



**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
COLLEGE OF NATURAL SCIENCE
DEPARTMENT OF COMPUTER SCIENCE**

**A FRAMEWORK FOR PERVASIVE CONTEXT-AWARE
ETHIOPIAN AGRICULTURAL MARKETING
INFORMATION SERVICE**

**BY
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Dedication

To: My beloved daughters:

Rediet Yared and Meklit Yared, and

My mother Aselefech Bayou

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List of Acronyms

AMIS - Agricultural Market Information Service

AOA -Angle of Arrival

BS- Base Station

BSIC -Base transceiver Station Identity Code

BTS- Base Transceiver Station

Cell ID - Cell Identification

ECX – Ethiopian Commodity Exchange

E-OTD -Enhanced Observed Time Difference

GPS - Global Positioning System

GSM- Global System for Mobiles

HSQL - hypersonic SQL

LMU -Location Measurement Unit

MIS - Market Information System

MS - Mobile Station

NLoS -Non-Line of Site

NMR - Network Measurement Result

PC - Personal computer

PCAAMIS - Pervasive Context-Aware Agricultural Market Information Service

RSS -Received Signal Strength

RSSI- Received Signal Strength Indication

SMS- Short Message Service

TA -Timing Advance

TDoA -Time Difference of Arrival

ToA- Time of Arrival

Abstract

A lot of work has been done on the development of context-aware applications that focus on enabling pervasive computing using mobile devices. Most of these systems are context-aware mobile systems which aim at delivering information and services tailored to the current user's context. Furthermore, several intelligent mobile marketing frameworks have been proposed and prototypes have been developed. Context aware services have the ability to utilize information about the user's context to adapt services to the user's current situation and needs. In this work, we propose a framework for pervasive context-aware agricultural marketing information service that targets in providing agricultural market information to the end users based on the user's interest, preference, and current location and time. The framework is designed in client-server architecture that has two types of clients and a server. In this framework the local agricultural market data are collected using smart phone (with built in GPS receiver) from the local marketplaces, and stored in the context repository for reference. The agricultural market information is delivered to the end user in two modes pull and push. In pull mode, the system provides a list of possible preferences and request for the user to explicitly pass his/her preferences and interests to the server, and the server analyzing the user request (interest and preference) and performs reasoning and decisions based on context data store in the context repository backend databases. Then, it delivers the relevant information to the user that matches to his/her interest and preference. On the other hand, in push mode, analyzing the user's interest and preference from the user profile history or during special event trigger, the system pushes notification message to the user. Besides this, in this work the user's location is determined (identified) by using cell-Id and RSSI measured value of the currently servicing and neighboring BSs that are fetched from the user's mobile phone (without built in GPS receiver). To demonstrate the validity of the proposed framework, we developed a prototype that implements the core components of the proposed framework.

Keywords: Pervasive Computing, Context-awareness, AMIS, MS, RSSI, Cell-ID
PCAAMIS Framework. PULL-MODE, PUSH-MODE:

CHAPTER 1

INTRODUCTION

1.1. Background of the Study

In Ethiopian commodity sellers especially of small-scale farmers, who produce 95 percent of the country's agriculture output, come to market with little market information [1]. They are always reliant on market information obtained from traders they know in their locality [1,2]. The availability of information concerning what is going on in the market significantly improves the decision making capability of the farmers and consumers, and strengthens their bargaining power [2]. With volatile and unrewarding prices, they will simply lack the motivation to raise production, productivity, and most importantly maintain quality [1]. The resulting impact on national economy is devastating, for a nation that desperately relies on a foreign currency earned from the export of agricultural commodities [1]. Due to these, priority must be given to ensure the accessibility to information, its delivery, and its outreaches so that informed decisions can be made. Hence, designing and implementing quality marketing information system that would enable to generate and disseminate up to date and real time information to all market actors is of paramount importance. The characteristics of quality information involve relevancy, accuracy, sufficiency, and timeliness [3].

There is growing interest in the use of context-awareness as a technique for developing pervasive computing applications that are flexible, adaptable, and capable of acting autonomously on behalf of users. Pervasive computing is a new computing trend that emerged out of distributed and mobile computing [42]. Among the important characteristics of pervasive computing, context awareness, invisibility, ad-hoc networking, and sensors are mostly mentioned. Context refers to information that is used to express a situation of an entity, where the entity can be a person, or any other thing [28,29,30]. Context can be location, preference, emotion, or activity of the entity from which the context is captured. Hence, the ability of a given system to understand the context of an entity is termed as context-awareness [29,30].

Emerging pervasive computing technologies transform the way we live and work by embedding computation in our surrounding environment. Users can manage their information “anywhere

and anytime,” using portable devices or devices embedded in the environment. To simplify a user’s everyday activities, however, users should not be exposed explicitly to the complexity of new technologies. It is unreasonable to expect a user to configure and manage hundreds of computationally enhanced appliances that he may use in a pervasive-computing environment, particularly when the devices and their interactions change as the environment changes around them [31].

Location is very important parameter in mobile services. It is usually determined using a network of satellites (GPS) or a network of antennas, either wide area (GSM/GPRS) or local area (e.g. Bluetooth) [49,56, 57, 67]. There are many different techniques that have been developed for location identification. Some of them are more appropriate for outdoor environments, and some of them are better for indoor locations. The most common mobile positioning methods are based on Cell Identification (Cell ID), Time of Arrival (ToA), Received Signal Strength (RSS), Time Difference of Arrival (TDoA), or Angle of Arrival (AOA) measurements determined from the MS signals received at the BSs [49,56, 57,67]. In this corresponds, we focus on mobile positioning using Cell-Id and RSS information. Signal strength is an easy and low-cost method to implement in GSM, because it does not require any changes to the handset and existing network infrastructure. RSSI information is readily available to the user’s applications on almost all GSM phones. Such systems have the potential of localizing 80-85% of today’s cell phones [66]. For these reason, We decided to use RSS positioning method for identifying the user’s location. The MS continuously measures the signal strength from each base station and reports this information back to the serving base station. With this signal strength information, it is possible to calculate the position of the MS, by taking into consideration the fact where the received signal strength degrades as the distance between the transmitter and receiver increase. However, there are number of factors that limit the effectiveness of this method. Some of them are the distance between MS and BTS, the characteristic of terrain between the transmitter and receiver, and the issue of indoor attenuation [49, 56, 57, 67].

Hence, in order to minimize the existing unfair trade practice in the country, developing a framework that provide agricultural market information service to user through the

implementation of pervasive context aware system using the existing wireless network infrastructure is important.

