

Survey Of Location Based Wireless Services

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1. ABSTRACT

The penetration of mobile wireless technologies has resulted in larger usage of wireless data services in the recent past. Several wireless applications are deployed by service providers, to attract and retain their clients, using wireless Internet technologies. New and innovative applications like ring-tone/wallpaper downloading, MMS-messaging, Video-clip delivery and reservation enquiries are some of the popular services offered by the service providers today. The knowledge of mobile user's location by the service provider can enhance the class of services and applications that can be offered to the mobile user. These class of applications and services, termed as "Location based Services", are becoming popular across all mobile networks like GSM and CDMA.

Locations based services, projected as a future technology by wireless operators, are positioned with a focused objective "To assist with the exact information, at right place in real time with personalized setup and location sensitiveness". These services integrate geographical location and end-user context dynamically to deliver information interactively with geographical and logical views. The market projections indicate a user base of over 400 million^[2] and revenues of over 10 billion USD^[10], by 2005 using location-based services. Many of these services depend on the backend network infrastructure to provide the user's location to the required precision and thus require deployment of additional infrastructure by the wireless operator. Several standards are emerging to define protocols for interaction between the various subsystems providing the end-user services. Some of the bodies formulating standards include^[13] Open Mobile Alliance (OMA), IETF, Open GIS consortium, International Earth Rotation Service (IERS), GSDI (Global Spatial Data Infrastructure), G-XML, ISO/TC 211, EOSDIS, Open Location Services Initiative, GeoVRML^[15] [An official Working Group of the Web3D Consortium with the goal of developing tools and recommended practice for the representation of geographical data using the Virtual Reality Modeling Language (VRML)], 3GPP and ANSI. These standards address the concerns regarding the security and privacy requirements of mobile users and provide a basis for deployment of location-based services across all wireless networks, based on open standards.

This paper presents a brief survey of Location based services, the technologies deployed to track the mobile user's location, the accuracy and reliability associated with such measurements, the network infrastructure elements deployed by the wireless network operators to enable these kinds of services. A brief description of all the protocols and interfaces covering the interaction between device, gateway and application layers, are presented. The aspects related to billing of value added services using the location information and emerging architectures for incorporating this "location based charging" model are introduced. The paper also presents some

popular location based services deployed on wireless networks across the world.

2. LOCATION BASED WIRELESS SERVICES AND THEIR USAGE TRENDS

2.1 Location based wireless services

For all the location-based wireless services, "location" is an essential parameter. In any wireless network, service provider's infrastructure determines the location of the user. A typical location based service hosted by service provider, analyzes the user's request, prepares a reply according to the user's location and sends the response

Consider the two following simple examples:

2.1.1 User, who is looking for a nearest Pizza point, sends a SMS "Nearest Pizza" to a predefined number. Subsequently, gets a SMS as reply "Domino's Pizza, 124, Andheri Kurla Road, Chakala, Andheri (East), Mumbai-400093. Phone: 820 3940; Hungry Helpline: 1600-111-123".

Steps executed in serving the above request are as follows:

- The position of the mobile user is determined by the network infrastructure of the service provider.
- The position is mapped later to the nearest landmark as "Andheri".
- Identified the request to locate a nearest Pizza point.
- Service located a Pizza point in Andheri nearest to the user and replies the address details of the same.

2.1.2 Owner of a fleet of trucks embedded with mobile terminals wants to monitor them and view their locations on his desktop at periodic intervals. Based on the location of the fleet he assigns them additional jobs.

Steps executed for monitoring are as follows

- Service provider's network infrastructure tracks the position of the mobile terminals embedded in trucks at predefined intervals.
- These positions are mapped onto the geographical maps.
- The positions of the trucks at different time intervals are displayed on the map by the application.

Technology and infrastructure for determining the position and transformation of the position to a geographical landmark will be discussed in section 3.

2.1 Usage Trends

Location based services can be broadly classified as Emergency Services, Informational Services, Tracking Services and Entertainment Services. Emergency Services include Security Alerts, Public safety. Typically Informational Services include News, Sports, Weather, Stocks, Mobile yellow pages, Routing assistance. Tracking Services include Asset/Fleet/Logistic monitoring, Person tracking. Finally entertainment services include Locate a friend, Dating, Games etc.

