SENSORML-NT: INNOVATIVE CLOUD SERVICE SENSOR DESCRIPTION FOR MOBILE DEVICES HANDLING ENVIRONMENTAL ISSUES

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SENSORML-NT: INNOVATIVE CLOUD SERVICE SENSOR DESCRIPTION FOR MOBILE DEVICES HANDLING ENVIRONMENTAL ISSUES

BY

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LIST OF ABBREVIATIONS

AGPS	Assisted Global Positioning System
API	Application Programming Interface
CAT	Web Catalog Service
CEOS	Committee for Earth Observing Satellites
DISA	US Defense Information Systems Agency
EPA	Environmental Protection Agency
GeoLocation	Geographic Location
GIS	Geographic Information System
GML	Geography Markup Language
GPS	Global Positioning System
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transfer Protocol
ISO	International Standards Organization
J2ME	Java 2 Platform, Micro Edition
JITC	US Joint Interoperability Test Command
LBS	Location Based Services
MGR	Mobile-to-Grid Gateway Replication
NASA	National Aeronautics and Space Administration

NGA	US National GeoSpatial-Intelligence Agency
O&G	Observation and Measurement
OASIS	Organization for the Advancement of Structured Information Standards
OGC	Open Geospatial Consortium
OGSI	Open Grid Services Infrastructure
Open GeoSMS	Open Geospatial Consortium Short Message Systems
PDA	Personal Digital Assistants
PND	Personal Navigation Devices
POI	Point of Interest
REST	Representational State Transfer
SAIC	Science Applications International Corporation
SDI	Spatial Data Infrastructure
SensorML	Sensor Model Language
SensorML-NT	Sensor Model Language – Network Translator
SFS	Simple Features – SQL
SMS	Short Message Systems
SN	Sensor Network
SOAP	Simple Object Access Protocol
SOS Station	SOS Station
SSG	Sensor Service Grid

SWE	Sensor Web Enablement
TML	Trivial Markup Language
W3C	World Wide Web Consortium
WCS	Web Coverage Service
Wi-Fi	Wireless Fidelity
WMS	Web Map Service
WPS	Web Processing Service
WSN	Wireless Sensor Network
WSRF	Web Services Resource Framework
XML	Extensible Markup Language

SENSORML-NT: PERIHALAN PENGESAN KHIDMAT AWAN YANG INOVATIF UNTUK PERANTI MUDAH ALIH YANG MENANGANI MASALAH ALAM SEKITAR

ABSTRAK

Peranti mudah alih hari ini boleh didapati di mana-mana dan semakin banyak dilengkapi dengan set pengesan terbenam yang berkuasa. Disebabkan oleh sifat pengunaan peranti-peranti ini, ia secara tidak langsung telah membina satu rangkaian pengesan berskala besar di serata dunia. Jika diperhatikan, kepintaran pengguna yang mengawal peranti-peranti mudah alih serta pengesannya mampu memberikan lebih nilai pada data yang dikumpul. Objektif tesis ini ialah untuk menggunakan khidmat Awan secara inovatif untuk menangani masalah-masalah alam sekitar, dengan menjadikan peranti mudah alih sebagai pengesan. Penggunaan perihalan pengesan dapat membuka peluang-peluang besar dalam menghasilkan satu landasan global yang berkuasa, yang mampu melenyapkan batasan rangkaian asas pengesan mudah alih. Rangka ini mampu merevolusi banyak sektor dalam masalah alam sekitar, iaitu mengumpul, memantau, memproses maklumat dan menstor. Tesis ini menyarankan *SensorML-NT* (Sensor Model Language-Network Translator), menggunakan piawai *Open Geospatial Consortium* (OGC) (SensorML dan Open GeoSMS). Spesifikasi ini mencirikan satu palam lutsinar dan memainkan perihalan pengesan automatik untuk peranti mudah alih. Mengikut pelaksanaan, yang diwujudkan dalam rangka seni bina yang dirumus, pendekatan ini telahpun dinilai untuk menyelesaikan rangkuman peranti mudah alih terhadap data georuang menerusi khidmat Awan. Skema *SensorML* yang terakhir dihasilkan, kemudiannya

disahkan menggunakan *VisAnalysis* dan khidmat sesawang pengesah *Systems Technology* (VAST) *SensorML* dengan memberikan URL bagi arus data kami pada "Sensor.Network".

SENSORML-NT: INNOVATIVE CLOUD SERVICE SENSOR DESCRIPTION FOR MOBILE DEVICES HANDLING ENVIRONMENTAL ISSUES

ABSTRACT

Today's mobile devices are pervasive and equipped with growing sets of powerful embedded sensors. Due to the application nature of these devices, they have unsought build a large scale sensor network worldwide. Notice that the intelligence of human users controlling mobile devices and its sensors will give the collected data more value. The objective of this thesis is to innovatively use the Cloud services for handling environmental issues, considering mobile devices as sensors. Applying sensor description, allows significant opportunities for producing a powerful global platform which eliminates the limitations of basic mobile sensor networks. This framework can revolutionize many sectors of environmental issues, i.e., collecting, monitoring, processing the information and storing. This thesis proposed the SensorML-NT (Sensor Model Language-Network Translator), using the Open Geospatial Consortium (OGC) standards (SensorML and Open GeoSMS). This specification features a transparent plug and play automated sensor description for mobile devices. According to the implementation, established in a formulated architectural framework, this approach has been evaluated for solving the mobile device comprehension to geospatial data via Cloud services. The final SensorML schema created is later validated using VisAnalysis and Systems Technology (VAST) SensorML validator web service by giving the URL of our data stream on "Sensor.Network".