1.2. Motivation

Lack of accurate and relevant market information has been identified as a major obstacle in efforts to improve the agricultural sectors in most of developing countries [8]. Market information is an important aspect of Agricultural Marketing. It becomes necessary for ensuring fair returns to the farmers with remunerative prices to the farmers for the sale of their produce, to boost up their efforts for increasing and sustaining the agricultural production [9, 10]. Hence, providing market information is one strategy for sale and buy of agricultural produce at reasonable prices, in the absence of organized and timely market information [9, 10, 11]. In addition to this, currently there is a challenge that could bring marketing information to the rural farmer, producer and consumer due to the lack of a means for providing marketing information based on consumer and producer preference, except that by using SMS, e-mail, and media which is not based on customer preference [10,11]. Since agricultural marketing information is one of the public interest, researchers dig out available pervasive context-aware computing technologies to be applied for this domain.

This motivated us to search for a solution that makes use of the existing wireless network infrastructure to provide context aware market information service to fulfill the needed service in the domain. Moreover, to provide the context-aware information service to the user at any time-anyplace paradigm, the user's location has to be identified. There are different techniques for locating mobile phone. Identifying user location using GPS techniques requires GPS receiver built-in the mobile phone that makes the mobile phone very expensive. As the result of this, using GPS techniques to identify user location is not cost effective. Furthermore, in Ethiopia, most of the people, especially the farmers, use an ordinary cell phone (without built-in GPS receiver). Hence, we are also motivated to identify user's location using an inexpensive way in GSM mobile network environment without incurring any additional cost using the existing wireless network infrastructure. Besides this, we also motivated to contribute for the development of location based services to reach the rural region in the country.

1.3. Statement of the Problem

There are anti-competitive and unfair trade practices in Ethiopia. The market dominance practiced through informal agreements between merchant with the object of setting prices. Consumers and farmers not only suffer unfair deals but are also unaware of their rights and responsibilities with regards to buying and selling of goods and products. Consumers at the domestic market place need to bargain wisely. They need to have the power of discerning and judging properly as to what is true or right amount for a product to pay, which lead them for unnecessary wastage of their time and labor. In most of domestic market place consumers waste their time and money in searching of the desired product with the reasonable price. There are so many defects in service delivery, market places, public transport, and promotion and communication. The people always get a raw deal because they don't have access to essential information that would make their day-to-day life easy.

There are a lot of abuses in the local market practices on the consumers and farmers on product prices with regarding of the location where the product exists, season, and in the case of low availability of product and transportation. Consumers and farmers are also deceived by unfair trade practice caused by brokers and dealers. In the market place consumers have no rights to get sufficient and accurate information of the quality and type of goods and services. They also have no right to claim compensation for damage they suffers because of transactions in goods and services. It is estimated that 28 million farmers sell their crops in informal local markets where they fail to gain the right price for their products [14].

All of this is the result of the existence of marketing information gap and lack of consumers' awareness. The lack of market information represents a significant impediment to market access especially for smallholder farmers. Farmers are getting only a small portion of the profit or sometimes none due to existence of multiple middlemen at every stage of the market chain. The fact that Ethiopia has dispersed and underdeveloped markets, poor infrastructure, and low farmer income presents obvious challenges to the dissemination of markets information to the farmer [2].

This problem will be addressed through providing marketing information to consumers and farmers, which has an important role in facilitating fair trade practice and in creation of consumers and farmers awareness. This will be done by disseminating marketing information to

them with the currently existing infrastructure and capacity. Fairness of commodity trading and adequate protection for consumers and farmers is essential for determining fair market place and commodity price discovery. Rumors or false information mislead the public in making a commodity trading decision.

Market information is supposed to give farmers and consumer more bargaining power. If they know the current real price of the product, they are less vulnerable to traders' greed. This can help them determine and find a better market place for sale and purchase products. In the country, there is a need of location based market information provider center. Lack of such marketing information system is a common phenomenon in the country. Marketing information includes: market price, product availability, market place, market opportunities, sales offers, etc.

Problem Description

Consider the following two scenarios:

- 1. Andarge is a small hold farmer, who lives somewhere in the rural village of the country. This year, he produced more teff, because at farming time there was enough rain and adequate fertilizer with reasonable price. Due to excess yields, he wants to keep some of the produced teff for his household food consumption, and to sale the rest. However, he has no idea about where he should ask a better teff price. He also does not have information about the level of production and price of teff in other places. He thinks that the price of teff may decline, because of excess yield in his area. Since he doesn't know with what price to sell it, he may not gain the expected profit if he sells it now. As the result, he desires to refrain from selling it now, and he wants to sell it another time at a better price. But, he doesn't have any clue what will be the price of teff in the near future. May be next time, the weather condition is good or not good, or the price of fertilizer becomes high or low. Consequently, the price of teff may rise or decline more, and he may not attain his expectation. Because of this, he is in dilemma whether to sell it now or keep it for the next season to retain from loss or to attain profit while selling it with a better price.*

Hence, to make such decision Andarge needs real time reliable marketing information, about current market price, market place, level of crop production, and availability of crops based on his current location as well as his preferences. He would like to interact with the respective service via mobile devices, such as mobile phones etc.

2. *Almaz is a consumer who lives somewhere in a small village. In her living area this year, the weather condition is not good for crop production. Because of lack of enough rain at farming time, the local merchants, who have an intention of selling more teff with high price to earn unreasonable excess profit, disseminate false information about the existence of drought in the country this year. Because of this, Almaz is worried about having enough teff with reasonable price. She thinks that there may be shortage of teff and its price may become higher due to drought. She doesn't know the current market price and availability of teff in other market place. Moreover, she has no idea where and by how much to buy it. As a result, she may blindly go to the nearest local market and buy more teff with high price. Thus, she is in crucial condition whether to buy more teff with high price than the usual or not to buy. Hence, she needs to have reliable information for making a decision whether to buy more teff with high price and keep herself and her family from the drought or to refrain from buying teff to reduce the risk of unnecessary loss of money.*

Hence, to make such decision Almaz needs real time reliable marketing information, about market place and local price of teff based on her current location as well as her preferences. She intends to interact with the respective service via mobile phone, which she already uses for daily communication.

Such problem can be solved by designing a framework that is able to provide reliable marketing information according to the interest of consumer or farmer at anytime and anywhere using the existing infrastructure based on context of the user. The proposed framework is able to support these individuals in having the necessary marketing information, throughout the country at anytime and anywhere based on their interest using their wireless mobile devices, such as cell phone, etc.