A survey analysis among focus groups, conducted in ^[14], lists the following key findings:

- Users expressed a higher level of interest in "Routing Assistance" than any other wireless Internet service.
- Most users would prefer a portable device to a vehicle-mounted device for accessing wireless Internet services.
- Users expressed a high level of interest in location-based "Roadside Assistance service". Many would prefer talking to a live roadside assistance operator rather than depending on an automated system.

GSM based location services are getting deployed very fast in European countries.

For example, Today all four major operators in Germany offer location-based services:

- **T-Mobile** - Location-based services are available via the WAP portal T-Motion. They cover search facilities for taxis, hotels and cash dispensers as well as local weather services.
- **D2 Vodafone** - D2 offers search facilities for the nearest gas station and D2 shop in addition to the traffic information, the shopping information and the hotel guide. D2 is also enhancing its services in cash dispensers, pharmacies, restaurants, cinemas, entertainment, business services in the field of sales and logistics allowing locating field agents and vehicles, locating friends and children.
- **E-Plus** - Location-based services are still in the testing phase. They offer yellow pages, restaurants, hotels, E-Plus shops and a route planner.
- **O2** - O2 offers two ways of accessing location-based services: via the WAP portal M-Kompass and also via SMS. This is an advantage over other operators, as they only offer WAP access. WAP portal M-Kompass offers a route planner, yellow pages and information about cash dispensers, hotels, restaurants and traffic.

3. Technologies used for location determination

3.1 Accuracy and Reliability

Usage of location services depends on the accuracy of the position of a mobile terminal. More accurate the position determination is, more relevant will be the information provided. In a typical GSM network, inside the city, the position accuracy, as determined by the cell, varies from 100 to 500 meters. At the same time, countryside accuracy varies up to 10 Kilometers, since the cell size is bigger in size.

Accuracy of the position depends on the technology and infrastructure used and also the time provided to determine. For example: accurate position of the user is insignificant for emergency services where as "nearest restaurant" needs more accurate location of the user.

Various position determination methods used are Satellite based positioning, Network based positioning and local positioning methods. Satellite based positioning methods includes A-GPS (Assisted Global Positioning System), GPS (Global Positioning System). Network based positioning methods includes EOTD (Estimated Observed Time Difference), OTDOA (Observed Time Difference On Arrival), AOA (Angle on Arrival), CI (Cell Identity) and TA (Timing Advance). Local positioning methods include W-LAN (Wireless LAN), Wi Fi, Blue tooth etc.

Each of the method has their advantages and de-merits.

For example:

Satellite based positioning provide the best of the accuracy (up-to an average of 5 meters), but at the same time, does not work well in case of indoor positioning. Even GPS technology implementation needs additional infrastructure from the operator side and from the user side to have a GPS enabled handset.

Network positioning methods do not need any additional infrastructure or special handsets, but accuracy is varied and depends on the coverage area. Smaller cell size provides better accuracy in network-based methods.

A-GPS technology is a hybrid technology that uses both satellites and network infrastructure of the operator to provide a reliable accuracy of 5-30m. Many LBS solution providers predict A-GPS as the future LBS technology. Such a solution is already deployed in Japan and user experiences are really encouraging.

Local positioning methods, includes technologies such as indoor sensors, wireless local area network set-up to measure the movement of the mobile terminal closely. These technologies provide greater accuracy, but are limited in terms of geographical coverage.

Many technical papers ^{[5][3][8][4]} are published on various location determination methods and their deployment architecture along with their advantages and constraints.

The bottom line is, technologies can be implemented together to have their advantages to cater to the future requirements of LBS and to ensure high quality service to the customers.

3.2 Infrastructure requirements from operator's perspective

The key elements of location-based services are

- Service Channels
- Service Context Layers
- Service Interfaces

3.2.1 Service Channels

Location based services can either be pull-based or push-based services. For example: user initiated request for "nearest tourist place" is a pull based request where as, a message "Traffic jam at M.G. Road", popping up on the user's handset is a push based service.

Most of the location-based services available today are pull-based since it provides an effective and easy way of implementation. Further it gives service to the user whenever he/she needs it.

