Geographical Information Systems Participating into the Pervasive Computing

Nuhcan Akçit
Department of Geodetic and Geographic Information Technologies
Middle East Technical University
Ankara, Turkey
nuhcan@metu.edu.tr

Emrah Tomur
Department of Information Systems
Middle East Technical University
Ankara, Turkey
etomur@metu.edu.tr

Mahmut Onur Karslıoğlu
Department of Civil Engineering,
Geomatics Engineering Division,
Department of Geodetic and Geographic Information Technologies
Middle East Technical University
Ankara,Turkey
karsliog@metu.edu.tr

***Abstract*—The popular term "pervasive computing" describes the concept of computers being everywhere. The Geographic Information System (GIS) technology began with completely centralized systems after the influence of the Internet; the GIS then changed into decentralized systems. In the last few years, the GISs have been included in many areas of pervasive computing, such as the Internet of Things and sensor networks. Changing and developing states of the GIS such as Internet, mobile, web GIS, ubiquitous GIS, the Internet of Things and sensor network are the different elements of the evolution. From the beginning of the evolution until today, pervasive computing is described in this study. In addition to GIS as a part of pervasive computing technology, the activity of Open Geospatial Consortium (OGC), which works on geospatial and location standards in these technologies, is also discussed. This paper investigates the evolution of GISs from centralized systems to a distributed system, summarizes the steps and use areas of the GISs to participation in pervasive computing, and compares different GISs concepts in application areas. In addition, future trends and expectations of the GISs are included.**

Keywords-GIS; pervasive computing; WEB GIS; mobile GIS; Internet of Things

I. INTRODUCTION

The Geographic Information System (GIS), a system designed to store, capture, analyze, manipulate, and manage all types of geographic data, is an interdisciplinary area that combines cartography, analysis, statistics, and computer technology [1].

In recent years, ubiquitous and pervasive computing domains have increased considerably. They are a part of the daily life because of the technological evolution and new applications. In this paper, the goal is to provide information about geographic information science, a system that has developed considerably and is involved in our lives more than ever. The fundamental areas of geographic information science are remote sensing, surveying, photogrammetry, and analyzing spatial data.

The focus of this paper is GISs, which are becoming part of the ubiquitous computer domain. In this paper, we provide a brief information about the GIS and its development from the 1990s to 2010. We mainly focus on after 90's because distributed and Internet GIS [2] started to be formed in this period, and our ubiquitous domain is more interested in development after 90's. We also discuss future trends in this area. The GISs are huge; therefore, we focus on the development and evolution of the ubiquitous and pervasive computing domains. Thus, elements of the development of the GISs are beyond the scope of this paper.

The GIS is not familiar to the public. We first provide general information about the GIS and application areas. Then, we discuss the evolution of the GIS from the 1990s to today [2]. In the last few years, the GISs have become a larger part of the ubiquitous domain [7]. This study is a brief summary based on books, articles, and other sources. We mainly investigate information about the GIS, development stages, and evolution steps until today.

This paper is structured as follows: We discuss GISs in Section 2. The effects of the Internet on GISs are analyzed in Section 3. Data Centralized-distributed GISs are considered in the Section 4. Decentralized distributed GISs are considered in Section 5 (location-based services, web GIS, mobile GIS, the open geospatial consortium, ubiquitous GIS sensor network, and the Internet of Things).

II. THE GEOGRAPHIC INFORMATION SYSTEMS

Generally, GISs are systems that "integrate hardware, software, and data for capturing, managing, analyzing, and displaying the different forms of geographically referenced information" [3]. All types of geographically references data can be organized by The Geographic Information Systems. Today, the major components of GISs are people, hardware,

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software, data procedures, and the network [3]. A GIS allows us to understand all types of reports, data, and visualize, interpret, and find relationships between them. A GIS helps people answer questions and solve problems by looking for data in a way that is quickly understood and easily shared. GIS technology is used by any kind of work which can be integrated easily with GIS. Spatial analysis is mainly used in many areas; thus, with the help of the GIS, analyzing data and finding results in different domains is easy, a key element of the GIS.

General benefits of using the Geographic Information Systems include saving money, increasing efficiency, aiding in making better decisions, improving communication, keeping records better and deleting the managing data geographically or the relations [4]. Different types of data management and different types of software deal with different types of data. However, these details are beyond the scope of this paper. In many open source and commercial programs, the usage is based on the work someone wants to do exactly, which means the selection changes with the context of the work. Only basically say that the data types include different raster, vector and hybrid format[3]. The data sources include images, digitized or scanned maps, GPS data, and data transferred from other places with the required program.

