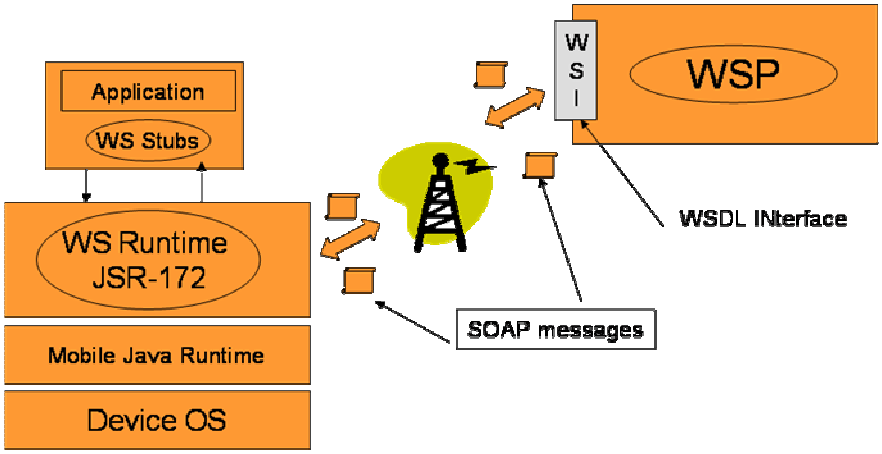


**Figure 5: J2ME Web Services Specification Overview**

The Figure 5 shows how a WS runtime i.e. JSR-172 functions in a Java micro edition enabled mobile device. The applications communicating with Web Services Provider interacts with the help Web Services stubs, which can be generated by the tools provided in Java 2 Sun Microsystems Wireless toolkit[52] or any other vendor's Web Services toolkits(for example Nokia's Web Services Java toolkits)[33]

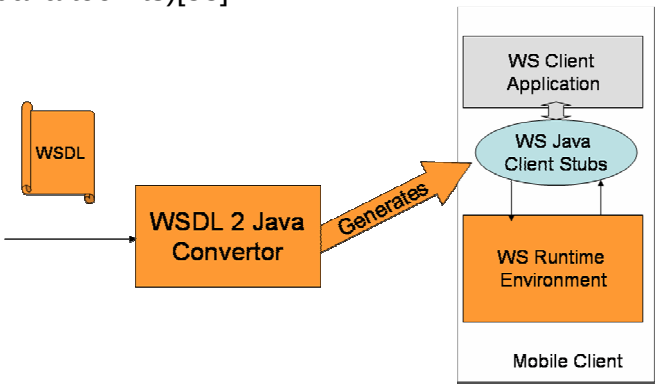


**Figure 6: Web Service Client Stub Generation Process**

The Figure 6 shows the Web Services client Stub generation process. The developer needs to have a Service description interface, i.e. a WSDL file reference, and provide this as an input to the WSDL 2 Java Converter. The tool on receiving this will generate a WS Java Client stub code. The service/application developer will then utilize the stub interface to develop the necessary User interface and include the Web Services interaction logic into the Java micro edition code base.

The JSR-172 is compliant with WS-I Basic Profile, supporting SOAP 1.1 and HTTP 1.1. It supports limited and primitive XML Schema (XSD) data types such as:

- Boolean, byte, short, int, long, float, double, string
- Arrays of primitive types, and complex types (structures containing primitive or complex types)
- Encoding:
    - Document/Literal message mode

The Java Micro edition's JSR-172 Mobile Web Services does not support capabilities of Web Services such as:

- SOAP with Attachments.
- SOAP message handlers.
- Web service producer.
- Service discovery support

The JSR-172 implementation does not require support for XML encoding on the device and makes the validation of XML optional. It provides support for SAX2.0, XML Namespaces and UTF-8 & UTF-16 based character Encoding. The JSR-172 does not support DOM or XSLT. The major limitations of JSR-172 is that it

can not be used with many available Web Services deployments available as they are not necessarily limited with a very simple data set supported by JSR-172, i.e.: *boolean, byte, short, int, long, float, double, string* array of primitive data types.