3.2.2 Service Context Layers

Location-based applications use the following three context layers

- Location Detection
- Location Transformation
- Location Tracking/Monitoring

For all location-based services, location detection layer is the foremost concern. To determine the location, operator needs hardware and network set-up, which provides the basic parameters of location such as latitude, longitude of a mobile terminal. Some services convert the location to a geographical landmark. This process is referred to as 'Location

Transformation'. To support this conversion, map servers or GIS is used. Typical map servers take location information as input and provide landmark as output. Location transformation is discussed in the section 'Protocols and Standards'.

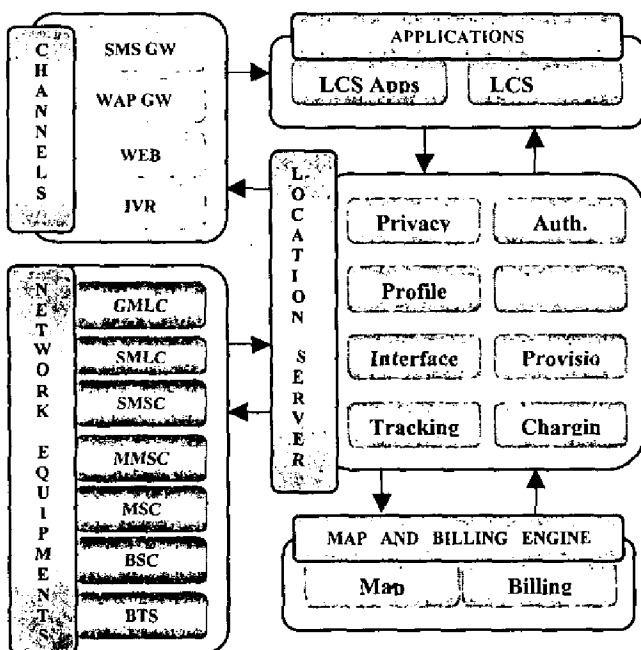
Location tracking/monitoring is a service layer, where the mobile user is constantly tracked and location updates are provided at periodic intervals. Such services are very useful for fleet, asset management and tracking friends and family.

As discussed above, all the above three layers are used in push-based services and only the first two of them are used by pull-based services. Each of the location based service falls into either of this pull or push based service category.

3.2.3 Service Interface

In both pull/push-based services, user needs an interactive environment where, he/she can filter the information layers to get exact information as required. Carriers offer these services through SMS, IVR, MMS, WEB or WAP. WAP provides interactive environment, but it is expensive because the user pays for the time he/she remains connected. SMS is a better option even though it is non-interactive because it is cheaper, faster and easy to provide. From operator's perspective, it optimally utilizes the SMS network traffic (of core 2G infrastructures).

4. Architecture



(Figure 1: Schematic Diagram of Location Service Platform)

4.3 Deployment Layers

Location based services as discussed above need various supportive interfaces to be deployed. All the required interfaces are deployed in the following layers

1. Device/User Layer
2. Middle layer (Location Access and Control)
3. Network Layer
4. Application layer

Each of these layers is briefly described below along with its significance in the deployment of location-based services

4.1.1 Device/User Layer - Typical user layer requirements are

User interfaces – The user interfaces for the location-based services are through SMS, WAP, WEB, IVR, and MMS. Location based services are accessed through pro-active mode such as SMS, IVR, WEB or through an interactive services like using WAP. User interfaces and handset requirements are related more towards the device requirements in this layer.

Handset requirements – WAP, MMS enabled handsets avail the best services of location-based applications.

4.1.2 Middle Layer – The middle tier supports the following services.

Privacy Management and Access Control – Privacy Management ensures protection of subscriber's profile and location data. Privacy management allows the user to specify the desire whether/how to control the location information from other group of subscribers/location clients. Some of the policies are

- Do not allow at all.
- Allow with notification and acceptance.
- Always allow to every body
- Restricted allowed or never allow exception list

Privacy set up is provided through SIM tool kit option, WAP or SMS. User specifies his/her exception list, which includes range of subscribers who are allowed or not allowed to get the location information of the user.