What is unclear about the GISs are whether; systems are inter-disciplinary or a separate discipline. According to some, the GISs are inter-disciplinary; others believe since the system has been developed, it is a separate discipline. Since this issue does not affect the capability or development of the GIS, this issue is not important in this paper. This paper focuses on GIS capabilities and how the GISs have affected daily life since being developed in the 1990s.

Now looking at some little information on how GIS is developed at first. The GIS was first developed in Canada in the mid-1960s to identify land resources, where they were, and how they were used. In the late 1970s, Harvard University's Laboratory for Computer Graphics and Spatial Analysis developed a general purpose GIS [1][5]. In the early 1980s, the price of computing hardware decreased, which helped sustain the software industry and led to the development of cost-effective applications. This is making the more powerful and efficient standalone systems which have been introduced in the 1980’s. During the 1990s, map analysis and modeling start to increase this software programs. After the 1990s, the Internet grew rapidly, which led to new concepts: distributed GIS and Internet GIS [2].

III. Effect of the Internet on the Geographic Information Systems

The Internet grew rapidly in the 1990s, and has become part of society. Ubiquitous access to the Internet makes it more powerful for people to process, exchange, and access information. The Internet also changed GIS data access, manipulating, and sharing. The Internet led to an important change and improved GIS in terms of spatial analysis. The Internet affected the GIS in three areas: data access, spatial information distribution, and processing [2]. The Internet provides analytical results for a much wider audience than the traditional GIS. People start to search online and use free search and query analysis for spatial objects without purchasing expensive GIS software. In the processing field, the Internet enhances the reusability and accessibility of the analysis tools and dynamic download and upload, which also helps interactive work on data, which is discussed later in this current study.

Accessing data over the Internet was the first step for the Internet GIS [2]. Accessing data online allows people who have stand-alone GIS on their local machines to transfer data over the Internet. This method is suitable for accessing data quickly and easily but harder for the analyzing data independent from the location, which is the next important step. Online GIS processing continues to improve to increase the analytical abilities of the Internet.

IV. data Centralized- Distributed GIS

The GIS influenced the advancement of information technology. The development of the GIS resembles computer development, which evolved from a mainframe GIS to a desktop GIS [2] and then distributed GIS, which includes Internet GIS and mobile GIS.

Distributed GIS has subtypes which are Local Area Network (LAN) based GIS, Internet based GIS and mobile based GIS. In this paper we are interested with the distributed GIS refers to GIS programs working on the internet (Internet GIS) or wireless network environments (mobile GIS)[2].Distributed GIS is mainly based on improving the Internet and wireless technologies based on the rapid expansion of low-cost bandwidth [2] over the Internet, and web-enabled desktop and mobile devices.

The distributed GISs differentiate the client-server LAN-based traditional method [2], which does not require the installation of a GIS program on the user’s desktop. This method relies on the access to analytical tools and data anywhere through Internet access or wireless coverage. The client is any device that can be connected to the Internet or may be connected to a wireless capable device to access the data or tool. There are two concepts in distributed GIS: Internet GIS [2] (can be wired or wireless also) and mobile GIS (wireless). This is important because depending on whether communications are wired or wireless, the applications may change. Although these issues are very important for developing a GIS, the interoperability of the data is very important.

V. Decentralized Distributed GIS

In distributed GISs, many names are used: online GIS, distributed geographic information (DGI), web-based GIS, or web GIS [2][6]. Internet GIS and web GIS sound as if they are the same, but they are completely different from each other. Internet GIS involves using the Internet to exchange data, perform analysis, and present results; however, web GIS primarily uses the World Wide Web (WWW). Internet GIS and web-based GIS use the client

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server as a model [2][7]. Web GIS uses web browsers, which are a major part of the Internet, but Internet GIS is broader and, it uses more than browsers.

Distributed GIS mainly uses the client server as a model [2][7]. The server itself performs the job and sends the result to the client or sends the data and analysis tool to the client to calculate the result. The connections and the communication are based on the standards of the client server or Internet standards (which are not discussed in this section because they are the same as the general use of Internet standards and the client-server architecture). The thick and thin client model can be also seen as distributed GIS [2].

Distributed GIS are hosted on several hosts connected by a communication network. One subclass of such distributed GIS is Internet GIS. WebGIS is a subclass of Internet GIS which is significantly more usage last years based on the WWW (World Wide Web), and its add-ons to provide interactivity between the user and the distributed GIS program. To enable interactivity, HTML (Hyper Text Markup Language), XHTML (Extensible Hyper Text Markup Language), WAP (Wireless Application Protocol), and vector-based GIS can be used [2]. Users can then manipulate the data and maps interactively. Users also can perform GIS functions such as rendering, spatial queries, and spatial analysis using a web browser or other Internet-based applications.