### 5.2.2 kSOAP

kSOAP [20] is a light weight SOAP based application framework developed over Java Micro Edition. kSOAP is based on kXML, which is basically a XML based pull parser and writer; this was specially developed to be suitable to Microediton platform. kXML was originally developed by the AI Unit of the University of Dortmund. kSOAP together with kXML has a very small footprint making them suitable and usage in Applets or Java applications running on mobile devices. The kSOAP object model as shown in the Figure 7 the main object is the "SoapObject", a higher level class enabling applications to create or consume a SOAP message. The methods basically getProperty() and setProperty() facilitate the developer to create and interpret SOAP Objects. This framework is a Java based implementation and is suitable for deployment into Java Micro edition. The general advice to utilize such frameworks is to first check the target device and if there exists already some sort of native Web Services capability. It is better to utilize the native deployment available as this will reduce the application size and ensures highly efficient solution. kSOAP is certainly very important to get initial hands on in developing java based Mobile Web service client. The kSOAP by itself does not support Web Service provider functionalities, but this can be suitable to be developed towards that path if needed.

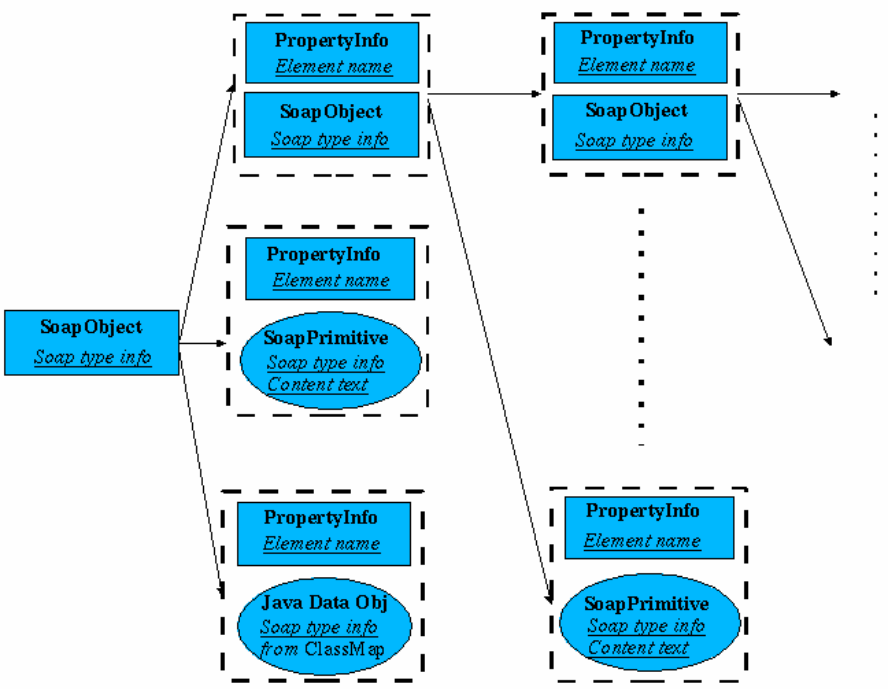


**Figure 7: kSOAP Object model[20]**

### 5.2.3 eSOAP

eSOAP[13] is small lightweight implementation of SOAP specifically designed for embedded systems. This toolkit is a SOAP engine built using Ansii C++ Library suitable to be included into embedded systems. The toolkit also contains tools to help inter-operate with n-tiered application architectures. The engine and implementation is based on the W3C's SOAP1.1 standard and is a very small footprint of 150KB. It is very compact and efficient in processing SOAP Messages.

### 5.2.4 gSOAP

gSOAP [17] is tool built to support Web services development in C and C++ application environments. It provides tools to map native platform data types expressed in C or C++ into semantically equivalent XML data types. gSOAP uses compiler technologies to analyze the data structures and accordingly map and generate web service stubs and skeletons to match specific Web Service interfaces and vice versa. gSOAP unlike other tools, which provide SOAP object API, keeps the developer transparent to the underlying SOAP communication APIs and converts C and C++ to SOAP as part of compiler generated SOAP specifics. This way it simplifies the necessity for the developer to go deeper into the SOAP specifics and helps focus at a platform and application level semantics. The developer can utilize the SOAP level interfaces to make any extensions if needed.

gSOAP is suitable for inclusion into embedded systems and integration with any native C or C++ based environments. gSOAP provides a couple of tools to help develop Web Services, namely:

- **WSDL2H:** This tool is used to import one or more than one WSDL documents and convert them into Header files with interfaces depicting the WS operation and correspondingly maps all XMLdata structures into their respective C or C++ data types.
- **SOAPCPP2:** This tool takes in Header files and generates XML serializer for the data types (soapH.h and soapC.cpp). It also generates the Client side stubs (soapClient.cpp) and Server side skeleton (soapServer.cpp) interfaces. This tools can also generate the WSDL definitions provided the C and C++ Header files.