The study aims to answers the research questions:

- What are the major attributes that are appropriate to identify the requirement for pervasive and context-aware agricultural market information service?
- What type of pervasive context-aware marketing information service lets user especially consumers or farmers express their interest?
- How do we sense and collect contextual information autonomously from cellular stations and devices?

- How do we extract, represent and manage various types of contextual information and update it dynamically to consider contemporary issues during service preparation?

In this study, it is hypothesized that, a consumer or farmer can obtain the necessary and reliable marketing information at anytime and anywhere based on his/her interest and preference that helps him/her in the decision making through the implementation of pervasive context aware marketing information service using the existing cellular network infrastructure.

1.4. Objectives of the study

The general objective of the study is to design a framework of pervasive context-aware marketing information service that can be used to provide agricultural market information to users at anytime and anywhere through using the existing cellular network infrastructure.

The specific objectives of the research are to:

- Identify, integrate and analyze market related information.
- Identify the appropriate attributes that can be used to extract context aware information.
- Investigate the applicability of the existing cellular network infrastructure for implementation of architectures of pervasive systems related to marketing information service.
- Identify components of the proposed framework that best suited for delivering pervasive context-aware marketing information service.
- Investigate how the framework components are integrated to deliver the intended service.
- Develop the prototype of the proposed framework.

1.5. Scope of study

This study is mainly concerned with developing pervasive context-aware agricultural marketing information service framework using the existing wireless infrastructure. It focuses on providing context-aware market information service through collecting contextual data from local marketplaces using smart phones based on user interest, preference, time and location. The study will address identification of location of users and nearby market place. Even though it can be extended to other products, the main focus of the study is on delivering agricultural product market information, especially for farmers and consumers at anytime and anywhere. Implementation and testing is based only on prototype.

1.6. Methodology

In order to carry out this study, the first step is to understand and analyze the research domain (agricultural marketing environment) through studying the art of pervasive context-aware computing. This is performed by conducting extensive literature review relevant to the research topic. In other word, extensive literature review is conducted on context-aware, pervasive computing, and mobile marketing, mobile positioning techniques and related issues in pervasive environments to gain deeper understanding of the research domain. Doing extensive literature review helped us to gain a better and solid understanding of the problem domain.

Data collection and Modeling: The relevant data for this study is gathered by using both primary and secondary source of data. Data is collected through physical observation of necessary documents and interviewing the appropriate person to capture raw facts and to come up with appropriate marketing information service. The context raw data is modeled based on ontology modeling techniques. The analysis of data is performed by identifying system and user's requirement in the proposed framework, and capturing marketing information constructs using ontology modeling approaches.

Materials and methods: For this study, we use software tools, technology, and protocol which are found to be appropriate to the research. The Java programming language, IEEE 802.11 wireless LAN communication protocol, MY SQL database management tools for backend context storage, Android Development Tools for wireless mobile devices, Protégé Ontology development tools for developing domain ontology, and Apache-Jena Semantic Web framework for context representation and reasoning are used in the prototype implementation. After identifying the necessary tools, technologies, and protocols required, we develop the prototype to test and validate the proposed framework.

1.7. Significance of Study

The proposed framework will allow anyone at anytime and anywhere in the country where the wireless network exists to obtain market related relevant information based on his or her desire using his or her wireless devices. More specifically, the significance of the study will be to:

- Increase the level of awareness of farmers and consumers about existing market information.
- Empower farmers and consumers to attain more bargain power and ability to determine markets more efficiently and profitably.
- Encourage investment in the country through developing better and appropriate marketing service that minimizes unnecessary wastage of time and effort in finding appropriate information.
- Support in monitoring unfair domestic trade practices and minimize the market dispute, and facilitate faire trade relation in the country.
- Helps in fulfilling the expectation gap between the market demand and the supply chain through providing timely and appropriate market related information.
- Support for developing an efficient and stable marketing system in the country.
- Assist consumers and farmers in obtaining reliable and sufficient marketing information services.

1.8. Thesis Organization

The rest of this thesis report is organized into the following Chapters. In Chapter 2, we discussed the agricultural market trends in Ethiopia, state of the art in pervasive computing, mobile market and mobile positioning techniques with propagation path loss model. In Chapter 3, we discuss related works. Chapter 4 presents the detail of the proposed pervasive context-aware agricultural market information service framework, and provides architecture holding components of proposed framework. Chapter 5 presents the prototype implementation with general description of implemented components, tools and technologies manipulated, and implementation scenario of the proposed framework. In Chapter 6, we present conclusion of the study and future work. Finally reference and appendices close this thesis report.

CHAPTER 2

LITERATURE REVIEW

2.1. Agricultural Marketing in Ethiopian

2.1.1. Agricultural Market

Agricultural market in Ethiopia is characterized by insufficient market information, poor quality, unstable price, lack of trust among trading partners, and uncoordinated markets [2, 4]. It is estimated to be about 42% of the total population of Ethiopia depends on the market for all or part of its food supply [6, 7]. Almost all urban consumers are dependent on the functioning of agricultural markets to acquire their food, which accounts for about 65% of total household expenditure [7]. It is clear that an inefficient marketing system entailing substantial costs to consumers will have detrimental effect on the food security and wellbeing of the society.

Farmers normally bring their marketable products to markets that are 5 to 20 km away from their villages and about 79% of their annual sales occur immediately after the harvest when they need cash to purchase their immediate needs [6]. In Ethiopia, farmers and merchants do not have access to high-quality market information upon which they base their marketing decisions. The information that farmers get in particular does not assist them in deciding what crops to plant and how much. There is practically no market extension service in the present system that guides farmers in their production, storage and marketing decisions [5].

2.1.2. Characteristics of the Ethiopian agricultural marketing system

Agricultural marketing system in Ethiopia have many specific characteristics determined by a range of economic, demographic, social, legal and climatic factors. Effective marketing systems are shaped by these influences and will tend to change as these underlying influences change. Some of the major factors that influence the nature and performance of the Ethiopian marketing system are [15]:

- Wide variety of crops.
- Regional variations in production and marketing that lead to the need for a complex marketing system and significant inter-regional crop flows.