Distributed GISs take advantage of the Internet as a distributed system [2], which means GIS data and the analysis tool can be on different computers over the Internet. The data can be in different places at a company or institution and, it can be accessed, combined, or analyzed with help of the Internet or intranet. In addition, public agencies can provide data for users or other providers. Individuals can search and download data or tools over the Internet. Choosing different applications for different types by the same user is possible. The main advantage of distributed GIS [2] is being connected dynamically to data sources. Real-time information can be used in a real-time connection such as a real-time satellite image, emergency response information, and traffic movement.

Another important issue is the accessibility of the GIS from different platforms. It must not be limited to one type of a system. As long as people have connections to the Internet, individuals can access and use distributed GIS. Cross-platform and inter-operable GIS tools [2] are important, so everybody can access or operate the tools independently of the system they use. In addition, interoperability means individuals can access the GIS from various devices. The Open Geodata Interoperability specification [2] and geography markup language (GML) [8] by the Open GIS Consortium (OGC) set standards and rules for interoperability [2][8]. (There are also many different standards for other concepts that are created by the OGC during 2000s, which will be discussed in detail later.)

Distributed GISs are required for many purposes. One is the uniqueness of the data over the Internet. For example, a road map is more usable by tourists if there are points of interest on the map (hotels, parks, restaurants). This example shows the importance of using geographic data increasing with the inter-operability and cross-platform issues [8], people rarely focus on this issue for actual implementation in the beginning. These needs must be achieved in cross-platform programs when a system is designed in concept of the GIS. It must be well defined to make the program truly inter-operable and cross-platform. This requires the community to revise meta-data. This requirement led to research on meta-data for geospatial data and software components in the late 1990s. Integrated meta-data is one of the successful points of distributed GIS.

Distributed GIS is used in many other areas today [2], which means a flexible and dynamic scheme is more usable. Delivering data with traditional GIS has difficulties. Different programs have unique processes and data sets that make life more difficult. Needs are divided into three perspectives: management, user, and implementation perspectives [1][2]. From the management perspective, there are two main reasons why distributed GIS should be more useful. First is the globalization of geographic information series distribution. Data were distributed in papers or paper maps previously, but in recent years, many data sources have become publicly available on the Internet. To provide a GIS community global system, they built data to distribute [6] online in the 1990s. It provided a large scope for conducting scientific research, and GIS users obtain information easily from the community. Second, Internet GIS services are related to decentralization of managing and updating the system [2] [6]. Data gathering techniques such as global positioning systems (GPSs), satellite images, remote sensing data, and other GIS [1][9] application data mean people must deal with huge databases. Since the databases are huge, this creates maintenance and update issues. Internet GIS provides a solution to this situation. Data sets are maintained at the source site instead of a centralized location [2]. Another advantage is the increasing reliability failure of one location. Thus, the entire distributed Geographic Information System does not fail. This increases the efficiency of the system and reduces the cost of maintaining the database.

From the user perspective, there are three main reasons why Internet-based distributed GIS services are important. The first is the huge GIS data sets and processing are not possible. Smaller workstations and a distributed system provide a chance for dynamic processing at servers and encapsulate the results for return to the client. The second is customization of GIS modules. With distributed GIS, individual software modules are updated, which provides more flexible solutions to users. The third reason is the public's demand for location-based information due to the popularity of the Internet and mobile devices. Popularity began with the GPS, in-car navigation, and wireless access to the Internet. Distributed GIS services have a real potential to bring GIS to the masses [2].

From the implementation perspective, there are three main problems in distributing the system. The first is that Internet-based GIS [2] services lack high-level architecture, which means there are temporary solutions for distributed systems. The second problem is the interoperability issue [8] of data and processes. The third problem is data overload because of the many different sources. Each source may have the same data. This means loss of power and high costs to duplicate the data from different databases. These are solved if the GIS users have the knowledge required to integrate different sections and critical issues.

Distributed GIS has a wide range of applications that can be categorized into four main groups: data sharing and dissemination, simple search and querying, online data processing, and location-based services. In data sharing, the system shares data on the Internet perhaps over a web browser, FTP, or other type of Internet application. Information is disseminated via maps and data processes by specialists. Specialists give users user permission to use these materials. Online processing makes people work on providing inter-operable software development, or they process different parts of the problem and put them together to solve problem with online processing. Another important process is location-based services (LBS) [2][10], which refer to real-time implementation. LBS help people find the best route to their destination. Distributed GIS can meet needs easily. In addition, mobile GIS [2][7], which is described in detail later, can offer mobile users real-time traffic information, landmarks near users, and points of interest.

