LOCATION-AWARE TELECOMMUNICATION SERVICES

Dario Bruneo, Luca Paladina, Maurizio Paone and **Antonio Puliafito**
Università di Messina, Italy

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Summary

Location-aware telecommunication services experienced a significant growth since 2000. The advances in wireless technologies, the spread of powerful portable devices and the development of sophisticated positioning systems enhance the diffusion of pervasive computing. In such a scenario location-aware services play a primary role. Using location data in service provisioning allows us to offer advanced value-added services able to dynamically adapt their behavior to user position. In this context, several market opportunities could be uncovered in the field of both public and business services. The management of highly heterogeneous environments calls for a careful investigation of several technological aspects ranging from positioning systems to middleware solutions. Social and economical implications have also to be taken into account. This chapter introduces the issues concerned with the location-aware service design presenting the state-of-the-art and focusing mainly on the technological aspects. Several possible scenarios will be mentioned presenting the different actors involved with. Particular attention will be also paid on the several standardization committees acting in this area.

1. Introduction

Location-Aware telecommunication Services (LASs), also known as location-based or location- related services, are applications that integrate location or position data with other information in order to provide value-added services. Typical examples are car navigation systems, tourist tour planning, and mobile marketing, and so on. LASs are a subset of context-aware services, i.e., services able to automatically adapt their behavior depending on the context of specific targets. It is important to highlight that, in such a context, targets not always correspond to users but they can be viewed as general entities that must be "located" (e.g., goods, vehicles, people).

LASs have a long history. In fact, a well-known navigation device is the magnetic compass and the first vehicle navigation system dates back to the invention of the south pointing carriage in China around 2600 BC. In recent years, the Global Positioning System (GPS), conceived for military purposes by the Department of Defense of the U.S.A in 1970s and made freely available in 1980s, gives to the industries the opportunities to create new devices and services based on position or location data. GPS reaches a high accuracy level and it is able to localize targets in a range of few meters. However, modern interest in LASs started in 1990s with the introduction of mobile phone technology. Since then, mobile network operators were widely deployed in Europe, Asia and U.S.A., and a new cell-id technology was implemented able to localize users according to their position in the cellular phone network. Cell-id technology offers low accuracy levels ranging between 100 meters to 3 kilometers depending on the target physical position (either urban or rural area). However, the significant diffusion of cell phones with a great computing power, a high-resolution screen and a fast data connection has enabled the LAS entrance into the service market. Without doubt next generation devices will integrate also GPS features, increasing localization precision and enhancing the spread of more and more sophisticated LASs.

A widely accepted definition of LAS is not available in the existing literature. The GSM association, a consortium of 600 GSM network operators, presented some examples of possible LASs: to show the location of a target on a map, to activate event-triggered tasks when a target enter or leaves a predefined location etc. The 3rd Generation Partnership Project (3GPP), a federation of many international standardization authorities, distinguishes between LAS and location services. For 3GPP, location services deal only with the determination of the position of a target. Then, a location service has not to process location data. The position data are provided to other entities that finally provide LASs. LASs need always a location service to carry out their functions, therefore LASs and location services mostly appear in conjunction. In the following, we will not distinguish between location and location-aware services and we will use the term LAS interchangeably.

The LAS market copes with both business and consumer services and can be classified in vertical and horizontal market. The vertical market has been the traditional market of LASs. It is related to all the environments where the management of location information is an integral part of the business. Many are the examples for this class of market: airports that need to know the position of each airplane to control the air traffic or taxi companies that need to know taxi position in a city in order to improve taxi assignment. On the other hand, horizontal market is characterized from all those environments where location information potentially represents a new service or an added value to an existing service. Today, it offers big business potential, especially for application developers that are enabled to invent new services or to enhance traditional services. For example, security agencies now are able to provide a real time tracking of people or object and some important services could be provided such as child tracking, vehicular tracking and so on.

The provision of powerful LASs involves several aspects (economical, technical, social) that have to be taken into account. Economical aspects are related to billing and accounting issues while social aspects are related to privacy and security. Finally, technical aspects can be divided into three abstraction levels:

- the lower level deals with all the issues related to the positioning technologies (GPS, triangulation etc.);
- the intermediate layer deals with networking issues (network integration, routing etc.);
- the upper layer deals with application level issues (service coordination and provisioning).