CHAPTER 1

INTRODUCTION

1.1. Introduction

Today's mobile devices are equipped with at least two sensors: the camera and the microphone. If there would be a way to collect and process the data, the mobile devices can be considered as sensing nodes. Additionally, it is possible to connect other sensors to the mobile phones using capabilities such as Bluetooth. Due to the nature of these mobile devices, the widespread and ubiquitous around the world, they have unsought build a large scale sensor network. Furthermore, for places that installing immobile sensors are impossible, not allowed or even may be expensive, this ability of mobile device, allows, efficiently sensing more environmental information. Also, each mobile device is associated with a human user, whose intelligence and assistant, may often be used, to enhance their functionality.

The goal of this research is to enhance the usability of the available mobile devices, for handling the environmental issues using the Cloud; considering the Sensor Web Enablement (SWE) framework which is one of the main standards of Open Geospatial Consortium (OGC) and integrating it with the Open GeoSMS specification that is designed to be used by short message systems (SMS) applications on mobile phones, to share Location Based Services (LBS) Information (OGC 09-142r1).

Grid and distributed systems are connection of super computers, clusters, networks and other resources which produce a virtual environment that is geographically invisible, and can support more heterogeneous collections. Grid computing is optimized for workloads that are composed of several independent processes or jobs, that do require sharing any data during the computation process between jobs, which violates the requirements of being deterministic. So it is clear that, the grid services are a great and useful choice for processing environmental issues.

From the other point of view, this ability will only help collecting environmental information. However for using this information, they must first be processed. Due to their limited resources such as, (slow processors, limited memories, single tasking, etc,) the data cannot be fully processed on the mobile devices; for a faster and better processing also for solving big and time consuming global problems such as environmental issues, the use cloud and distributed computing are obligatory.

This proposed research will illustrate a more scalable and transparent way for using widespread and ubiquitous mobile devices around the globe to manage spatial data using the Cloud; Creating a plug and play mobile sensor to add new data to data bases.

1.2. Background

In the past, mobile handset devices were just wireless cell phones used for mobile telecommunications (i.e., mobile telephony, text messaging or data transmission), over a cellular network of specialized base stations known as cell sites. However, these days mobile devices (e.g., personal digital assistants (PDA), smart phones, laptops, and wearable computers) are increasingly popular amongst those who require the assistance and convenience of a conventional computer in environments where carrying one could not be practical.

Due to the rapid growth in technology and cost effectiveness for the researchers, mobile grid computing is an interesting research area. The main advantages for using the mobile devices is its ability to interact with the Cloud any time at any place, collaborating to share data, resources, innovative user experience, convenience and novel application experience. In the same way, the number of devices available in a mobile grid can be unpredictable, because at any point they can leave and some other devices can join the network. However, the device can be disconnected for several reasons, for example due to battery power loss, by movement out of the communication coverage or probably by turning the device off by the user (Ahuja and Myers, 2006; Magoules and Thi, 2009).

The grid-based mobile environment will allow mobile devices to interact effectively and efficiently by off-loading resource demanding to more powerful devices and computers (Millard *et al.*, 2005). Although, mobile device facilitates the user by giving the advantage in terms of primary resources and computing platform, they also have serious limitations in terms of computational power, storage area and above all the security prospective (Millard *et al.*, 2005).

The use of mobile devices that act as sensors will play an important role, handling the environmental issues of a considerable size. To create a feasible solution which will undertake the accessing, collaboration and sharing, one could apply the available standards that handle the environmental data, using the base grid technologies. However, the data that is sent by the mobile device itself must be readable and useful. The data which is sensed by the mobile device must be collected and converted by a particular standard, so it can be usable. Therefore, a middle component for converting the Open GeoSMS, received from the mobile device, is obligatory.

1.3. Research Problem

Due to the limited recourses which mobile devices have (i.e., limited power, memory, slow processors, etc), to get results which they require, they need to be connected to the Cloud. However, connecting a mobile device to a distributed system and getting useful results, has its own challenges.

Firstly, the mobile device has to find a way to contact to the Cloud. The data that is collected by the mobile device must be converted to a standard type. Additionally, the request should have an understandable format, for both the mobile user and the Cloud services. The system must understand the message, translating it, and then redirect it to a particular system that is specified for the job; causing the system the transparency. Finally, the destination server, should process the data, categorize and storing it in an understandable and efficient manner.

Lastly, the other fundamental challenges, is the scalability of the Cloud. Where in this context, the scalability which is addressed, has the following definitions: First, how the system can adapt adding numbers of the mobile sensors and sensor data ensuring the system scalability. Second, how to enhance a system that adapts to the scalability of the processing tool managing huge data properly.