Let's take for example a Web Services available in xMethods called XSpaceService; this is a service which provides a Virtual Space for storing and retrieving SOAP Envelopes by set of SOAP Nodes authorized by users. When this WSDL is run through the tool WSDL2H it will generate a header file "XSpaceService.H" in which contains the corresponding interfaces along with the data types transcribed into C/C++ from WSDL's XML based data structures (XMLSchema based.) This header can further be processed by the SOAPCPP2 tool to build client stub software and if the service needs to be built locally a Server Skeleton modules can be generated accordingly.

### 5.2.5 Nokia Web Services Framework (NWSF)

Nokia Web Services Framework (NWSF)[29] is built on two supported platforms a native Symbian C++ based application framework and a Java based framework. NWSF provides a Set of C++ API's on Series 80 Platform [46], Nokia's device platform class namely the communicator devices. There is also a similarly Web Services platform available on Series 60 3.0[32] release devices, which are next generation smart phone devices. The Java based Web Services Framework also supports the similar platforms and features as it is built on top of the native Web Services framework.

NWSF is compliant to WS-I basic profile and mainly include support for:

- XML
- SOAP1.1
- WS-Security
- Liberty Alliance Web Services Framework (ID-WSF)[22]

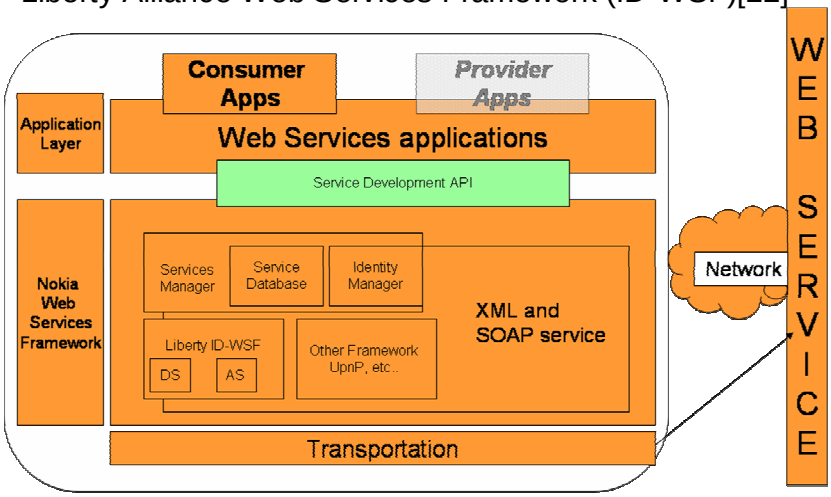


**Figure 8: Nokia Mobile Web Services Framework**

The Figure 8 shows the complete system overview of the Nokia Web Services framework. Here we will discuss the main components of the framework:

**Service Manager:** This module is used for coordinating the different service connections. It stores and includes service and user Identity information utilized for Identity management when interacting with Services.

- Service database: A database of Service information/description
- Service description: Contains information on how to access a specific service, as it contains details such as: Identity Web Services Framework used, Web Services end Point for the identity Provider, Endpoint reference for the actual Web Services
- Identity Providers: Maintains user accounts, Authenticates users / authentication assertions to other systems about these users.

**Liberty ID WS:** Provides a Discovery and Authentication Service to support Liberty identity Web Services Framework needs

**XML:** Supports based XML Parsing, handling and interpreting the SOAP Envelope and WS-Security headers

**Basic Services provided by NWSF:** HTTP Basic-auth and XML based security OASIS WS-Security support. Authentication service and security measures are provided by the following 3 main steps:

- Authenticating the requester
- Discover available Services
- Connection to the Service

The NWSF also provide few other services for developing Web services, such as: Service Matching, Security Policies. There are set of tools useful for converting WSDL 2 Symbian C++ client stub or Java client stub interfaces, which can then in turn be embedded into the application logic or software. Nokia today mainly provides support for Web Services client, but have discussed the need for Service provider interfaces with a various cases in their vision for Mobile Web Services. The NWSF seems to be most advanced Mobile Web Services Framework available currently.