- Large distances between production and consumption centers.
- Smallholder production for direct household consumption. One of the consequences of the large amount of output retained for home consumption is that any change in total production tends to lead to a proportionately much larger change in marketed volume and hence a marked degree of price instability.
- Poor rural infrastructure.
- Relatively sophisticated trading system

Lack of market facilities and low agricultural prices affected the scale of market participation. Even if ECX (Ethiopian Commodity Exchange) which focused on coordination and supporting of export market, currently there is a challenge that could bring marketing information to the rural farmer, producer and consumer due to the lack of a means for providing marketing information based on consumer and producer preference, except that by using SMS, e-mail, and media which is not based on customer preference [5]. This indicates that the consumer and producer would be unable to get current market information. It is as useful for commercial farmers to have a reliable market. Hence, it needs to solve this problem and developing awareness in the consumers and farmers, which facilitate in the development of fair market or business practices in the country through providing current and reliable information to customer and producer.

2.1.3. Agricultural Marketing Information System

Collecting and analyzing information is a costly process and often involves large fixed costs. Traders dealing in large volumes of produce are likely to be better informed about market conditions than a small farmer or consumer who is only intermittently involved in marketing activities [8]. Smaller traders, farmers and consumers are unlikely to be able to obtain similar information so readily or cheaply. Thus they have to make their marketing decisions not only with less information in general, but with substantially less information than those they are dealing with. This unequal bargaining position may allow the larger trader to take unfair advantage of the smaller actors' relative ignorance [9]. It is often claimed that large traders use this information advantage to „exploit“ consumers and farmers. The provision of market prices publicly can help in restoring this balance. It provides the small producer with some idea of the

likely level of market prices, which may influence the decision on whether to market, or not. It also provides a basis for estimating a reservation price for negotiations conducted outside a market, for example, with a trader who comes to the village [11].

Hence, one of the strategies to improve the agricultural marketing system at the national level is the creation of a permanent and public market information system (MIS) [10]. It would need to provide: market price information to help redress the balance between the information available to large traders and smaller traders and farmers; estimates or forecasts of future demand and/or supply conditions at the international, national and regional level to assist the private sector, donors, NGOs and governments plan their activities more effectively and to improve market performance; periodic policy studies to advise the government on new developments [4].

Marketing information facilitate traders to engage in spatial and temporal arbitrage. That is, they will buy products where they are relatively cheap and transfer them through space or time to markets where they hope that it can be sold at a higher price. To do this on a regular basis, they must have prior information on likely market prices in different markets or in future market periods [15].

Marketing information will benefit farmers and consumers through providing closer market integration. Dissemination of relevant market information (regarding : crop production prospect, temporal and spatial crop flows, and market prices assist and guide farmers in their planting, storage, and marketing decisions [9,10,12,13]. In various parts of the country; donors, government officials and others involved in food security and market stabilization operations also need to have accurate forecasts of crop prospects and areas of likely crop surpluses and deficits if they are to plan their operations effectively [15].

Although agricultural market information is still being collected by a variety of institutions the emerging problem of domestic price instability means that there is now an urgent need to establish a public-provision MIS on a permanent basis. This will enable accurate, regular and relevant information to be disseminated publicly.

2.2. State of the Art in Pervasive Computing

2.2.1. Pervasive Computing

2.2.1.1. Definition

Pervasive computing (also known as „ambient, physical, embedded, environmental or Ubiquitous computing“) was first introduced by Mark Weiser. He envisioned a world of fully connected devices with cheap wireless networks where information is accessible everywhere. A world in which computers and information technologies become invisible, and indistinguishable from everyday life: „anytime, anywhere and always on“ [16, 17]. The words pervasive and ubiquitous mean "existing everywhere." Pervasive computing refers to the emerging trend toward numerous, easily accessible computing devices connected to an increasingly ubiquitous network infrastructure [20]. It is the growing trend towards embedding microprocessors in everyday objects so they can communicate information. It refers to the use of computers in everyday life, including PDAs, smart phones and other mobile devices. It also refers to computers contained in commonplace objects such as cars and appliances and implies that people are unaware of their presence [20]. It relies on the convergence of wireless technologies, advanced electronics and the Internet. Pervasive computing devices are completely connected and constantly available.

2.2.1.2. Pervasive Computing Environment

Pervasive computing is about the creation of environments saturated with computing and communication capabilities, yet having those devices integrated into the environment such that they disappear [18, 21]. A pervasive computing environment is characterized as one saturated with computing and communication capability. That is, it is characterized by richness of context, mobility of users, variety of devices (PDAs, smartphones, . . .) and appearance/ disappearance of resources over time [18, 21]. In such a pervasive computing world, service provisioning systems will be able to proactively address user needs, negotiate for services, act on the user’s behalf, and deliver services anywhere and anytime across a multitude of networks.

As traditional systems evolve into pervasive, an important aspect that needs to be pursued is context-awareness, in order for pervasive services to seamlessly integrate and cooperate in support of user requirements, desires and objectives. Context awareness in services is actually

about closely and properly linking services, so that their user is relieved from submitting information that already exists in other parts of the global system [22].

2.2.1.3. Characteristics of Pervasive Computing

The goal of Pervasive computing is to meet the claim of “everything, anytime, everywhere” for data processing and transmission through the ubiquity of ICT systems [22]. It can be characterized by a set of attributes and capabilities that describe the extent of its functionality.

The following characteristics define pervasive computing paradigm [23]:

- **Miniaturization:** computing devices are becoming progressively smaller, more powerful, and more mobile.
- **Embedding:** As computing technologies are integrated into everyday objects, they transform them into smart objects. That is users are surrounded by a multitude of interconnected embedded systems, which are mostly invisible and weaved into the background of the surrounding, like furniture, clothing, rooms, etc., and all of them able to sense the setting and state of physical world objects via a multitude of sensors.
- **Ad-hoc networking:** computing devices are linked to each other and communicate generally via wireless ad-hoc network. They are therefore not part of a fixed environment or application, but are instead designed to form networks spontaneously. To prevent human attention from being overwhelmed, people are intentionally not integrated into many machine-to-machine interactions.
- **Invisibility:** While embedded computing devices are increasingly ubiquitous, they are at the same time increasingly less noticeable - or even invisible - to most people. Most components will interface with their surrounding environment in several ways but will not be visible. The ideal expressed by Weiser is complete disappearance of pervasive computing technology from a user’s consciousness. In practice, a reasonable approximation to this ideal is minimal user distraction. If a pervasive computing environment continuously meets user expectations and rarely presents him with surprises, it allows him to interact almost at a subconscious level [18, 21].
- **Context awareness:** computing devices use sensors and communication to collect information about their users and environment and adjust their behavior accordingly. [18,21,22,24]

Hence, the unique characteristics of pervasive computing are: composition of highly heterogeneous computing objects, dynamic request for resources and services, dynamic interaction among heterogeneous computing objects, and frequent environmental changes due to mobility of users and computing objects [22, 25]. It integrates numerous, casually accessible and inexpensive mobile devices with traditional distributed systems. It bridges the gap between the ever increasing variety of smart devices and the existing services which were previously invoked through conventional systems [20, 23]. It is about making our lives simpler through digital environments that are sensitive, adaptive, and responsive to human needs [20].