In the rest of the chapter all these concepts will be analyzed focusing on the technical aspects and presenting the state-of-the-art of all components involved in the provision of LASs.

2. A Brief Analysis of the Location Concept

To describe the LAS provisioning, an early study about the concept of location is needed. In everyday life the term “location” is much diffused, but its meaning is not univocally defined leading to several characterizations. The word location typically refers to *physical location*, that is the position of a person, an object or, in general, a target in the real world. It is possible to identify three different physical location categories: *spatial location*, *descriptive location* and *network location*. The term *spatial location* is related to a position in the Euclidean space. Each location can be represented by a point in a (two or three)-dimensional space and identified by a vector of real numbers. Several equivalent representations can be obtained by changing both the coordinate system (e.g., Cartesian or Spherical coordinates) and the reference point.

While electronic devices and in general computer and telecommunication systems work well with numeric values, people do not like such numeric representation. In order to simplify the human communication, the social communities name geographical objects using conventional identifiers. *Descriptive location* then comes to be a common concept in the social life. Rooms, buildings, roads, cities, territories are identified by names. It is more probably to say “See you at Colosseo” instead of “See you at (41°53'N, 12°29'E)”. The descriptive location provides less accurate position identification with respect to the spatial location. In fact, one descriptive locator can be mapped onto more spatial locators.

With the spread of networking infrastructure such as Internet, GSM, GPRS, UMTS etc., the concept of *network location* came to light. Since various types of communication networks can be developed, the network location can assume different meanings. For example, in a cellular phone system, such as the GSM, the location could be the cell a terminal is attached to, while, in the Internet, the location could be the IP subnet address of the LAN the user is part of.

LASs could be based on all categories previously discussed, and they must be able to map the different categories to make location information meaningful for all entities involved in the service provision. The mapping between the different categories and the translation from a representation to another are carried out by specific systems generally named Geographic Information Systems (GISs) that will be discussed later.

since 2000 the growth of the Internet community has lead to a new way of looking at the world. In analogy to the virtual reality, the *virtual location* came close to the physical location. From the virtual point of view, a location could be interpreted as a web site, a chat room or a mailing list. It is not easy to establish a rigorous mapping between virtual and physical positions. Furthermore, the two concepts of real and virtual are sometimes merged (e.g., in applications such as role playing games). Currently, LASs deal only with physical location, while the management of interaction between real and virtual world mainly concerns the application developers. However, the diffusion of virtual applications is going to grow in the near future calling for a careful management of such issues.

3. Design Issues of Location-aware Service Provisioning

Location-aware scenarios comprise a very great set of applications. Each of these has different characteristics and requires different services. A well-designed location-aware architecture must offer different services for different applications. Thus, it is mandatory to describe the typical scenarios classifying the location-aware applications and the requirements they impose on the LASs design, identifying the actors involved in the application scenarios and analyzing the coordination issues caused by the service provider heterogeneity.

3.1. Reference Scenarios

Looking at the market of service providers, it is possible to divide LASs application scenarios into two main categories: **business services** and **public services**. This characterization is based on the user typology: the services belonging to the former category have private individuals or business companies as their target, while those that belong to the latter offer services to public communities (e.g., cities, countries, etc.). In the following several LAS examples will be presented in order to provide an overview of different application fields. For a better explanation, such examples are grouped in different classes depending on the service typology. In each class it is easy to identify both business and public services even if not explicitly expressed. The following overview does not aim to be exhaustive and it could be opportunely extended over time.

Information services. This category includes all the services whose aim is to inform users about the location of a particular entity and the way to reach it. Location-aware information services can be viewed as an extension of the services offered by white and yellow pages, extension that is able to adapt the answers to the user context: location, movements and preferences. Services of increasing interest are guided tours, where tourists can obtain information about nearby sites of interest, such as monuments or natural spots, moving around in an unknown area. In this way, users can be informed continuously during their movements, without any operator aid. Users can indicate filters (e.g., on the distance from their position or from particular points of interest) in order to limit the output. It is important to notice that user queries can be both referred to physical objects (e.g., a particular building) and users or services location. Moreover, as observed in the previous paragraph, the output can be expressed by both physical and virtual locations. For instance, the answer to the question "Where is Mary?", can be both "She is at home" and "She is in the yahoo chat-room", depending on the query context.