Personal Profile and Vicinity setup – Subscriber has the privilege to create a profile and enable/disable services he/she wants to subscribe/un-subscribe from time to time. Subscriber profile helps the location applications to tailor the services as per the user's requirement. Profile information will include the enabling/disabling services, usage control and profiling functionality.

Provisioning – Provisioning allows user to mark certain cells as user's 'Home zone' and rest of the cells within the network as 'Roam zone'. When user leaves/enters his/her home zone, the location detecting elements send triggers to middle layer services to notify the updated position of the user. This allows a subscriber to be charged different rates depending on the his/her location

Network Layer interface – As discussed in the protocol section, network layer has many interfaces, which provides information about the position of a user and his/her movement across the cells in the network.

LCS Client Authentication – Any application or service channel, such as SMS Gateway or WAP gateway, is authenticated before accessing any location service.

Interface to external engines/services/applications – Apart from the service channel interface middle layer is also responsible to manage all the external interfaces such as charging gateway or IN or any other service delivery platform. Applications are abstracted to access the external components through middle layer.

4.1.3 Network Layer - The network layer will include all the location detection network equipment supporting location-based services apart from other 2G infrastructure equipments such as MSC, BSC, and BTS etc. Some of the examples of such location detecting elements are GMLC (Gateway Mobile Location Center), SMLC (Service Mobile Location Center) etc.. These network elements are capable of providing location information for a given mobile number within the network, with requested accuracy as desired by application. Triggers to middle layer are automatic from GMLC/SMLC to middle layer services to track the movement of the user.

4.1.4 Application Layer - The application layer is the layer where all the location-based services get deployed. Service elements, such as SMS gateway or WAP gateway, interfacing to middle layer redirect the request to location-based applications directly. Upon receiving the request, application executes following services before rendering the actual service

- LCS client source validation from middle layer Location Server
- Privacy and security requirements of the user, for the current request
- Subscription for the service (Enable/Disable)
- Location of the user as requested
- Application authentication at Location Server
- Validation of Charging requirements (if any)
- Serve the actual request from the User.

5. Protocols and Standards

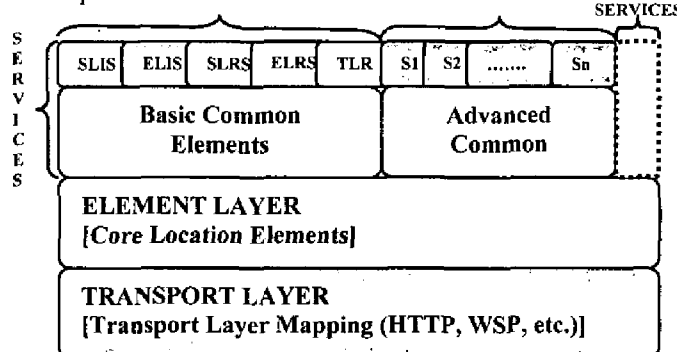
Location based services; with the concept to serve "anyone anywhere" need more adaptation and standardization to prove their versatile appliance. Standardization and implementation of consistent infrastructure help the location-based technology to support "standard location service interface". Such standardization overcomes the geographical barrier, application dependencies, user classes, product classes, presentation requirements and user interfaces, in all the layers as discussed in deployment layers.

Location based services are not limited to the subscribers of home network. They are more helpful to subscribers from foreign networks. Therefore standardization of user interface and device layer to access these services is important. This is achieved by standardization of services for e.g. using voice / SMS service which minimizes the users access time and effort to get the service whenever requested.

Many institutions, organizations and forums are working on standardization and common protocols for location-based services. Few of them are

OMA (The Open Mobile Alliance), formed in 2002 by nearly 200 companies world's leading mobile operators, devices and network suppliers and with supporters of Open Mobile Architecture and WAP forum. OMA is working to define open standard based framework to permit services to be built, deployed and managed efficiently, reliably in a multi-vendor wireless platform. OMA is the driving force, responsible for creating service level interoperability, implementation of open services and interface standards to ensure fast adoption of mobile services. OMA has defined MLP (Mobile Location Protocol) for determining position of mobile terminals.