2.2.1.4. Areas of Pervasive Computing Application

Pervasive computing has many potential applications, from health and home care to environmental monitoring and intelligent transport systems. [26, 27]. An example of a practical application of pervasive computing is the replacement of old electric meters with smart meters. In the past, electric meters had to be manually read by a company representative. Smart meters report usage in real-time over the Internet. They will also notify the power company when there is an outage, reset thermostats according to the homeowner's directives, send messages to display units in the home and regulate the water heater [18, 20].

Pervasive computing simplifies life by combining open standards-based applications with everyday activities. It removes the complexity of new technologies, enables us to be more efficient in our work and leaves us more leisure time and thus pervasive computing is fast becoming a part of everyday life [18, 21, 22]. In this wireless world we will have instant access to the information and services that we will want to access with devices, such as Smartphones, PDAs, set-top boxes, embedded intelligence in your automobile and others, all linked to the network, allowing us to connect anytime, anywhere seamlessly, and very importantly, transparently. Computational power will be available everywhere through mobile and stationary devices that will dynamically connect and coordinate to smoothly help users in accomplishing their tasks [18, 20, 21].

2.2.2. Context-Awareness in a Pervasive Environment

2.2.2.1. Context

It is difficult to give a complete definition for a context and, in fact, the notion of context is not universal but relative to some situation and application domain. According to Dey et al. [28], context cannot be enumerated, as they differ from situation to situation and depend on the purpose of the application. More formal and more generic definitions used either the user's environment or the application environment as the basis for establishing the meaning of context. And hence, context is defined in multiple ways, most often with location as the cornerstone. One source defines it as "location and the identity of nearby people and objects." Another describes it as "location, identity, environment and time".

However, the most common formal definition of context is "Context is any information that can be used to characterize the situation of an entity, where entity means a person, place, or object, which is relevant to the interaction between a user and an application, including the user and the applications themselves" [28, 29, 30]. Contexts can include information such as location (e.g., of people or objects), identity (user), time, execution state of applications, computational resources, network bandwidth, activity, user intentions, user emotions, and conditions of the environment [28, 29, 30]. However, as it being a general definition, it does not limit a context. Basically, it should answer the following questions "who?", "what?", "when?" and "where?" and, ideally, should allow the system to answer "why?" [29, 40].

Context information is derived from an array of diverse information sources, such as location sensors, weather or traffic sensors, computer-network monitors, and the status of computational or human services. While the raw sensor data may be sufficient for some applications, many require the raw data to be transformed or fused with other sensor data before it is useful. By aggregating many sensor inputs to derive higher-level context, applications can adapt more accurately [31, 32].

2.2.2.2. Context-Awareness

In order to provide adequate service for the users, applications and services should be aware of their contexts and automatically adapt to their changing contexts-known as context-awareness.

Context –awareness describes the ability of the computer to sense and act upon information about its environment, such as location, time, and temperature or user identity [33]. That is, Context-awareness is the ability of an entity to usefully adapt to or react based on context.

Hence, context-aware computing refers to a general class of mobile systems that can sense their physical environment, and adapt their behavior accordingly [28, 29, 31, 33]. It is the ability of computer systems to acquire contextual knowledge, process and reason about the context, perform dynamic adaptation to the changing context, and act in a proactive manner. In other word, context-aware computing deals with the ability of computer systems to take advantage of information from or conditions in the dynamic environment to provide added-value services or to execute more complex tasks [28, 30, 33].

In addition to dealing with explicit input, context-aware applications consider contextual information (implicit input). Today, Applications and services will have to be greatly based on the notion of context and knowledge, will have to cope with highly dynamic environments and changing resources, and will need to evolve towards a more implicit and proactive interaction with users...”. A system is context-aware if it can extract, interpret and use context information and adapt its functionality to the current context of use [34]. One goal of context-aware systems is to acquire and utilize information on the context of a device in order to provide services that are appropriate to the particular people, place, time, event, etc. These systems aim to provide context-aware access to information, communication and computation. A key characteristic for context aware systems is that they must maintain the capability of acquiring and using context related information through interaction with an environment that is sensor-rich, and that is also capable of providing accurate information about itself [35].

2.2.2.3. Context Modeling and Reasoning

2.2.2.4.1. Context Modeling

Development of context-aware applications is inherently complex. These applications adapt to changing context information: physical context, computational context, and user context/tasks. Context information is gathered from a variety of sources that differ in the quality of information

they produce and that are often failure prone. The pervasive computing community increasingly understands that developing context-aware applications should be supported by adequate context information modeling and reasoning techniques [36]. These techniques reduce the complexity of context-aware applications and improve their maintainability and evolvability.

Context modeling is the process representation of context conditions or circumstances which are relevant for context-aware applications [37]. To make contextual data usable, manageable, applicable, and shareable by applications, it is necessary to model sensor data values. The process of identifying relevant context consists of determining the conditions of entities in the applications universe of discourse (e.g., a user or its environment) that are relevant for context-aware applications [69]. In order to model data to meaningful context there are several requirements to consider: distributed composition, partial validation, richness and quality of information, incompleteness and ambiguity, level of formality, applicability to existing environments. To facilitate the development of extensible and interoperable context aware applications, it is essential to have a set of principles for specifying any given context from any domain. However, there is tremendous diversity in what can be context, and the way context can be acquired and modeled. To address the challenges in representing, structuring, managing, and using context, various knowledge-representation formalisms and techniques have been applied, such as Key-Value pairs, Markup Scheme, Graphical, Object Oriented, Logic Based, and Ontology Based [36, 37, 38, 39]. These approaches vary in their level of formalism, abstraction capabilities, support for quality of information, ease of retrieval and domain independence [36, 38, 39]. Currently, most context modeling approaches are based on ontology techniques.