A. Location-Based Services (LBS)

The development of technology and technological trends has involved more location-based services in daily life. Improvement in distributed GIS also aided in the development of location services.

Technology is rapidly changing, particularly in Geographic Information Systems. GNSS is the global navigation satellite system. One type of GPS (global positioning system) is operated by the United States. However, there is also GLONASS (Globalnaya Navigatsionnaya Sputnikovaya Sistema), which was operated by Russia. Other systems in development include Galileo (the European Union [EU]) and Beidou (China) [9]. There are also GISs that are not GNSS: radio frequency identification and location-sensing technologies with varying accuracy.

Location-based services [2][10] are mainly services or applications that extend spatial information processing to users or GIS capabilities via the Internet or wireless devices. GIS capabilities are based on the networked or distributed concept. Many LBS are used today, including social networking. LBS are targeted at many people, and are inter-operable and cross-platform [8][10]. LBS evolved from online map services and Internet GIS applications. LBS are used for more concentrated lightweight devices [10]; GIS applications are more general. However, LBS definitions and uses overlap with those of the GIS.

Since GIS have interoperability and cross-platform issues, LBS evolved from GIS for more cross-platform and diversity. LBS have more simultaneous and dynamic processes [10] in which data are obtained from the traffic or remote sensed by satellites, which is based on GIS applications and concepts. LBS were developed for more independent use and are useful only for location services. There are different types of LBS; however, since the 2000s mobile phones have been equipped with GPS receivers. Thus, all over the world, this type of LBS is commonly used.

LBS capabilities are limited to finding locations and tracking objects with small sensors [2][10]. Locations are found based on the following questions: Where am I going? How do I get there? Where am I now? LBS work very well in this context. LBS have two modes: pull and push [10]. The push mode services are pushed to the user automatically and are not based on needing the information. In the pull mode, the user requests the data voluntarily to access information.

The object tracking capability of LBS with small sensors is attached to the object that people want to track. However, sensor networks are better at tracking objects, and will be discussed later. The sensor network is better at giving users what they need to track. In the future, ubiquitous computing based on Weiser's visions will help improve [11] LBS.

LBS applications must be designed from the user's perspective in the GIS context. LBS work thanks to the georeferencing system, which may use GPS (or any GNSS system) for global positioning or take the initial location as a georeference and calculate indoors based on geometric models. There are actually two types of modeling: geometric and symbolic modeling. GIS use geometric modeling to calculate LBS. Geometric models have limitations since the public uses more verbal location with expressions of spatial features, location, and spatial relations. Some initiatives are integrating symbolic and geometric modeling. A new concept is the semi-symbolic model that contains a geometric location and a symbolic representation. Context-aware computing is also part of LBS, but the context is the most difficult part [10]. The context affects users' actions, behavior, and information retrieval. The context used by mobile users changes frequently; therefore, the LBS must take the changing issues continuously to provide service to mobile users. Geospatial data are a key concept in LBS [10], which means this topic is related to the GIS. It uses mainly geospatial data and GIS to determine locations. Determining the location is meaningless if it does not refer to a georeference place. If georeferencing is not used, positions are found relative only to other materials; thus, people do not know where they are exactly. In addition, the base layer and additional position information are needed to find locations on the earth.

The model mainly proposed a domain of ubiquitous computing with some exceptions, data modeling conducted in GIS. LBS can be treated as a special type of geographic information services. Research on spatial ontologies has implications for the development of LBS. The uncertainty of geographic information is linked to data processing and modeling in LBS [10].

The ubiquitous use of the GIS [12] affects many concepts in this domain. The next-generation GIS is related more to the ubiquitous domain since information from the mid-2000s reflects technology today. In addition, the OGC has a role as this organization creates regulations regarding the interoperability of LBS in terms of geographic and geospatial aspects.

B. Web GIS

The rapid expansion of the Internet has led to new disciplines; Web GIS is one of them. It changes geospatial information by acquiring, publishing, sharing, and visualizing. Web GIS is a milestone in the development of the GIS. In 1993, the first web GIS was introduced, by the Xerox Pablo Alto Research Center (PARC) Web-based map viewer [2][7][11]. It was an experiment for retrieving information on the web that did not directly access data. This viewer provides simple zooming, layer selection, and map projection capabilities. The GIS can be used without local installation.