Emergency services. New technologies for tracking and locating people have improved traditionally emergency services. An example is represented by emergency calls. People who usually call the emergency response agencies, such as the police, cannot often communicate their location, in many cases simply because they do not know it. Traditional 911 service, that is the emergency number in the U.S.A., is based on the fixed telephone network, thus automatically delivering the caller location to the nearest public safety agency. But if the call is made by a mobile phone the service cannot identify the caller location. Therefore, in the U.S.A., mobile operators were forced by the government to locate the callers of emergency services. In this way a new service, called E-911 (Enhanced 911), was introduced.

Location technology plays an important role also in vehicle assistance services. For example, if an airplane disaster occurs, radio equipments can broadcast their location to help the rescue team operations. Such scenarios represent historical application of emergency services, but new field of application are emerging. For example, the emergency roadside assistance for drivers is a promising business area in the market of service providers. In fact, drivers often do not know their exact location where their vehicle breaks down. An infrastructure able to provide positioning information could localize the damaged vehicle and call the assistance service, improving its speed and efficiency.

Entertainment services. Applications such as community services allow users sharing common interests to interact each other while staying in the same real location. Forum or chat sessions can be formed "on the-fly" among people in a particular location. Today chat programs connect people across the Internet; users have to compile a list of "contacts" that they want to keep track of (the so-called "buddy list"). Next-generation programs, such as location-based chat, are able to connect people on the base of their real world location and their interests, without user-generated buddy lists. Location-based games are other applications that have emerged in the last few years. Due to the increasing capabilities of mobile computing devices, many laptops or PDAs can be used as game consoles. These games merge the real world with the virtual reality. Players interact with the virtual entities of the game, moving around real buildings, roads and cities. Simple location-based games are the virtual treasure hunts, which are usually played using hand-held GPS receivers. A more complex game is Pac-Manhattan, a real-life version of the well-known Pac-Man. The playground is Manhattan, where people playing the Ghost role chase the person playing the Pac-Man role. Using cell-phone contact and Wi-Fi connections, players are tracked by a central system that controls the whole game coordinating the game characters.

Navigation services. This is an area of increasing business interest. The capability to find the location of a mobile user and to map this information on geographical data allows the development of several navigation-based services. A well-know example is the navigation system that is able to guide drivers to the desired target, proposing alternative routes or finding free parking. In order to offer these services the traffic and weather conditions in the interested area must be taken into account, as well as the presence of events such as accidents or roadwork. Another research field is the inter-vehicle communication, consisting in the exchange of messages to inform neighbor drivers about the local traffic situation or to automatically run the braking system to avoid an accident. The information obtained by this communication and the vehicle position can be sent to a central system that will be able to coordinate the traffic incoming in the area.

Tracking services. Services related to object tracking gave rise to increasing interest in the LAS market. Such applications deal with the coordination by a central entity of entire fleets of vehicles or teams of people. Essentially, they are based on the knowledge of real-time movements of targets. Typical examples are taxi management, air traffic coordination, personal security systems, etc.. These services can also suggest, on the basis of statistical observations, hypothesis on the future movements of a target. Tracking services can be used by companies to locate their personnel, offering customers accurate service times. Another example refers to tracking postal packages that allow companies to know the exact location of their goods at any time. Finally, a taxi company can monitor the vehicle movements, in order to improve the efficiency in terms of fuel consumption, arrival times, etc..

Billing services. Another area of interest is related to toll systems. Frequently, drivers have to pay tolls to use roads, tunnels, bridges or other infrastructures. A local staff usually controls the access to such structure. People have to pay before or after passing the structure. Such an approach leads to traffic congestion, thus worsening traffic conditions. Alternatively, in some countries, such as Switzerland and Austria, drivers have to buy vignettes (i.e., colored stickers affixed to motor vehicles) proving the road toll payment, usually valid for a fixed time. But this solution does not take into account the covered distances by drivers. In order to individuate the covered distances toll systems have to keep track of the vehicles position. To solve these problems most countries have started many practical or research activities aiming at recording the driver routes, thus calculating tolls automatically. Another issue is represented by the difference of the toll systems developed by each administration entity (counties, regions, etc.). These different systems are often incompatible, thus making the management of the entire system difficult to be carried out.