Ontology-Based Context Modeling

Ontologies represent a description of the concepts, functionalities and relationships among the concepts and provide a common vocabulary that can be shared and reused among software agents and users [36, 37, 38, 39]. Ontologies as explicit formal specifications of the terms in a domain and the relations among them are a widely accepted tool for modeling context information in pervasive computing domain. The reason for this acceptance is twofold. In one hand it has several advantages over other traditional modeling approaches. On the other hand, the Semantic Web languages and tools have clearly gained maturity over the past years. As a result,

ontologies are promising instruments for modeling context information in pervasive environments due to their high and formal expressiveness and possibilities for applying ontology reasoning techniques [36, 37, 38, 39, 41,70].

Ontologies therefore provide a vocabulary for representing and communicating knowledge about some topic and a set of relationships that hold among the terms in that vocabulary. In practical terms, the design of ontology includes [41,70]:

- the definition of classes or concepts in the ontology
- the arrangement of the classes in a taxonomic (subclass-superclass) hierarchy, if it exists
- the definition of properties and the description of the allowed values for these properties
- the definition of restrictions on the values of the properties, such as cardinality

Ontology, together with a set of individual instances of classes with specific values of properties, constitutes the knowledge base of the application.

2.2.2.4.2. Context Reasoning

Context-aware applications use context information to evaluate whether there is a change to the user and/or to the environment situation; taking a decision whether any adaptation to that change is necessary often requires reasoning capabilities [36]. Reasoning techniques can also be adopted to derive higher level context information. Therefore, it is important that the context modeling techniques are able to support both consistency verification, and reasoning about complex situations [36]. Hence, one of the central requirements for modeling is reasoning.

Context-reasoning is a process of deducing new and relevant information to the use of application(s) and user(s) from the various sources of context-data [44]. But, context is by nature hierarchical in the sense that raw context-data can be further mapped into higher level categories. The raw data that is supplied by the underlying data sources is called low-level (implicit) context while the context information that is ready for consumption is called high-level (explicit) context [43]. Usually, context reasoning in context-aware systems enables to derive high level context from low level context/s and reconciling context inconsistencies [43, 44]. Sensing the low-level context refers to techniques to measure context information from physical sensors, for example,

measuring the location of a user and the time or temperature of a place [45]. Building higher-level context refers to refinement activities (context aggregation and interpretation), for instance, location in form of latitude and longitude can be associated with a specific street or building [45].

Context reasoning can be applied either by hardwiring reasoning logic into context data source like sensors or by separating the reasoning logic from the context data representation and collection [44]. The specific reasoning technique ranges from simple IF-THEN kind of associating actions with conditions to more complicated rule-based and assumption-based reasoning techniques [43]. Ontologies support reasoning tasks because of its simpler representation formalisms. Ontological reasoning can be executed for inferring new context information based on the defined classes and properties, and on the individual objects retrieved from sensors and other context sources. For instance, it is possible to derive the set of individual objects that are related to a given one by a particular property, or to calculate the most specific class an individual object belongs to [36].

2.2.2.4. Context-Aware Services

With the recent advances in mobile computer technology and the penetration of wireless networks, the nature of the services proposed to the users is moving towards mobile and context-aware services [71]. The use of context is becoming important in interactive computing. Context information can be used to facilitate the communication in human-computer interaction [71]. Due to an increase in number of mobile devices and mobile applications, running over different types of networks (e.g., WiFi, GPRS, UMTS, Bluetooth) that enable any-where, any-time kind of applications, today's computation is shifted towards context-aware application [23,45]. Context is very important, since it provides information about the present status of people, places, things and devices in the environment.

Context aware services have the ability to utilize information about the user's context to adapt services to the user's current situation and needs. A service is called context aware if in its operation it uses context information other than explicit application logic related input [23, 45]. The quality of the context-aware services directly depends on the quality of the information

gathered from the context sources. For this reason, handling context activities should be carefully explored in context-aware systems [45].

Typically, a context-aware service uses context information to [72]:

- Automatically deploy services for a user or control an environment
- Associate context information with other information, allowing subsequent access to this based on “contextual” search criteria (e.g. “find all information relevant to this place”)
- Personalize modes of interaction between the user and the service
- Select services relevant to the user in a given environment or situation (Context-Aware service discovery and provisioning).

2.2.2.5. Context-Aware Applications

Context-aware application is a distributed application whose behavior is affected by its user’s context [21, 29]. An application is context-aware if it automatically adapts to a discovered context by changing the behavior of the application. In other word, an application is said to be context aware if it uses contextual information to provide relevant information and services to the user, where relevance depends on the user’s task. Dey [28] proposed three categories of context aware applications: information and services delivery to a user based on the context, automatically executes a service when the user enters a specified context, and tags information to contexts for later retrieval. Context-aware applications respond to context changes by adapting to the new context. These applications are active in nature and their actions are triggered by asynchronous occurrences [28,29,30]. Much effort in context-awareness has been spent in building innovative applications, without explicit attention for the use of platform, middleware or modeling. Context-aware applications range from location information; such as Active Badge system and the ParcTab, to innovative context-aware applications have been proposed in various domains, such as in the health domain. Some of the interesting projects are the placeMap and the foodLab [22,28, 29]. Context-aware application mainly focused on supporting three main types of functionalities: presentation of information and services to a user (e.g. Tour guide, Active Badges), automatic execution of a service (e.g. Smart homes (turn off lights, adjust temperature)), and tagging of context to information for later retrieval (e.g. Digital camera meta-data (time, location)) [28, 29, 30].

2.3. Mobile Marketing

The mobile communication technologies allows the creation of context-sensitive Mobile Marketing applications by using identity- and context information and thereby enabling the efficient targeting of current user needs [46,48]. They play a special role because they allow a number of new services that people can use while on the move. Mobile communication devices, including smartphones, tablets, laptops, and net books, have provided people with new approaches to access web content and commercial services in a convenient and flexible way which fully takes the advantages of mobility and timeliness. As a result mobile technologies are providing many opportunities for marketing activities, especially direct communication opportunity with consumers anytime, anywhere [47].

Marketing is widely considered to be more effectively delivered with mobile communication technologies, since mobile network offers the ability to distinctly identify its mobile users, as well as to determine their current location and time of usage [48]. Furthermore, mobile communication techniques have features such as ubiquity, context sensitivity, identifying functions and command and control functions that allow potentials for mobile marketing activities [48]. Indeed, most business and brand owners today are exploring mobile marketing as a new way to improve customer interaction. Compared to the features of traditional mass media marketing, mobile devices can provide benefits such as interaction, exclusiveness, location and situation dependency, targeted addressing of customers, immediate transaction and measurement of campaigns' effectiveness [48].