On the other hand, for a using the collected information, one should use a standard method, so the data can be understandable. Thus, the role of the worldwide standard organizations, are very important. For this thesis, due to the need for handling environmental and spatial data, mainly the OGC is used and also introduced.

1.4. Objectives

The objectives of this thesis are to study and find a better solution for handling environment issues using mobile devices to gain the following advantages:

- Finding a more solid and comprehensive ways to collect the numerous amount of geospatial environmental data from around the globe any time needed;
- Using the mobile devices as sensing nodes as opposed to systems where they are using basic sensor networks;
- Saving and categorizing the information in a standard manner that can be understandable and usable for systems / users that are performing according to OGC standards;

Overall, a more scalable sensing platform with a higher transparency for the mobile devices will be the main research purpose of this study.

1.5. Importance and Significance of this Research

Individuals frequently own a collection of mobile devices. With the growing numbers of powerful embedded sensors available in them, they can observe and collect data. Oppose to basic sensor networks, because of the intelligent human users, the collected data would be more valuable. The mobile devices could be used in situations where basic sensors cannot be employed (e.g., tunnels, shopping malls, earthquake, etc.). To be able to handle the environmental issues, there would be the need for huge amount of data over long period of time; therefore, with the help of voluntary data a richer data base could be achieved.

1.6. Scope of the Research

The scopes of this research are as follows:

- A survey for the possible solutions that can be used to connect the mobile devices to the Cloud;
- A study on how one can handle environmental data by the use of mobile devices;
- After finding the best possible answer for this research, it will also be tried to do a simulation of an enhanced version web service, using a mobile phone to act as a sensor;

- All materials used and investigated in this thesis are limited to the standard and published work related to this research.

The main concern of this thesis is limited to the transparency for the mobile user, supporting sensor plug and play which includes registering mobile node and archiving, which leads to a scalable system.

1.7. Contribution

The contribution of this thesis is to introduce an innovative way of communicating between the mobile devices and the Cloud in an improved manner for using mobiles devices as sensing nodes so they can be used in handling environmental issues. Creating a web service which can guarantee more transparency, automation and accessibility for the users; also the capability to Plug and Play mobile devices.

1.8. Organization of Thesis

Chapter 2 includes all the relevant literature review of the present topic and study. A general introduction of the use of web services for handling mobile device communication will be given. The literature starts with the review of using Mobile phones as sensors; continuing by, spatial data handling and standards from Open Geospatial Consortium, for standardizing the platform and data.

Chapter 3 contains the research methodology of the topic. The chapter begins with the research procedures, continued by introducing the theoretical framework, the justification of the research problem, research design, and the existing limitation of the research, also the list of assumptions.

Chapter 4 contains the purposes the techniques of using the mobile devices as sensors, communication methods, and the selected methods web services, and further details about the methodology are gathered.

Chapter 5 contains the detailed overview of the simulation framework, the various tools that were used; followed by a scenario which has been chosen for presentation and evaluation purpose of the platform's workflow.

Chapter 6 contains the conclusion and scope of the future works in the area of this research is discussed.

1.9. Summary of chapter

In this chapter, first the general backgrounds of the research problem or the introduction has been concluded, continued by the research statement, research questions, scope which must be achieved, the importance and significance of the research. At the end, the summary of what will be covered in the next chapters has been included.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter will explore the literatures that are relevant to understanding the development of, and interpreting the results of this convergent study. Throughout this chapter, the use of cloud for handling mobile device communication will be introduced; in such a way, which they can be used as sensing devices, for environmental issues. It is in this chapter that we also describe the basic assumptions for the problem solving of this research, and also the methods of interpreting the results.

The first part of this literature survey will cover reasons, for using mobile devices as sensing nodes; In brief, how they would be involved in handling environmental issues would be mentioned. Hence, the existing limitations will argue with the review of previous attempts, the existing communication methods of mobile devices are also introduced.

The other presented overview in this chapter would be, a summary of research literature on effective problem solving using the Open Geospatial Consortium (OGC) standards for the environmental information. Consequently, the importance of using standardization and also metadata will be projected, and therefore, a comprehensive overview of Standardizing Sensors and the universal observation with the role of SensorML will be presented.

2.2. Mobile phones as sensors

With the rapidly growing numbers, mobile phones are turning to the central computer and communication devices for people, noting that they are mostly equipped with rich sets of embedded sensors. Anywhere people are, mobile devices can be found. It is Important to note that the mobile phones have minimum one sensor (i.e., microphone); however, new mobile devices are also equipped with cameras, and other sensors such as accelerometer, digital compass, gyroscope and GPS are widely available on many mobile devices. Other sensors can also be easily connected to mobile devices using their capabilities such as Bluetooth.

Furthermore, due to the nature of the mobile devices, they are widespread and present everywhere (especially at the same time) around the world, so they have unsought build a large scale sensor network (Lane *et al.,* 2010; Kansal *et al.,* 2007).