MLP (Mobile Location Protocol)^[12] specification is an application level protocol for determining the position of the mobile terminals, independent of underlying technology. MLP acts as an interface between Location Server and Location Service Client (LCS). MLP defines the core set of operations that are required by a Location Server. The purpose of MLP specification is to define a simple and secure access method that allows wireless Internet applications to query location information in a wireless network, irrespective of the underlying air interface technology and positioning methods. Services defined and supported by MLP include Standard Location Immediate Service, Emergency Location Immediate Service, Standard Location Reporting Service, Emergency Location Reporting Service, ADVANCED MLP SERVICES, Repc BASIC MLP SERVICES, OTHER MLP SERVICES



(Figure 2: MLP Structure)

IETF (Internet Engineering Task Force) drafted a new protocol, **SLoP** (Spatial Location Protocol). The purpose of this protocol is to have a standard way for an application to acquire spatial location of an identifiable resource over or represented on the Internet, in a reliable, secure and scalable manner. SLoP responses address the following data items (provided that the specified scheme and format has such capability).

- Used location type (e.g. absolute/descriptive location)
- Framework (e.g. WGS84, UTM, etc)
- Syntax/Format (e.g. longitude, latitude, altitude in degrees)
- Geocentric Position, Accuracy
- Time Stamp (Date, Time, Time Zone), Time to live
- Others (e.g. Direction, Velocity, Orientation etc.)

OGC (Open GIS Consortium), an international industry consortium of more than 220 companies government agencies and universities participating in a consensus process to define publicly available geoprocessing specifications. The main objective of OGC is to provide open interface and protocol specifications, that support inter-operable solutions that "geo-enable" the Web, wireless and location-based services. OGC is also devoted to develop inter-operability standards using "spatial" or "location" information on the Internet. OGC protocols also supports GML 2.0 (Geographical Markup Language) for storing and transporting the geographical information for the applications. OGC is working on all the layers discussed in the section 'Deployment layer section', but Mapping and Presentation layer has been addressed below, which is related to 'Location Transformation'. Some of the requests that OGC protocol supports (functioning in

correlation to Map Server requirements) are *GetMap*, *GetFeatureInfo*, *GetCapabilities*.

The service, which caters to the above requests are called Web Map Service (WMS). WMS keeps the ability to display 'Map' upon request, which is a visual representation of geographical data. Further a map is not the data itself. Request is for the visual representation with respect to some context or interest. This is called "Points of Interest" or "Layers".

For example, a client requests to see all the hospitals existing in a geographical region. In this case "hospitals" is the point of interest or 'layer'. Map for the geographical region along with the hospital landmarks on the required location is the response.

GetMap service gets the map image whose geospatial and dimensional parameters are well defined. Dimensional parameters refer to latitude and longitude information. Map image representation supported can be vector maps, scalar maps with multiple formats of image.

GetFeatureInfo service gets information about particular feature shown on a map. In addition client can specify which feature properties to fetch and can constrain the query spatially and non-spatially.

GetCapabilities service gets service level meta-data, which is a description of the information content. It indicates the feature types and operations supported on each feature type. For example, basic map features include Zoom in, Zoom out, Panning, geo-coding, reverse geo-coding etc.

MapServer is an open source product, which follows and supports OGC Map server architecture and requirements.

6. Location based charging models

Location based services are treated as value added services (VAS). The charging model

- Allows the service provider to specify the location definition, service dependent parameters, populating this information in the charging requests, for example current zone information, while accessing any information service.
- Allows the service provider to define, the relationship between services and the parameters required for charging. These definitions are dynamically configurable without interrupting the service.
- Provides the charging scheme in case of change of zone for a user.
- Validates status (active/inactive) of the user before charging to ensure the correctness of charging.

7. Conclusions

This paper briefly surveyed all the location technologies and capability arrays of location based services. It discussed the challenges and facts restricting the location-based services being deployed, in the contemporary arena of mobile computing. The architecture and layers discussed above need further simplification to reach the subscriber, to show significance in day-to-day usage. Work is in progress to improve the location-based technology, methods to determine location with better accuracy and improving the interfaces

with the user. This paper maps these technical aspects to the requirements of location-based services and expects that it will help to create more location-awareness, in the user community.

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