Context-awareness is one of the rising trends of mobile technology, and due to advances in technology development, new applications and service concepts are being developed and demonstrated in an ever-increasing manner [35, 46]. Context awareness is often categorized into pull and push [40], where the first type is initiated by the user and the second is event-triggered and initiated, for instance when device integrated sensors detect a certain triggering event. Businesses are deriving new revenue streams from context-based services, in which real-world and digital data are reconciled in order to provide new services [47]. Since consumers today

expect businesses to deliver personalized services through mobile communication technological advancements and access to context-aware services.

The substantial development in information and communications technology accelerates the movement towards personalized marketing communications. Consequently, companies' interactions with customers are increasingly managed by technologies that enable the firms to personalize communications in real time across multiple media platforms and channels [46, 47]. Thus, marketing communications is nowadays increasingly interactive by nature. Given this new communications environment, marketers are increasingly using new, interactive and highly targeted media [47].

The increasing use of mobile marketing is indirectly associated with developments in mobile technologies and the fast adoption of mobile devices [46]. Due to the lack of common conceptualization, practitioners and academics have proposed numerous definitions of mobile marketing, i.e. marketing through the mobile channel. For instance, the Mobile Marketing Association has suggested that "mobile marketing is any form of marketing, advertising or sales promotion activity aimed at consumers and conducted over a mobile channel" [47]. Mobile marketing can also be defined as "the use of the mobile medium as a means of marketing communication", the "distribution of any kind of promotional or advertising messages to customer through wireless networks", and "any marketing activity conducted through a ubiquitous network to which consumers are constantly connected using a personal mobile device" [46].

However, the most agreed definition of mobile marketing is "It is marketing that uses interactive wireless media to provide customers with time and location sensitive, personalized information that promotes goods, services and ideas, thereby generating value for all stakeholders" [47]. That is, it is defined as "the use of wireless media as an integrated content delivery and direct-response vehicle within a cross-media marketing communications program [47]. Hence, mobile marketing is marketing on or with a mobile device, such as a cell phone, smart phone, etc. It is the use of multi-channel or multi-touch marketing campaign(s) to provide consumers with content (e.g. a message or offer) through any mobile devices. Mobile marketing is commonly

known as wireless marketing, although viewing advertising on a computer connected to a home local area network is not considered to be mobile marketing [47].

The two possible ways of doing mobile marketing through the mobile medium are: pull-based (or permission-based), and push-based communication. In pull-mode the user has to send an explicit request each time he wants to get information. However, in push-mode the user receives information without having directly requested it, but hopefully he indirectly requested the information by giving his permission some time before [34]. For instance, if a user enters his mobile phone number in the webpage of a merchant to receive notification about bargain offers via SMS. If one week after this the user receives the first SMS he won't perceive the message as being directly requested.

The figure 2.1 [38] shows the two modes (PULL and PUSH) of communication to send and understand data in a context-aware system, and how context-aware service providers can interact with customers. Quality of context and service determines when it is time to update contextual data.

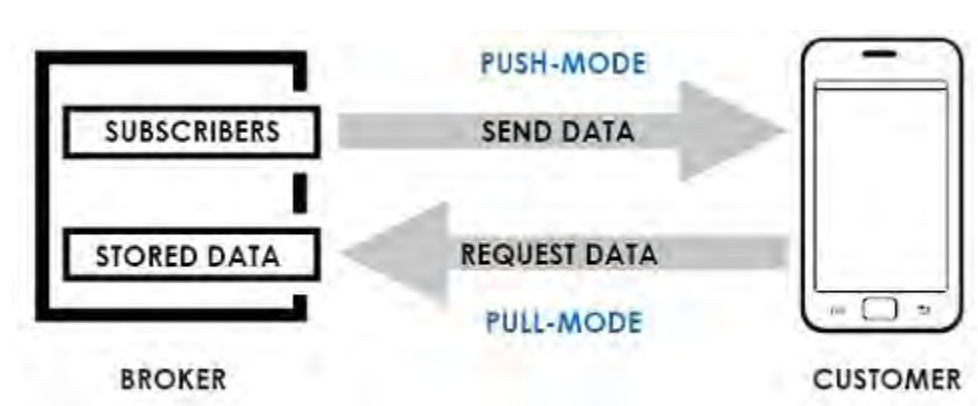


Figure 2.1: Interaction between broker and customer

Here, in PULL-MODE: A customer wants to use a service and has to request the service provider / broker. In PUSH-MODE: A service has a list of subscribers. If the stored context changes decisively for certain subscribers, the broker sends an update. The more updates of context data are sent (push) or requested (pull) the higher is the quality of it. Brokers have to be proactive to update their contextual data and the caches of customers (subscribers) to guarantee a homogeneous grade of service [38].

Mobile marketing is carried out through various delivery mechanisms, which includes mobile Internet, mobile applications, short message service (SMS), multimedia messaging service (MMS), Push notification, Mobile web marketing, Bluetooth, Infrared, Proximity Systems, Location-based services, and User-controlled media. The attributes inherent to mobile marketing (i.e. personalization, ubiquity, interactivity and localization) generate significant potential for this innovative form of marketing communications. Mobile marketing provides opportunities for reaching customers at multiple locations, for personalizing offerings and services in fresh ways and for making possible new types of services and shopping experiences [47].

2.4. Mobile Phone Positioning Techniques

Nowadays mobile phones become more ubiquitous in our daily lives, which results in the increasing of the need for context-aware applications. Knowing the location of mobile phone is important information for various activities. Since Location is one of the main context information, it enables a wide set of mobile phone applications including navigation service, location-aware services, and security applications [49, 56, 67].

Mobile location estimation is about obtaining the location of a mobile station (MS). Since the medium of communication in mobile devices are radio signals, MS location information in terms of latitude and longitude is made possible by measuring some properties of the radio signals transmitted or received by the mobile device [49, 55, 57, 67]. That is, it attempts to locate the MS by measuring the radio signal travelling between the MS and a set of fixed stations. However, the radio signals which is unguided and have no control over the signal after it gets transmitted, there are several factors that can affect the accuracy of the location technologies like Multipath Propagation, Non-Line of Site (NLoS) propagation and many more [49,53,55,67]. A wide variety of location techniques has been proposed so far, each one presenting certain advantages, as well as drawbacks.

The three fundamental types of GSM-based localization techniques are those based on signal strength, angle, and time measurements [49,56, 57, 67]. The highlights of these major techniques with cell base and GPS based positioning techniques are presented in the following subsections.