Using mobile devices as sensors has a significant advantage over basic wireless sensor network, due to the intelligence of the human user, associated with mobile phone. Firstly, a relatively predictable power supply, based on an initiated charging (Kansal *et al.,* 2007). Next, providing a wider coverage also lowering the cost, where static sensors are hard to deploy or cannot be installed. Note that, No single entity can place sensors across the complete coverage domain required by an application, such as subways, public parks, shopping malls, and hotels. Additionally, there might not be a need for sensors to be available at all times. Lastly, more relevant and useful data will be collected, with the assist of the human user. For instance, aim the sensors, to that particular direction for data collection. Likewise, only using the mobile phone to capture voluntary data (GoodChild 2009), that are not predicted such as natural disasters for instance flood. Having in mind, Mobility increases the overall accessibility (Millard *et al.*, 2005).

In spite all the research, “mobile phone sensing is still in its infancy”. Mentioned by (Lane *et al.*, 2010), on the sensing architecture, there are little or no consensus for the mobile and Cloud. Furthermore, without interpretation, the raw data that is collected by the mobile devices are worthless. Figure 2.1, shows a mobile sensing architecture.

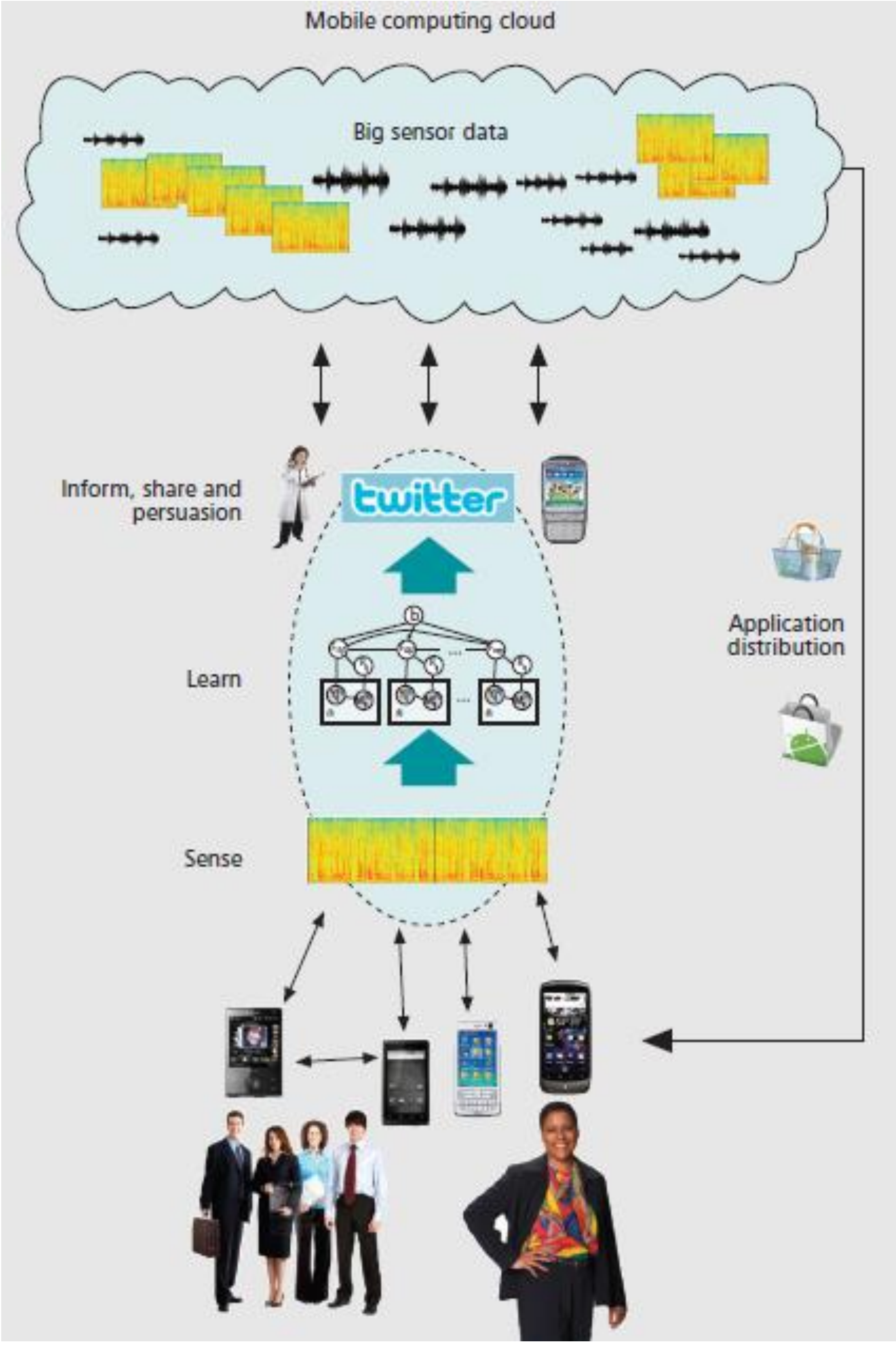

Figure 2.1: A mobile sensing architecture (Lane *et al.*, 2010).