New web GIS [2][7] applications then emerged: in 1994, the Canada National Atlas Information Service and in 1995, topologically Integrated Geographic Encoding and Referencing (TIGER), a US mapping service. In 1996, MapQuest, a web application that allows people to view maps, look for local businesses, find the optimal routes to destinations, and plan trips, was introduced. It is still used today.

Web 2.0 formed at the end of the 1990s and after that Web GIS changed [2][7]. Then, Web GIS evolved from web browsers to a web GIS that served desktop and mobile clients in addition to web browsers. This distributed information system has a server and a client where the server is a web application server and the client is a mobile application, a desktop application, or a web application server. The server contains an URL, so it can be easily reached by users [2]. The client sends a request and receives a response from the server. Today, web GIS refers to a type of any GIS that uses the web [7].

Web GIS is closely related to Internet GIS and geospatial web. However, they are slightly different. The relation between GIS and web GIS is shown in Fig. 1 [7]. The Internet supports many services; web is only one of them. A GIS that uses a service other than a web service on the Internet is considered Internet GIS. Web GIS is more frequently used on the Internet, which means web GIS is the most pervasive of the Internet GIS [2][7].

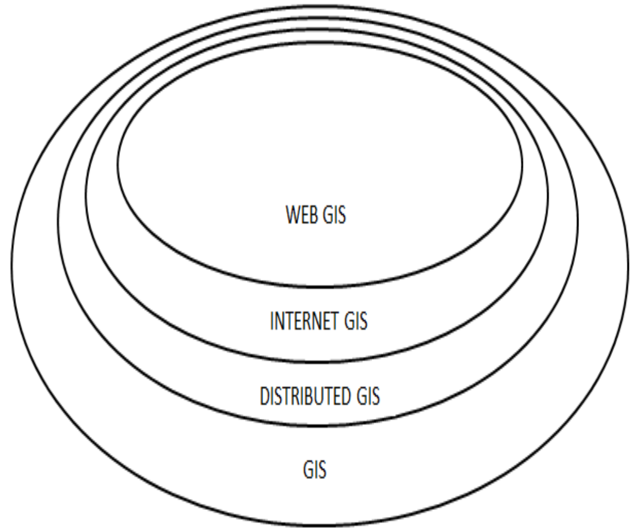

Figure 1. Types of GIS.

The geospatial web (geo web) is another term used instead of web GIS [2][7][13]. The geo web is slightly different from web GIS. The geo web merges geospatial information with non-geospatial information [2][13]. Another explanation is that the emerging geo web distributes global GIS, collaborates on information and knowledge with widespread worldwide sharing and interoperability [2][8][13]. This gives the idea that the geo web may be more developed in the future than web GIS to achieve the whole requirements.

The main characteristics of Web GIS are :global reach, a large number of users, better cross-platform capability [2][7][13] (because all web browsers use standards), low cost average by the number of users, easy to use by end-users, unified updates, and diverse application based on the use region. These characteristics create advantages, but also challenges. Web GIS stimulates public participation, but users with no GIS background must be considered. The increase in user numbers must be considered to provide good service based on the users' hardware, connection, and software limitations or capacity. These issues must be considered for appropriate communication or use.

Web GIS [7] can provide all GIS functions but also has unique strengths. These strengths include collecting geospatial information, mapping and querying functions, disseminating and analyzing geospatial information. An example of collecting geospatial information is an open street map formed by volunteers who collect data and share them in different parts of the world. This includes volunteered geographic information (VGI) [7]. We do not provide the details in this study as it is beyond the scope of the paper.

Web GIS is a new business model used by companies (the business location and the sponsor location of web sites on the map advertise them). It is a powerful tool for e-government. They have grown since 1993 and web GIS has

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grown more, but the fact that they engage the powerful representation and analysis capability of the GIS [7] makes things on online maps easy to understand. Another use is the infrastructure for e-science, which provides a low-cost, newly established readily accessibility infrastructure for computing capability. Web GIS [2][7] uses a component of daily life with the spread of mobile devices and the mobile web. Web GIS helps us in everyday life, by telling us where to go, what to do, where to eat, and how to get there based on LBS.

C. Mobile GIS

Mobile GIS refers to mobile use of the GIS [2][7]. A special aspect of mobile GIS is when data users are in someplace and are interested in information about a particular location. There are four types of locations in a GIS [2]: the user's location (u), storage location of data (d), the location where it is been processed (p), and the area subject to the GIS project(s). In a traditional GIS, the user sits at the location and projects to the world in which (u) not equal to (s). However, in mobile GIS u=s, which means the user is located at the projected area [7].