# 6 Mobile Web Services Standardization organizations

In this section we will briefly discuss the mobile industry's main standardization bodies involved in specifying and architecting the different aspects of mobile web services. The three areas of specifications and standardization in realizing the Mobile Web Services are:

- **Web services technologies as middleware in the device environment:** Enabling basic web service technologies, Security and trusted interactions from the device environment. We will look into how Liberty Alliance Project and Open Mobile Alliance, OMA address this area
- **Web Services specification:** Specification of the core mobile web services network operator and infrastructure providers can host to enable Internet based web services providers can utilize. In this domain mainly OMA and Parlay-X Web Services are addressing the different service interfaces
- **Binding the middleware to human consumable services:** Addressing how the Web Services protocols can be utilized into application and in turn generate the necessary user interface. W3C's Mobile Web Initiative is addressing how the Web can be adapted to support the Mobile devices infrastructure.

## *6.1 OMA*

Open Mobile alliance (OMA)[38] is a Leading industry forum for developing market driven, interoperable mobile service enablers. OMA was Formed in 2002 by nearly 200 (currently over 360) companies including the world's leading mobile operators, device and network suppliers, information technology companies and content and service providers. It creates interoperable mobile data service enablers that work across devices, service providers, operators, networks, and geographies. OMA is a result of Consolidation of several Mobile Standardization Bodies, such as : WAP Forum, Location Interoperability Forum (LIF), SyncML Initiative, MMS-IOP (Multimedia Messaging Interoperability Process), Wireless Village, Mobile Gaming Interoperability Forum (MGIF), and the Mobile Wireless Internet Forum (MWIF)

The main goal of OMA is to facilitate global user adoption of mobile data services by specifying market driven mobile service enablers that ensure service interoperability across devices, geographies, service providers, operators, and networks, while allowing businesses to compete through innovation and differentiation.

### 6.1.1 Web Services working group

OMA has had a Web Services Working group which provided guidelines on how the Mobile service interfaces should be specified using Web Services technologies. The working group main purpose was to:

- Drive application of Open standards for inter-operable Mobile Services
- Specify and define the application of web services within the OMA architecture.
- Generate a recommendation with a set of best practices guidelines that describe how to apply web services to the different OMA service Enablers in the OMA Architecture.

OMA Web Services Working group ensures reuse of existing key technologies developed in various bodies and standardization activities. It provides relevant guidelines on how to utilize the most relevant web technologies to expose mobile industry's service enablers to the web based platform. The lists of service enabler that fit within the scope of the OMA activities are:

- Billing,
- Browsing,
- Client provisioning,
- Data Synchronization,
- Device Management,
- Digital Rights Management,
- DNS,
- Download,
- Email notification,

- Games,
- IMS,
- Presence,
- Mobile Location,
- MMS,
- Push to Talk Over Cellular,
- User Agent Profile,

### 6.1.2 OMA Web Services Enabler

OMA's Services Enablers which expose their interfaces as Web service interfaces utilize WS Standards such as SOAP, HTTP, Optionally: UDDI. The specified guidelines and interfaces are compliant to the WS-I Basic Profile 1.0.

The Web Services Enabler release 1.0[36] was made in July 2004. It consisted of

- **Overview:** Overview of OMA WS Enabler[42]
- **Core Specification:** Basic Web Service infrastructure that is needed to offer and consume Web Services in an OMA environment [41]
- **Network Identity specification:** Network Identity related capabilities of the OWSER[35]
- **Best Practices WSDL Style Guide:** Guidelines to design and develop WSDL interfaces for the mobile Web Services. It documents the use cases and Web Services design Patterns to specify Web Services for the Mobile domain.

### 6.1.3 Role of OMA Web Services Enabler Specification (OWSER)

OWSER [36] provides specifications and guidelines for Web Service technologies, implementations and deployments to integrate and interoperate within the OMA architecture. The specifications ensure interoperability across servers and terminals supporting web services protocols through the use of standardized protocols. OWSER provides a Common Functionality across the different Enablers available at the Network/service operator Infrastructure, such as:

- **Service Discovery**
- **Messaging.**
- **Security**
- **Identity**
- **Charging**
- **Management & Provisioning**
- **Service Level Agreement & Management**

The specification has left out many of the rich features out until there are more mature and standardized technologies available in the industry. The features

such as: Messaging, Security, Policy, Management, Service Level agreement, Coordination are left out.

The OWSER takes into account support for Web Services in two levels:

- **Direct:** When the Web Service requestor is fully capable for a complete Web Services stack
- **Indirect:** When a WS Proxy is needed when the Web Services requestor can not contain

The OMA WS Enabler specification provides Guidelines and notational representation of Practical Web Services Deployment patterns. The different Deployment Patterns categorized into: Web Services Requestor, Web Service & Web Services Registry. The specifications have also developed use cases and scenarios which require different patterns of web services deployment such as: Routing, Gateway, Proxy, Interceptor, Adaptor, Delegate, Filter, Orchestration, Referral, Sequence, and Workflows.