2.2.1. Challenges of mobile devices

While mobile devices are growing, still there are a large number of challenges that these devices are facing. Limitations such as memory, processing power and the communication channels, impose great difficulties to provide user as an option to solve complex problems (Palmer *et al.,* 2009; Ozturk and Altilar 2007) considers PDAs and mobile phones in the same category (i.e. minioms) since they share the same communication protocols, although they have different hardware and software.

Additionally, the existing and growing number of wireless mobile devices often demands more computational power than currently provided by their devices (Kurkovsky *et al.,* 2004). Relatively, to overcome the limitations of the mobile devices, several attempts have been addressed by previous authors.

2.2.2. Previous attempts

A grid based mobile environment allows mobile devices to become more efficient by offloading resource-demanding work to powerful processors (Venkata 2007); this paper uses a java based mobile device. (Mangs *et al.,* 2008) also presents a framework, enabling the mobile devices to access web services on Globus-based grids. On the other hand, (Chu and Humphrey 2004) introduces Mobile OGSI.NET to overcome the limitations for mobile devices which do not support OGSI runtimes.

However, the existing middleware platform, Globus, does not fully address mobility (Sajjad *et al.,* 2005). Due to this weakness, the real ontology services would be available via gateways; as used by (Grabowski *et al.*, 2006) to overcome the limitations faced while using J2ME technology. (Minh *et al.*, 2005) also introduce a new mobile-to-grid Gateway Replication (MGR) to improve the reliability of grid services provided to mobile devices.

(Millard *et al.*, 2005; Guan *et al.*, 2005; Tzu-Chi *et al.*, 2005; Phan *et al.*, 2002) employed the proxy as the central of the infrastructure, that allow the local mobile devices look ahead to the next generation of WSRF-GRID infrastructure (Web Services Resource Framework). The proxy based architecture, allows favourable deployment, interoperability, scalability, adaptively, and fault-tolerance to emerge as well.

Illustrated in Figure 2.2., is the shared sensor network of mobile phones, introduced by (Kansal *et al.*, 2007). This system consists of 3 key entities:

- Sensors: the mobile devices which sense the physical world.
- Network Infrastructure: includes a data repository that stores all the sensor data provided by the mobile devices, a tasking server that enables applications to program the sensor network as per their requirements, and a sensor proxy that allows disconnected operation for sensors while making their data available to applications.
- Users: applications that access the shared Sensor Network or human users who access the sensor data through a graphical user interface.

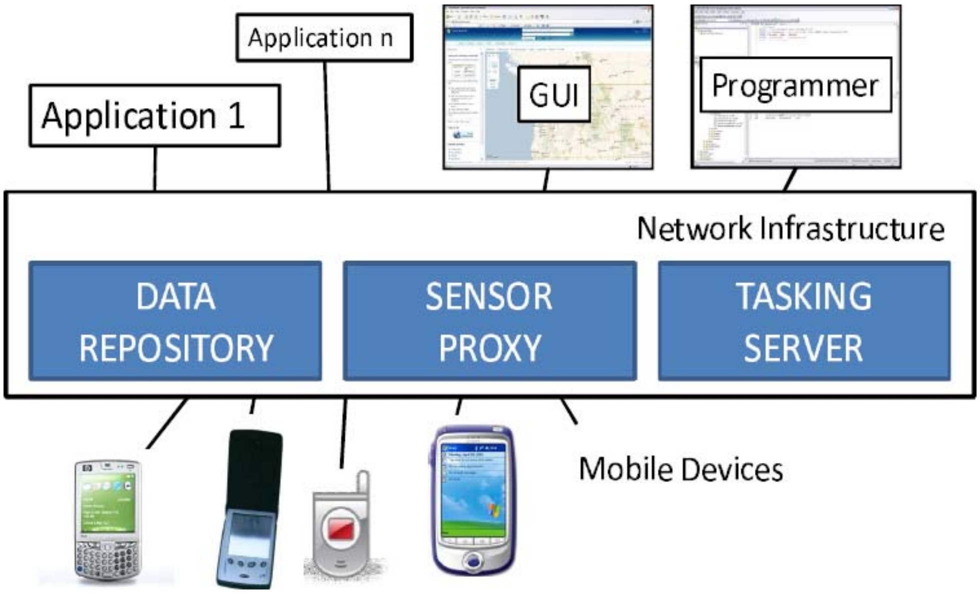

Figure 2.2: A shared sensor network of mobile phones (Kansal *et al.*, 2007).

2.2.3. Summary

To conclude, previous authors have tried to overcome the limitations of basic mobile devices by connecting them to the gird and grid services. Moreover, with the use of proxy servers, they guaranteed a more reliable connectivity while there is mobility. Furthermore, there are practices on using the mobile phone as sensors; however, there are little consensus on Cloud and mobile devices.

Thus, most attempts are based on wireless connection, such as Wi-Fi. However, communication using mobile phones via the internet might not always be possible. On the other hand, cellular networks have a higher coverage for these devices. So far, cellular networks would be a suitable option to overcome the existing communication problems and might even be less costly.