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Bibliography

Becker, C., Dürr, F. (2005). *On location models for ubiquitous computing*. ACM Personal Ubiquitous Computing. **9**(1), 20-31. [An overview of existing location models, based on general properties of both symbolic and geometric coordinates, allowing for position, range, and nearest neighbor queries]

Ciavarella, C., Paternò, F. (2004). *The design of a handheld, location-aware guide for indoor environments*. ACM Personal Ubiquitous Computing. **8**(2), 82-91. [This defines design criteria in developing location-aware systems for indoor environments. The design of a location-aware guide for museum visitors is described like a case-study]

Hazas M., Scott J., Krumm J. (2004). *Location-Aware Computing Comes of Age*, IEEE Computer **37**(2), 95-97. [A comprehensive overview of location-aware scenarios and technologies]

Hong, J. I., Landay, J. A. (2004). *An architecture for privacy-sensitive ubiquitous computing*. In Proceedings of the 2nd international Conference on Mobile Systems, Applications, and Services (Boston, MA, USA) ACM Press, 177-189. [This work presents an infrastructure for facilitating the development of privacy-sensitive ubiquitous computing applications. An analysis of privacy needs for both end-users and application developers is also presented]

Kupper A. (2005). *Location-based services: Fundamentals and Operation*, John Wiley & Sons (Halsted Pr), ISBN 0470092319. [This book presents a detailed analysis of location-aware services, including positioning methods, location protocols and service platforms]

Mansley, K., Scott, D., Tse, A., Madhavapeddy, A. (2004). *Feedback, latency, accuracy: exploring tradeoffs in location-aware gaming*. In Proceedings of 3rd ACM SIGCOMM Workshop on Network and System Support For Games (Portland, Oregon, USA), 93-97. [This describes the key components of future location-aware gaming platforms]

Patterson C. A., Muntz R. R., Pancake C. M. (2003). *Challenges in Location-Aware Computing*, IEEE Pervasive Computing, **2**(2), 80-89. [A general overview of location-aware computing: location technologies, wireless communications, and infrastructure models]

Schiller, J., Voisard, A. (2004). *Location Based Services*, Morgan Kaufmann Publishers Inc., ISBN 1558609296. [This book introduces location-aware services by addressing many issues and challenges facing researchers and practitioners]

Schmandt C., Marmasse N. (2004). *User-Centered Location Awareness*, IEEE Computer **37**(10), 110-111. [This presents a brief analysis of possible cooperation between location awareness and communication technologies]

Biographical Sketches

Dario Bruneo received his degree in computer engineering from the Engineering Faculty of University of Palermo (Italy) in 2000, and the Ph.D. degree in Advanced Technologies for Information Engineering at the University of Messina (Italy) in 2005. He is currently a research associate at the Engineering Faculty of the University of Messina. The scientific activity of Dr. Bruneo has been focused on studying distributed systems, particularly with regard to programming and management techniques. His main research interests include distributed systems programming, Grid computing, mobile agents, mobile middleware, network management techniques and QoS management.

Luca Paladina received his master degree in Electronic Engineering from the University of Messina in October 2003. Since, he has been engaged in research on mobile and distributed systems. He is now attending the 3rd year of the PhD course in "Advanced Technologies for Information Engineering" at the Engineering Faculty of University of Messina. His scientific activity has been focused on studying mobile and distributed systems, particularly with regard to QoS management techniques in mobile wireless networks. Recently his research interests include also wireless sensor networks.

Maurizio Paone received his Degree in Electronic Engineering from the Engineering Faculty of the University of Messina (Italy) in 2003. In December 2006, he received the Ph.D. degree in Advanced Technologies for Information Engineering from the University of Messina. Scientific activity of Dr. Paone has been focused on studying mobile networks systems. His research interests include QoS management in mobile wireless networks (infrastructure and ad-hoc topologies) and routing in Wireless Sensor Networks by adopting the Swarm Intelligence paradigm.

Antonio Puliafito is currently a full professor of computer engineering at the University of Messina. His interests include performance and reliability modeling of parallel and distributed systems, networking, GRID computing, multimedia and mobile agents.

He is the coordinator of the PhD course in Advanced Technologies for Information Engineering currently available at the University of Messina. He has contributed to the development of the software tools WebSPN, MAP and ArgoPerformance, which are being widely used from the scientific community. He is currently responsible of all the ICT and e-learning initiatives at the University of Messina.