In the 1990s, mobile GIS were used for vehicle navigation and field surveying. GIS data were obtained from preloaded data in the system with a disconnected mode [9]. Then, with the advantages of wireless technologies, a GIS application is instantly connected to the Internet in real time to gather or view data [2]. These applications use web GIS services over the Web, which are advantages of the latest updates of the data and post the new data on the application to the server. That means that over the years mobile GIS has evolved to connect online to the resources and become a component of web GIS [7]. Mobile GIS overlaps with some parts of web GIS.

Since the use and popularity of mobile devices have increased, the increasing speed of data transfers by wireless networks has forced users to adopt the new form of web GIS, which is mobile GIS. Mobile GIS functions are quite compatible with some GIS functions. The following functions work well with mobile GIS [2][7]: information capture and updating, dissemination, storage, analysis, and presentation. Based on the types of applications, there are two mainsubtopics: consumer mobile GIS application and enterprise mobile GIS application.

The consumer mobile GIS application answers general daily life requirements, which mainly refers to location services based on LBS [2][10] and provides added value such as points of interest. Enterprise mobile applications are used to complete tasks such as field mapping queries and decision support, field inspection and inventory of assets, field surveying, incident reporting, collaboration, and tracking. Enterprise applications have more functions than consumer applications.

The advantages of using mobile GIS instead of a paper application are mobility, large volume of users, location awareness, versatile means of communication, and near-real-time information [7]. Supporting technology of these types of application include mobile phones, pocket PCs, portable PCs, and special devices such as operating system embedded or GPS receiver-embedded mobile devices. Mobile positioning [7] techniques used in mobile GIS include the navigation satellite-based approach, cellular-network-based approach, cellular-network-based approach, assisted GPS approach, Wi-Fi based approach, and IP address-based approach. In addition to mobile approaches some use different types of browsers such as mini browsers, full html, mobile browser plug-ins, and WAP.

D. Open Spatial Consortium

The OGC is an international industry consortium of 482 companies, government agencies, and universities that make sure publicly available interface standards are developed [2][8]."OGC® Standards support interoperable solutions that 'geo-enable' the Web, wireless, and location-based services and mainstream IT" [8]. The standards empower technology developers to make complex spatial information and services accessible and useful for all types of applications.

The standards are developed in unique consensus supported by the OGC's industry, government, and academic members [8]. Members want to make certain the geoprocessing technologies interoperate, or are "plug and play." Products based on OGC standards receive the OGC certificate [8]. For interoperability and standardization issues, if people want to be in the market or create products that work well and are compatible with other products, they must follow OGC standards.

OGC standards are the documents established by consensus and accepted by members that have achieved the optimal degree of interoperability [8]. In 1998, the first standards were created; in 2000, the first web service standard was created; in 2004, the name was changed into to its current name; and today, there are 35 standards and 482 members [8].

The most important OGC standards are the sensor web standards [8], a type of sensor network. Many people think it is part of information technology, but the sensor network is in the geospatial domain. The main topic areas for which the OGC creates standards include cryoscopy, hydrology, meteorology/oceans, defense, intelligence, sensor web, aviation, and 3D modeling and visualization.

When the OGC was first started in 1994, the organization was interested only in creating standards for distributed GIS data and software interoperability [8]. Today, open GIS web coverage service, open GIS web processing service, open GIS service model implementation standard, open GIS georeference table joining standards, and geography mark-up language (GML) [2][8] standards are examples of standards created by consensus of the OGC.

E. Ubiquitous GIS

Ubiquitous GISs are based on a type of geographic information provided to users or systems at any time and any place through communication devices when the distributed system was formed [2][12][14]. Ubiquitous GIS (UBIGIS) is closer to the aim that people access data and processing them at anywhere and anytime. The information provided for the user is based on the user's context. The GIS has contextual awareness. It includes a set of practices and standards for spatial and geographic information which is accessible in public by users. Its importance is that UBIGIS also processes the applications.

According to some researchers, four criteria must be applied ("distributed," "disaggregated," "decoupled," and "interoperable") for UBIGIS [12] [14]. In computing area and distributed GIS, interoperability is the most difficult issue; it is negotiated by the OGC. UBIGIS applications must adhere to the following standards:support applications, numerous users, collaborative work, working online and off-line, multi-functional, security, and integration with other applications and various networks [11][12][14].