2.3. Open GeoSMS

Open GeoSMS specification of OGC, designed to be used by Short Message System (SMS) Applications on mobile devices capable of handling SMS, facilitate the communication among different Location Based Service (LBS) or applications. Open GeoSMS proposing reason is to standardize the LBS information, solving the barrier in LBS industry development caused by the dissimilarity of different applications. Thus, without causing much effort or cost, SMS is the best choice (OGC 09-142r1).

2.3.1. Related work

Increasingly popular worldwide, Location Based Services (LBS) applications cover a wide spectrum of wireless users, for fleet management in location identification, for cases such as emergency, or travel aids. Current methods of GeoLocation would be classified into: GPS-based, cellular network based, or a combinations of both aka AGPS (AssistedGPS) (Mok *et al.*, 2004; OGC 09-142r1).

(Mok *et al.*, 2004) research, developed with ESRI's GIS Active X-MapObjects, sends a request to the service gateway for the mobile device's location. The location polling system is illustrated in Figure 2.3. The Position of the mobile device is send via internet, for the mobile device equipped with JAVA SIM card. The end the relevant information would be sent to the mobile device by SMS message.

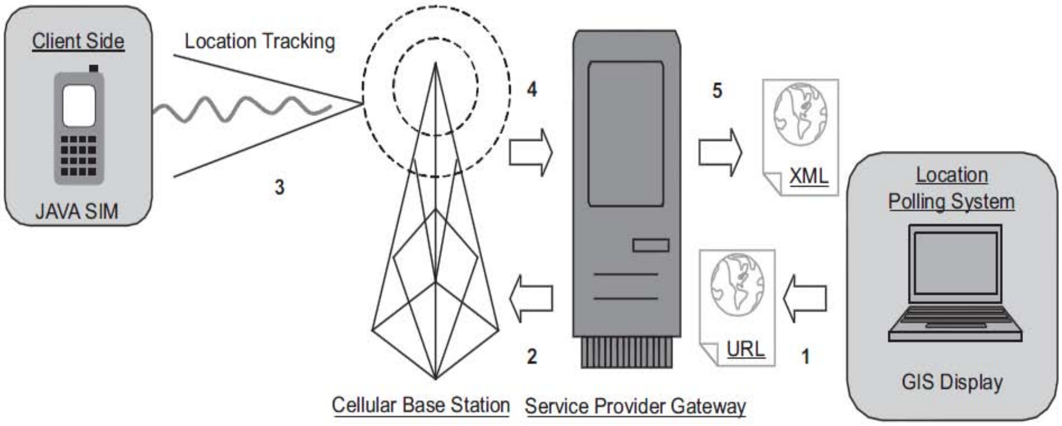

Figure 2.3: System Design of the LBS Test (Mok *et al.*, 2004).

(Licoppe *et al.*, 2009) methodology, experiments an empirical apparatus for collecting and aggregating data, using mobile phone; concerning the locations of users and their communications. (Hester *et al.*, 2010) as part of Mission 4636, after a 7.0 magnitude earthquake struck Haiti on 12 January 2010, conducted Crowd sourced Translation. Crowd sourcing, filter, verify, translate, and geo-tag, all the incoming SMS reports, by distributed entity.

2.3.2. Summary

To sum up, worldwide humanitarian crises would be facilitated with effective responses sharing information, with the use of distributed, SMS-based systems (Hester *et al.*, 2010). Previous authors have tried to overcome existing information sharing challenges, with the use of SMS-based systems; also geo-locating the devices. The best specification available, Open GeoSMS, introduces a standardized messaging format. However, there are no exact attempts on how it can use the mobile devices as sensing nodes.

2.4. Standardizing Sensors for universal observation

In this part, the available standardization for sensors and sensor networks also the standards for geographic information systems is covered.

2.4.1. Sensor and sensor network Standardizations

2.4.1.1. Introduction

Although all sensing devices can give an output, there must be a definition of what this output result defines. For instance, if collecting temperature, our sensing device would be a thermometer, and the output result could in Celsius or Fahrenheit or other measurements units. In this part, Standardizing Sensors for universal observation is gathered in brief.

2.4.1.2. Sensor Network

A Sensor Network (SN) is a group of computer accessible network of specialized transducers, spatially distributed devices, with a communications infrastructure intended to monitor and record conditions at diverse locations. Commonly monitored parameters are temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollutant levels and vital human body functions. A sensor network allows us to observe, and respond to phenomena in the natural environment, and in the physical and cyber infrastructure (Botts *et al.,*2007; Chao-Tung *et al.,* 2008).

2.4.1.3. Related Work

Related to the existing work, the fields of sensor network and grid computing would be grouped in 3 categories:

- SensorWebs- to enable timely and secure access to sensor readings, different kinds of sensors are connected together via middleware;
- Sensors to Grid- to facilitate scientific collaborations,

  Different sensors and instruments are connected to the grid, for research and visualization;
- Sensor Networks to grid- aims to integrate sensor network, mainly by the grid services and enable queries on 'live' data.

(Tham 2006), describes a concept of Sensor-Grid computing and the architecture of SensorGrid. This paper shows the uses of SensorGrid for event detection, classification and decision-making. Although, this architecture builds on the three categories, there are limitations due the centralized approach.