## *6.2 Liberty Alliance Project*

This is a joint Industry Alliance project involving close to 150 international companies, non-profit and governmental organization, operating since 2001. Liberty's main mission was to define open standards for federated network identity that supports all current and emerging network devices. The alliance was set out to mainly provide businesses, governments, employees, and consumers a more convenient and secure way to control identity information. Liberty alliance specifies a Web Services Framework called the Liberty Identity Web Services Framework. This framework is based on SOAP1.1, WSDL1.1, SAML and WS-Security open standards specified by W3C and OASIS

The Liberty WSF supports the following key functionalities:

- *Authentication*
- *Message protection*
- *Service discovery & Addressing*
- *Policy*
- *Common data access Protocols*
- *Transport Protocols*

There have been a few Liberty web Services framework (Liberty ID-WSF) based public demonstrations made in the recent year.
**Nokia-AOL demonstrated Radio@AOL service**Error! Reference source not found.**:** Access to a Personalize internet radio service. This service demonstrated the usage of Liberty Authentication, Service Discovery and permission-based attribute sharing.

**Gaming:** Vodafone, Trustgenix and Game federation together demonstrated a multi-player mobile gaming proof of concept[31]. Liberty Framework was utilized in this service for Authentication and personalization of services.

### 6.2.1 Liberty Web Services Framework

Liberty Alliance project specified the three specifications to enable Web Service architectures based federated network identity.
**Federation Framework (ID-FF):** Provides core protocols, schemata and profiles. This allows implementers to create standardized, multi-vendor identity federation network.
**Web Services Framework (ID-WSF):** Provides a set of protocols, schemata and profiles to provide a basic framework of identity services, such as: Identity Service discovery and invocation.
**Service Interface Specification (ID-SIS):** Utilize the ID-FF and ID-WSF to provide network Identity services, such as contacts, presence detection or wallet services that depend on networked identity.

## *6.3 Parlay*

Parlay is an industry consortium consisting of Leading IT companies, Internet service vendors (ISVs), software developers, network device vendors and providers, service bureaus, application service providers (ASPs), application suppliers, and large and small enterprises. The main purpose and goal of this consortium is to link IT applications with the capabilities of telecommunications world by specifying and promoting application programming interfaces (APIs) that are secure, easy to use, rich in functionality, and based on open standards. Parlay specifies these as part of Open Services Access (OSA) activities which aims to provide open standard API's to access functionalities of Network Operators

The main mission of Parlay consortium is to support service and solution providers to utilize Mobile operator infrastructures and enable new services for mobile industry by leveraging Information Technology in mobile domain. The goal of the consortium is to:

- Ease application creation for both Consumer and Enterprise sectors and enable exploitation of the Operator Network capabilities and features.
- Enable IT Developer to exploit Telecom Operator Infrastructure
- Enable new Business models and relationship between Network operators and service providers.

As a mission to utilize IT and internet services and technologies Parlay specifies several Web Services interfaces for Mobile Network operator services, namely Parlay X Web Services. These services are jointly specified by the industry

consortium for the benefit of the mobile and internet and IT based technology vendors. We will discuss them in the next section in more detail.

### 6.3.1 Parlay X Web Services

Parlay X Services are Mobile Web Services based Synchronous access to Network operator's services for use by Service providers, specified as part of OSA activities. The services for example are: SMS, Multimedia Messaging, Payment, Account Management, User Status, and User Location.

The main purpose to utilize Web Service technologies are to:

- Provide higher Inter-operability across Multi-vendor Service Components; Expand Telecom ecosystem into IT developer Space
- Decouple the protocols in IT & Telecom
- Manage and Expand the Mobile Environment with the success of the IT Solutions over the Internet/Web World.

The Parlay has currently specified a set of 16 Mobile Web Services Interfaces; as listed here:

- Common: Namespace conventions, data types,
- Third Party Call
- Call Notification
- SMS
- MMS
- Payment
- Account Management
- Terminal Status
- Terminal Location
- Call Handling
- Audio call
- Multimedia Conference
- Address List Management
- Presence

The service specifications are aligned with both the 3Gpp and OMA standardization bodies and made according to the industry guidelines and best practices.