The future development of mobile GIS in many disciplines and application areas are toward ubiquitous GIS which are: augmented reality, public participation GIS, dynamic demography, and 4D GIS [7] [12]. These topics are more related to ubiquitous GIS. Augmented reality combines information from databases with information from the senses. This is implemented in medical settings where mobile GIS are used instead of the senses [7][14]. For example, visually impaired people navigate with mobile GIS. Public participation GIS (PPGIS) makes each mobile phone owner as being a sensor [7]. This allows people to add data to the network collectively in real time. In addition, real-time environmental monitoring networks harvest valuable data from the intelligence of public participation. Dynamic demography is for the planning of traffic and transportation choosing retail store place and simulating diffusion of disease based on these demographic data. A four-dimensional GIS performs by collecting mobile GIS data in real time for 4D [7]. For faster networks with 4G, the GIS must become more ubiquitous for users.

F. Sensor Network

A wireless sensor network is a geographically distributed network that monitors physical or environmental conditions. Sensor networks are formed by sensor nodes called "motes" [15]. Motes ease communication between each other [15]. They are consisting of radio transceivers which also contain memory, onboard power supplies and a variety of sensors. The motes work by collecting and analyzing the sensor readings independently but can also link up with neighboring motes with mesh topology to send information to each other or to the sink [15]. There are different applications in different areas and many more details; however, in this paper, we are more interested in the sensor web. This is a type of wireless sensor network based on automatically communicating sensors and reacting to phenomena. The sensor network is defined after the sensor web.

A sensor web is a system that is wireless, an intercommunicating spatially distributed sensor that is deployed to monitor and explore the environment [8][16]. It is capable of automated reasoning, and it responds to changing environment conditions and carries out automatic recovery after automatically sensing a diagnosis. OGC-defined protocols create abstract heterogeneous communication inside or between different networks by abstracting the basis and communication standards of the sensor web [8][16]. Sensor Web Enablement (SWE) standards have been created by the OGC [7][8]. It is also related to the communication protocols and types of the hardware. Defining accessing sensor network is in real-time or archived data using standard protocols and application programming interfaces [8]. This issue is starting to relate to the "Internet of Things" issue, in which real object world is directly related to the Internet. The sensor web is a network of sensors accessible to the sensors, and stored old data can be discovered using the OGC standard protocols and APIs [8].

G. Internet of Things

The Internet of Things was first mentioned as identifiable objects in the virtual world, on the internet places with tags [17]. The Internet of Things is a trending topic today, which means real world objects communicate with each other from the base on the Internet directly; the sensor web is also part of this relation. It is really a new area to improve nowadays and is expected to be fully constructed by 2020. Protocols and key applications were introduced to us a few years ago, and they are developing now. However, technical details are beyond the scope of this paper. Key applications used today include a sensor web used for intrusion detection or environmental monitoring. Various organizations are working in this area and have proposed objects with auto IDs to communicate with each other over the Internet. Radio frequency Identification (RFID) tags are a prerequisite of the Internet of Things [21].

The most important application of the Internet of Things is the smart grid, an electrical grid that uses information and communications technology to obtain and use information, such as information about suppliers and consumers, in automated processes to improve the efficiency, reliability, economics, and sustainability of electricity production and distribution [18]. Another important application is electric vehicle charging, for which the standards are being determined. Two critical standards that have been introduced are for plugs and charging stations for extended use with one charge later, so different areas can charge different vehicles [18].

Since this area is still being developed, we will see clearer details and more applications in the future. In the next 10 years, many applications will be distributed and affect our daily lives with this application. Application fields include waste management, emergency response, intelligent shopping, smart product management, smart meter, and home automation. Several applications are not distributed, such as the home automaton application sensor network, but they are distributed around the house and provide information about the house that is connected to other processes that may act automatically.

VI. FUTURE GIS TRENDS AND RESEARCH AREAS

Future GISs research topics include VGI, PPGIS, geocollaboration, geotagging, geoparsing, geotargetting, online VR, Digital Earth, and cloud-based GIS. Future trends include faster and more mobile Internet and a smarter and more sociable web.

VGI is geospatial data about the environment generated by users [7] instead of producers. Examples include wikimaps, (Picasa, Panoramio, Flickr albums (geotagging)), OpenStreetMap, and Facebook (for location tagging). It provides public participation in GIS as people act as sensors, using their free time to provide data. Usually, producing data requires training, but since there are many data, we can choose the valuable one. In addition, people's adding data voluntarily will also help improve PPGIS [7][20].