2.4.1.4. Sensor Web

Sensor Webs are often confused with "distributed sensors" or "sensor networks". Nevertheless, as sensor networks mature, a common set of operations emerge; gathering in a conceptual framework, the Sensor Web is created (Kobialka *et al.,* 2009). The unique feature of the Sensor Web is that the information gathered by one node is shared and used by other the nodes. In contrast, a sensor web is a type of web accessible sensor networks or geographic information system (GIS) and archived sensor data that can be discovered and accessed using standard protocols and Application Program Interface (APIs) (Botts *et al.*, 2007; Delin and Shannon 2001).

Sensor networks simply gather data and information gathered by a particular node, in a network where it is not influence by the behavior of another node. Simply saying, sensor web enables distributed discovery, exchange and processing of spatially distributed data, available from multiple sensor networks or the internet (Fairgrieve *et al.*, 2009). Figure 2.4 illustrates the Sensor Web concept.

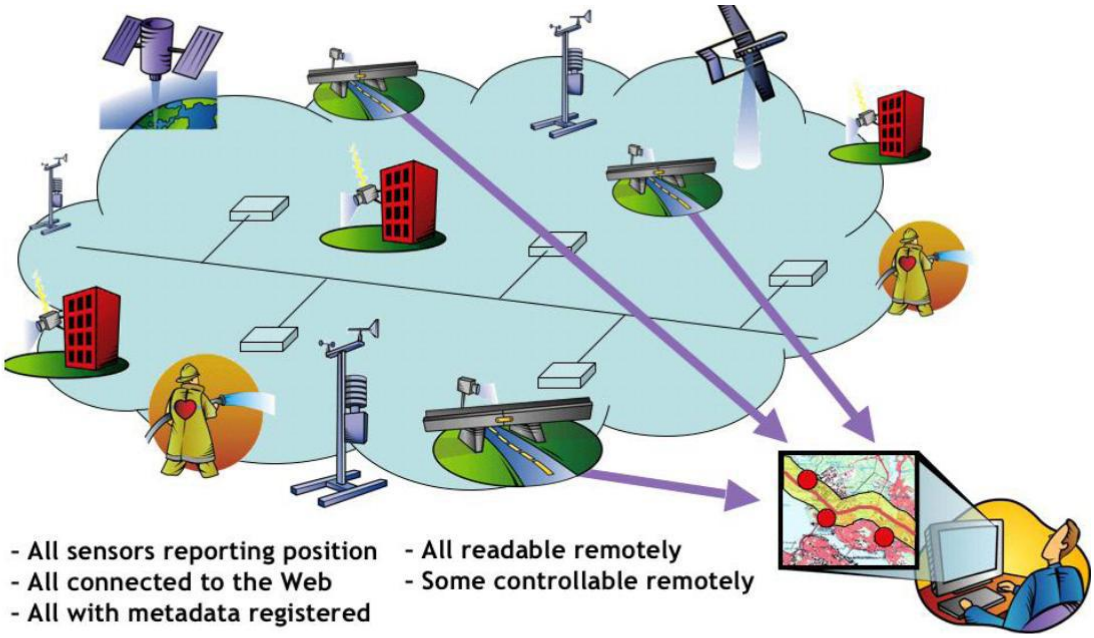

Figure 2.4: Sensor Web concept (OpenGeoSpatial).

2.4.1.5. SensorML

Under the international Committee for Earth Observing Satellites (CEOS), in 1998, Dr. Mike Botts introduced the Sensor description format as a standard mean of defining sensor systems terms to aid in the processing and geolocating of sensor observation; This describes the geometric, dynamic, and radiometric properties of dynamic remote sensors. In 2000, after receiving recommendations to define Sensor Modeling Language by utilize it with eXtensible Markup Language (XML) standard, sensor Modeling Language (SensorML) was introduced and funded under a NASA AIST Program for further development.

In year 2001, SensorML was brought under the Open Geospatial Consortium (OGC) standards body, served as a catalyst for the OGC Sensor Web Enablement (SWE) initiative. Further development of SensorML has also been supported by the following organizations; US Environmental Protection Agency (EPA), the US National GeoSpatial-Intelligence Agency (NGA), the US Joint Interoperability Test Command (JITC), the US Defense Information Systems Agency (DISA), SAIC, SEICORP, General Dynamics, Northrop Grumman, Oak Ridge National Labs, and NASA (OGCNetwork).

The Sensor Web is an open compel adaptive system; coordinated observation infrastructure, composed of a distributed collection of resources which can collectively behave as a single, autonomous, task-able, dynamically adaptive and reconfigurable observing system that provides raw or processed sensor data or sensor meta-data, via a set of standards-based interfaces. OGC SensorML standard is the predominant standardized mechanism of describing sensor resources for Sensor Webs (Zyl and Vahed 2009).