## *6.4 W3C Mobile Web Initiative*

Mobile Web Initiative (MWI) is a W3C charter with a mission of making "Web on the Move" happen, it aims to make mobile Web access as simple as Web access

from a desktop device. MWI aims to still maintain a One Web[1]. The two main areas addressed by the initiative are: interoperability and usability issues when considering challenges in the Mobile Web. The initiative recognizes the fact that there are more people who have access to mobile devices than access to a desktop computer. The access to internet and web will be significantly higher in developing countries and mainly the only means of accessing the web when compared to the Developed region, which is dominated by PC based access to the Web.

The main guidelines provided are for targeted towards: Authoring tool vendors, Content providers, Handset manufacturers, Browser vendors and Mobile operators. The "mobileOK" is the mark of trust ensuring an acceptable level of experience of the web from the mobile devices. The MWI aims to deliver guidelines in the form of Mobile web best practices guidelines and requirements to provide a Device description repository, which will enable content providers a means to adapt the web to the device characteristics. The charter also will provide a test suite to ensure the web content and site passes through the suggested basic mobile web best practices. The main deliverables are developed by 3 Working groups, namely:

- Mobile Web Best Practices Working Group
- MWI Device Description Working Group
- MWI Test Suite Working Group

The Main focus of this initiative today is focused towards providing a unified user experience from the service to the end user who directly views the web content, in this case web pages over a standard Web browser. The Web browsers are today the primary citizens of the Web based world. Browsers today are becoming the primary runtime platform for internet and web facing technology innovations. A clear development is the AJAX [5] based services being developed in the Web2.0 [60] evolution of the web. Browser based technologies are emerging as a ubiquitous platforms to run and host even mobile web services in the future. The intent of the Mobile Web Initiative is to ensure that the Web supports the mobile device environments equally or even higher to enable mobile devices to experience the web based technologies in almost the same experience level as experience via the PC world. Hence this initiative will be crucial also to ensure future mobile web services.

Let us look into the details of the various working groups within the MWI.

[1] One Web means making, as far as is reasonable, the same information and services available to users irrespective of the device they are using. However, it does not mean that exactly the same information is available in exactly the same representation across all devices[55].

### 6.4.1 Mobile Web Best Practices Working Group

The Mobile Web Best Practices Working Group (MWBP WG) aims to develop a set of technical best practices and associated materials in support of development of web sites that provide an appropriate user experience on mobile devices. This Working group plans to provide authoring guidelines, checklists and best practices to help content providers to develop Web content that works well on mobile devices, such as: PDAs, smart phones and touch-screen devices

*Mobile Web Best Practices 1.0* : The Mobile best practices help the creation of Web Sites that provide an appropriate user experience on mobile devices. The working group has listed 60 best practices at the time of this report. These guidelines are intended as the basis for ensuring the conformance to the "mobileOK" trust mark. By compliance to these best practices the content provider and creators can enable one Web experience to the end users.

The MWI Initiative is taking into account the key challenges and advantages when providing best practices when one needs to design Web sites, which should be suitable for mobile users. According to the Best practices[25] here are the few challenging aspects to keep in mind when design web for mobile users:

- Provide a view of the complete structure of the pages enabling user to create a mental image of the site. This can be assisted by designing pages and the site in a consistent style
- Keep the URI fairly small as Mobile devices often have only a very limited keypad, with small keys, and frequently has no pointing device. One of the difficulties of the mobile Web is that URIs is very difficult to type.
- Irrelevant data can contribute towards poor usability and contribute towards undesirable costs, due to bandwidth utilized in Mobile infrastructure
- Mobile users are typically less interested in lengthy documents or in browsing using mobile device. The device is not suitable for reading lengthy documents over a long period of time; instead the user will be willing to read through short burst of information.
- Popup and complex page designs make it very hard for mobile rendering and make the usage of such information computationally expensive

It is equally relevant to understand the advantages that can be leveraged with user being mobile in addition to having equally or deeper understanding of the needs of a mobile user. It is critical to design the web to cater to mobile. Here are a few key differentiating advantages which could be leveraged by the web designers:

- Mobile devices are very personal and hence one can expect to leverage the role of the device when targeting web content to the user.
- User would like to see the web content personalizable

- The access to the web content from the mobile is typically when the user is traveling.
- User of the mobile devices can be connected or initiate connection to the source as and when seen necessary
- The device when accessing the web content can provide its current location. The content/information can provide information which is location aware.
- Mobile devices are typically used with one-handed operation when accessing web content/information, so the UI should consider such situation. Mobile gaming kind of entertainment applications are some examples when UI is very adaptive in single handed users.
- Mobile users and devices could be always online
- Provide a platform for universally alerting user's Mobile device.