PPGIS is people participation in GIS. It is a type of VGI, but requires more people to add data. PPGIS differs from VGI because participation is needed in decision making through the use of GIS [7][20]. PPGIS wants public participation in satellite image, digital maps, and sketches. However, PPGIS has technical and social barriers. Some people not want to attend public organizations at specific times, and some are not comfortable speaking at public forums. Some people may find it hard to use these technologies. Most current PPGIS applications are experiments or pilot studies [20]. The plan is to involve the public in PPGIS in a web-map-based approach with specific comments with environmental areas, blog and photo sharing web sites. A social networking approach may help improve PPGIS.

Geocollaboration also called collaborative GIS, concerns a group of people working together on the same task [7]. Two types of spatial collaboration talk about the same location at different places looking at the same part of the map, the second one temporarily can be synchronous or asynchronous [7]. Five characteristics must be completed: facilitating dialog, accounting for group behavior, drawing the group's attention, allowing private work, and allowing saved and shared sessions. The possibility of increasing geocollaboration is promising for the future.

Geotagging involves adding location information to photos, videos, or other digital data [7]. This can be done automatically and manually. Photos taken with devices with GPS receivers are automatically geotagged, and others are manually geotagged. Geotagging provides value to a GIS by spatially organizing photos and other types of data, enriching the geographic information, and providing valuable data for data mining.

Geoparsing is the process of converting geographic locations to textual words or phrases in a document [7]. It is a new research area and can be linked to the semantic web [7]. Geoparsing searches documents quickly, plots locations on the map easily, and organizes a mass of documents spatially.

Geotargetting determines the physical location of the user and provides related content based on that information. An example is advertising swimsuits in hot regions and near sea locations and advertising warm coats in colder regions [7]. Methods for obtaining physical locations include obtaining user's registration information or a user's IP address or from GPS receivers in mobile phones. Geotargetting helps provide precise advertising based on location, prevents suspicious payments, and by legal and license regulation online services or products are delivered only certain countries and regions.

Virtual reality (VR) interacts with the real world virtually to examine or do things [7]. This provides vividness and interactivity. Online VR can rotate various 3D objects (Earth), viewing 3D structures (such as buildings you can see inside before you go), and high-end specialized VR, which is used in game consoles to make players feel as if they are inside the game.

Digital Earth is partly created with 3D mapping, Google Earth, or NASA World Wind, but the real target is eight key elements for Digital Earth: multiple connected digital earths for different needs of audience, problem oriented, allowing the search of the time and space to find similar situations, asking questions about changes, enabling complex data and analysis services, supporting visualization of abstract concepts and data types, multi-disciplinary education lab, and open access for the multiple different platforms and technologies [7][22].

Cloud GIS is GIS software and services on a cloud infrastructure and accessing GIS capabilities using web services. Cloud GIS is a computer paradigm for on-demand network access shared facilities [7][19]. Cloud computing offers an alternative method for GIS software and services to users or customers. Instead of running a GIS on computer systems, with a cloud GIS, the software and services reside on cloud servers mainly (not every time) and are made available through web technologies [19]. With the help of cloud computing, powerful tools are not needed because work may do on the server. However, a disadvantage is that the services may not be available all the time. A cloud GIS may reduce the cost of buying hardware or software to deposit data.

For the future trends, faster and more mobile Internet will be based on the development of a prototype being tested in the USA: 100 Gbit Internet. If the work goes well, this improved area will also affect the GIS. More IP addresses may provide IDs for all objects in the Internet of Things with help of IP6. More mobile is based on faster mobile network technology with the impact and tests conducted with 4G networks. Using more collective intelligence, lightweight programming models, software running on multiple devices, open geospatial web service, making more powerful web clients, mobile serving the pervasive platform, more intelligence on web GIS, and serving GIS directly from clouds are future research areas.

VII. Conclusion

The aim of this paper was to summarize the important concepts and main points of the GIS in the pervasive area. The main concepts of the GISs which are very important last few years, provided information about application areas, and compared some areas with each other. GIS use is based on the user's conditions and is application specific. In addition, GIS is a growing area. Many books and materials explain GIS in technical detail and provide examples. Mainly GIS challenge continues because of the technological evolution. This paper outlined the GIS evolution up to participation in the pervasive area, summarized the main points, and examined the beginning and current states of GIS. Mainly to sum up the work the internet effect on the GISs are positive and make the technology involve more our daily lives. Also the evolution continues, so we see many new things couple of years and these technologies growing and more important next years. As the challenge increases it is positive effect on the people. To conclude distributed and wireless systems make everything become easier than ever before, also examined new research concepts and future trends and suggested GIS trends that should be investigated in the future.

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