2.4.1.6. Summary

To sum up, while Sensor networks coordinate monitoring of particular phenomena by linking spatially distributed sensors, Sensor Webs are distinct; its loosely couple web services, enabling distribute discovery, exchange and processing the sensing nodes that are interpolated using standardized interfaces. To include interaction beyond sensor-to-sensor exchanges, (such as, sensor-to-forecast model exchange) making observation available, the role of Web applications come in play (Fairgrieve *et al.*, 2009; Durbha *et al.*, 2009).

Additionally, SensorML is one of the mechanisms for describing sensor resources on the web. Furthermore, completely distributed workflow descriptions on the web are facilitates by SensorML. However some existing challenges still remain on how to fully capture the requirements as relating to open and distributed environments using SensorML which some extensions are required (Zyl and Vahed 2009).

2.4.2. Geographic Information System (GIS)

Many environmental problems and habitat-monitoring tasks, disaster managements and etc., require near real-time field mapping and precise positional information (Tsou *et al.*, 2004). Also, many of our decisions depend on the details of our immediate surroundings and require information about specific places on the earth surface. They are called geographical information, due to the fact that they are distinguishing one location from another, to make decisions for the appropriate place.

Geographic information, allows us to apply general principles to specific conditions of each location, track what is happening at any place, and also helps us to understand how one place differs from another; similarly, this is essential for effective planning and decision making.

Geographic information system (GIS) is used generically for any computer-based capability for manipulating geographical data. A GIS not only includes hardware and software, but also the spatial data used for input data. Geographic information attaches a variety of qualities and characteristic to geographical locations, illustrated in Figure 2.5., These qualities may be any physical parameter, such as temperature, soil moisture level, as well as classifications according to type of vegetation, zoning, and ownerships and so on (Bernhardsen 1999).

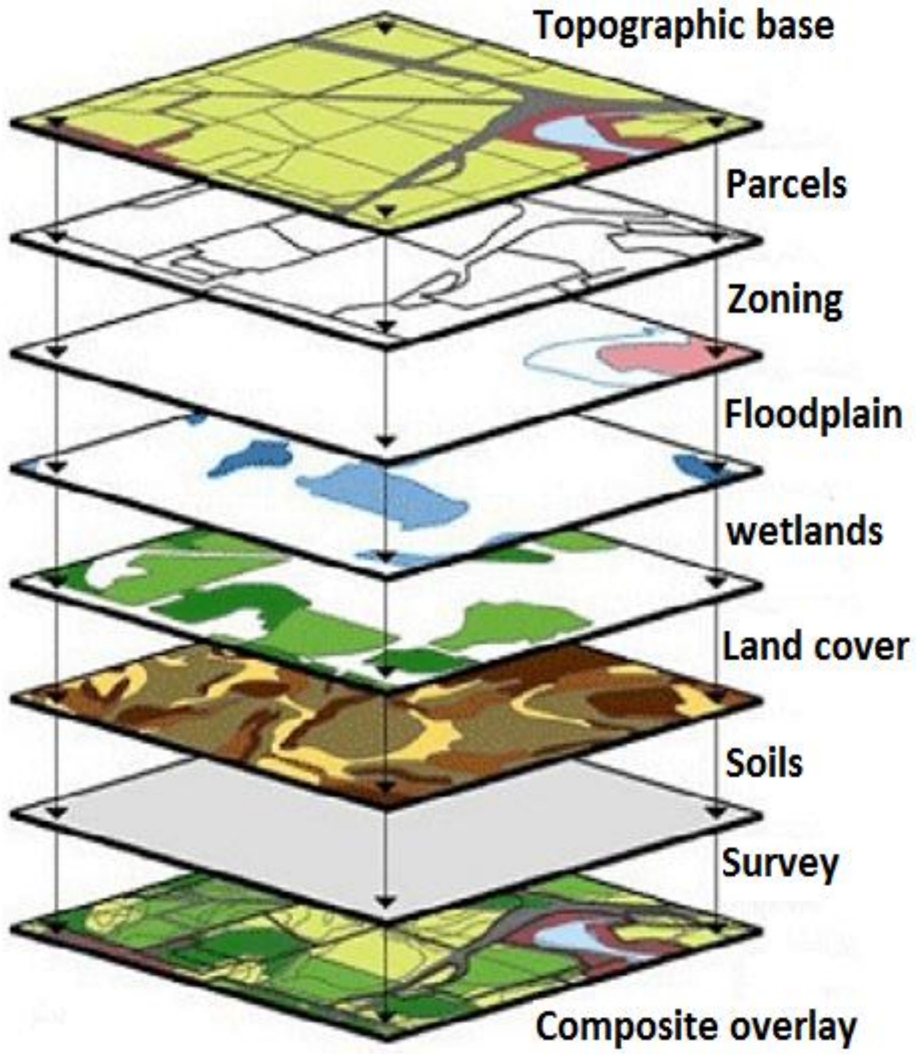

Figure 2.5: Visualizing the data stored as theme layers (Gistownofchapelhill).

However, the increase integrations and combinations of the geographical data, increase mutual understanding among users, and eliminate technical problems for exchanging data between different systems, the Geographical information and it system must be standardized, so the data can be useable and understandable that is. A standard will provide definition of data structures, data content, and rules (Bernhardsen, 1999).