This working group has resulted into providing 60 mobile web best practices [55] , which guides through the web content provider specifically on how to design, create and deliver web content taking into account the basic and complete set of the best practices to address minimalist and a complete advanced mobile device capabilities. The MWI takes into account the above discussed salient properties of the mobile devices and characteristics into account when suggesting the best practices for the Mobile Web.

These set of best practices provide valuable insights to Mobile web services client solutions as well as they can provide the bridge between the services and the UI limitations posed by the Mobile device environment by adapting the content locally to suite best the device capabilities. The Mobile Web services can also utilize the contextual data to be submitted and exchanged with the help of web services protocols, which normally are not very easy to exchange programmatically with a purely web centric user interfaces enabled by the browsers.

### 6.4.2 MWI Device Description Working Group (MWIDD WG)

It is fore-seen that the mobile web content will need to be adapted to suite a mobile devices form factor. This adaptation either needs to be carried out at the server or source of the content repository or at the destination of the content consumption based on the device capabilities, information the service receives along with the request for content. In order to carry out any sort of adaptation strategy or methodology to personalize or transform information suitable to a particular device, it is very important to understand the basic characteristics of the device. This information can be provided either at the design time for the content creator can pre-define and create content targeted to a particular device class / features or during access or delivery of the content time. The Web site servers or the delivery server can adapt the content to the device specific needs. The same can also be done at the end device software so that it can adapt the content suitable to it features.

In order to create such adaptation or transformation the Working group is working on 3 aspects, namely: Describe the device characteristics, provide a Repository to contain this description and provide an interface to access the information. The working group also addresses the complete eco-system which exists around this.

This working group with the MWI aims to:

- Identify essential device descriptions for enabling effective content presentation across mobile devices
- Describe the essential features of a device description vocabulary
- Describe the current and future ecosystem of device descriptions

This W3C Working group aims to produce the following three main results:

a. *Device Description Landscape :* This activity articulates and documents about what W3C and other organizations have developed about device information, which potentially could lead to an architecture how different technologies can operate together to make an elegant content adaptation capability. The working group is looking into how technologies such as CC/PP[10], UAPROF[53], CSS[12] Media Queries have been realized and learning's from the implementation is planned to be understood to derive the learning's from real deployments. The work will describe the current state of the various technology options that exist for providing Device Descriptions, enabling device-aware applications. The various motivations to record and provide device descriptions are to represent the various features and attributes of device features into a standard representation and provide with corresponding functional interfaces such as: Data structures, data integrity, capture, query & Access
b. *Device Description Ecosystem*: This work emphasizes the eco-system surrounding the creation, maintenance and use of device description, with elaboration on whom and why one would need such device information. What is the model in which such information is stored and provided as a service. The key use cases for such a repository usage and the stakeholders/players for devices description repository. Note that this group recognizes that there are many other use cases for Device Descriptions, and other areas within the mobile industry where they can be applied
c. *Device Description Repository Requirements 1.0*: In these efforts the device description is available to access and interact about device repository. The works in this areas aims to describe a set of requirements for a reference repository of device descriptions

The device description when available from the device and a centralized repositories will play a major roles with the network hosted Mobile web services as it will enable the service providers to analyze this device description and profiles and adapt the service accordingly to the device they need to provide

services. This will enable adaptive and intelligent mobile web services to both the end user and the mobile service providers.

# 7 Conclusions

The Web service technologies are technologies that are emerging in the mobile domain while the web platform has started to see large application of the web services. The Mobile device environments are computationally challenging to directly utilize Web technologies as they are more suitable to the PC centric world and hence there needs to be considerable effort to optimize the protocols to make them suitable for the Mobile computing environment. We discussed the role of the mobility and the various aspects and limitations in the mobility from both the platform and the end user point of view. The choice of services and the technologies utilized in the mobile domain has to be well designed and selectively taken into use after weighing in the benefits and relevance to Mobility. It is essential and crucial for the mobile user to understand the value of the services and has to be extremely simple to use. All that matters to the end user is the user interfaces and the experience the Web Services can provide and not exactly which protocols and technologies have been utilized. This means the value of a new middleware (such as: mobile web services) in mobile computing environment should clearly contribute to what an end user can perceive from user interface layer of the technologies and the enhanced interaction experience that it can contribute towards.

Mobile Web Services is available today and addresses mainly the middleware layer of the application stack. There are two areas which needs more development to realize the full potential of Web Services in the Mobile domain, these are: User interface and Mobile communication protocol support. Let's elaborate these two a bit more here:

**User Interface Layer Interfacing:** There is a missing a link between the middleware protocols and the application level user interface technologies. W3C's role in linking the Web services to User interface layer is seen to be very crucial in this phase of the mobile web services. There are a few developments addressing user interface technologies[62] such as xForms[67], Web Forms2.0[58] and Web 2.0[60] which will certainly mature to address this gaps in the Web Services technologies. xForms**Error! Reference source not found.** has already started to develop towards this by providing a SOAP binding to the latest xForms core standards specifications which is currently though only a Working draft.

**Mobile domain specific discovery, addressing and transportation:** The other major gap in the mobile web services is in making the web services accessible in a mobile infrastructure and with the domain specific communication or transportation modules. This is essential and specifically important so that Mobile devices can also play a role of service

providers. Mobile Web Servers[26], SIP**Error! Reference source not found.** and UPnP[54] are enabling technologies which currently provide technologies which solve the addressing, discovery and local interactions over proximity networks in addition to internet. They do not currently solve this gap but are technologies which can enable new sort of end user provided services. This will particularly be very relevant to small and medium sized business to run and host business services to their customers and business partners as many of the customer, i.e. the end users carry and hold mobile devices which they can use to interact with the service provided towards them.

In this report we discussed mainly the potential of Mobile Web services, the current state of the technologies and all the relevant standardization activities in the industry. The network hosted mobile services are here already in real deployments where as the mobile device hosted web services are yet to emerge and mature. The Mobile web services are yet to be deployed into business critical real solutions and services and this will be a while before they can be realized in large scale. This is due to missing technologies which can take an end to end perspective from middleware to application user interfaces later. There needs to be a standardized middleware which can help inter-operate across heterogeneous mobile computing platforms.

In conclusions the Mobile Web Services promises interesting applications that can be developed if a standardized means to interact with service platforms is put in place. The network hosted mobile web services are already available from mobile operators while the next generation mobile centric web services are maturing. The interesting possibilities are that the service provider can turn to be from Mobile user's own devices. The mobile centric web services is technical feasible to be enabled today, but since the usage and success is related to user perception on the usability and user interaction modes it enables the real deployment will happen after these aspects are addressed in a open and standardized manner.

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# 9 Appendix

## 9.1 List of Figures



## 9.2 Abbreviations

.NET – an Application runtime platform provided by Microsoft
cHTML- Compact HTML
CORBA – Common Object Request Broker Architecture
DCOM – Distributed Component Object model
DOM – Document Object Model
eSOAP - A lightweight implementation of SOAP specifically designed for embedded systems
gSOAP - A Tool built to support Web services development in C and C++ application environments
ID-FF – Liberty Project's Identity Federation Frameowork
ID-WSF – Liberty Alliance project's Web Services Framework
IM – Instant Message
IMS – IP Multimedia Subsystems
ISP – Internet Service Provider
IT – Information Technology
J2EE – Java 2 Enterprise Edition
JSR-172 – J2ME specification for Mobile java Web Services
kSOAP – A light weight implementation of Suitable for mobile computing device environment
MMS – Multi-Media Messages
MSP – Mobile infrastructure and service provider
MWS – Mobile Web Services
N-Tier Architecture – A Multilayered distributed platform architectures
PC – Personal Computer
PDA – Personal Digital Assistance
SAML - Security Assertion Markup Language
SAX2.0 – Simple API for XML
SMIL - Synchronized Multimedia Integration Language
SMS – Short Message Service
SOAP – Just SOAP, prior to this known as Simple Object Access Protocol
UDDI - Universal Discovery, Description and Integration
UPnP – Universal Plug and Play

UTF-8 & UTF-16 – data Encoding standards
WIFI – A brand which the wireless network with IEEE802.11 based wireless area networks
WLAN – Wireless Local Area Network
WML – Wireless Markup Language
WS – Web Services
WSC – Web Services client
WSDL – Web Services Description Language
WSI – Web Services Interface
WS-I – Web Services Inter-operability organization
WSP – Web Services Provider
WS-Security – Web Services security
xHTML – XML complaint HTML
XML – eXtensible Mark-up Language
XML Schema – XML Schema specification
XSLT – XML Stylesheet transformation