2.4.1. Cell-ID based Positioning

This positioning technique is the simplest and cheapest method for locating a mobile phone, since it requires no changes in handsets or network. The only thing is associating the cell ID with location. That is, this method estimates the MS location as the location of the cell tower where the MS is currently associated with it. Each BTS broadcasts both the LAI and the Cell-ID to its cells. Since a MS is always receiving these broadcast messages, it knows its Cell-ID. Hence, by knowing the actual geographical coordinates of BTS (cell tower or cell ID), we can know approximately where the MS is. That is, the MS is assumed to be located at the BTS coordinates independently of its actual position within the cell [49, 56, 57, 67]. However, a tower can cover a huge area (fig 2.3a)[67], from a few hundred meters, in highly dense urban areas, to several kilometers in lower dense rural areas. Since the mobile station can be anywhere in the cell, the location accuracy of this method is directly depends on the cell size (radius). This is the drawback of this method.

A Cell-ID is a number which is associated with a specific cell (the radio tower to which the handset is connected). By identifying the cell-ID of serving cell, the corresponding Base Transceiver Station (BTS) can be found. The BTS has a fix position and known properties, such as signal strength, and an area around the BTS can be calculated in which the handset should be located to receive signals in this cell as shown in figure 2.2 [49, 56, 57,67]. The location accuracy is considerably better in urban areas with a dense network of smaller cells than in rural areas where there are fewer base stations. This location technique does not require any network and terminal upgrade and it is therefore economic and can be immediately deployed.

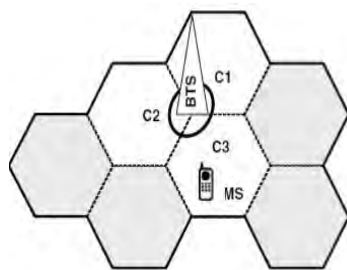


Figure 1.2: A simplified view of cellular network, the MS is within cell c3.

The location accuracy of this (Cell ID) method can be enhanced by using Cell sectors as in fig.2.3b [67]. In cell arrangement there is more than one antenna radiating different direction. Separate antennas radiate in different direction around the base station to cover the full circle around it. Therefore if the antenna that the MS is connected is known then it will be possible to narrow down the MS location to one sector of the cell coverage area [55, 67].

The location accuracy of this method can also be further enhanced by including a measure of Timing Advance (TA) as in fig 2.3c. In TDMA, as a result of inherent propagation delay, slot timing varies as a function of the distance between BTS and MS. TA is calculated by the BTS and sent to the mobile handset to re-synchronize time slots in function of the propagation delay. Knowing the TA, the MS can estimate the distance from the current BTS as a function of the delay [55, 67]. These measurements can be used for further reducing the positioning error.

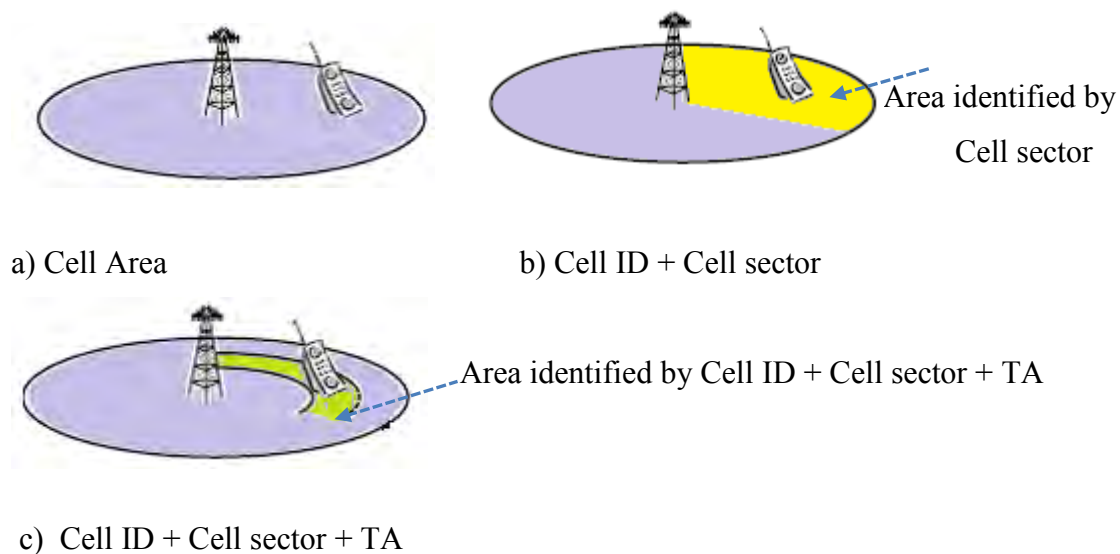


Figure 2.3: Positioning based on cell identification, Cell ID + Cell Sector + TA

2.4.2. Time based Positioning Technique

This type of positioning method involves measuring the time that the signal takes to travel from source to destination or time it takes to travel to destination and returning back to source [49, 56, 57,67]. Some of this type of positioning techniques are Uplink Time of Arrival (TOA), Downlink observed time differences, Time of Arrival (TOA), Time-Difference-Of-Arrival (TDOA), and Enhanced Observed Time Difference (E-OTD). All the time based methods suffers from multipath fading and NLoS propagation.

In time-of-arrival (ToA) based systems, the cell phone estimates its distance to a reference point based on the time a signal takes to travel from the reference point to it. Similarly, time difference of arrival (TDOA) based systems use the principle that the emitter location can be estimated by the intersection of the hyperbolae of constant differential time of arrival of the signal at two or more pairs of base stations [49,56,57,67].

Time of Arrival (TOA) method calculates the distance of a mobile telephone and a BS based on the TOA of a signal transmitted from the mobile telephone at the BS. It is assumed that the mobile telephone is located at the intersection point of three circles having the radius of the distances between the BSs and the mobile telephone [49, 56, 57, 67].

Unlike other time based methods E-OTD is a MS based method. The E-OTD positioning method is based on the MS measuring signals from the network. By observing when a signal arrives from a BTS the MS can calculate the arrival time difference between the bursts of nearby BTSs in GSM. That is, MS calculates the position itself using the assisted data from the network. Disadvantages of this technique are the need for software modifications to the handsets and the need for additional location receivers in the network infrastructure which is called a Location Measurement Unit (LMU) [49, 56, 57, 67]. This method operates using time measurements of signal travelling distances between the MS and the LMU. That is, the position of the MS is determined by comparing the time differences between the two sets of timing measurements. To determine MS position, MS and LMU have to receive signals from at least three BTS units. The Figure 2.4 shows the principle of E-OTD method [67].

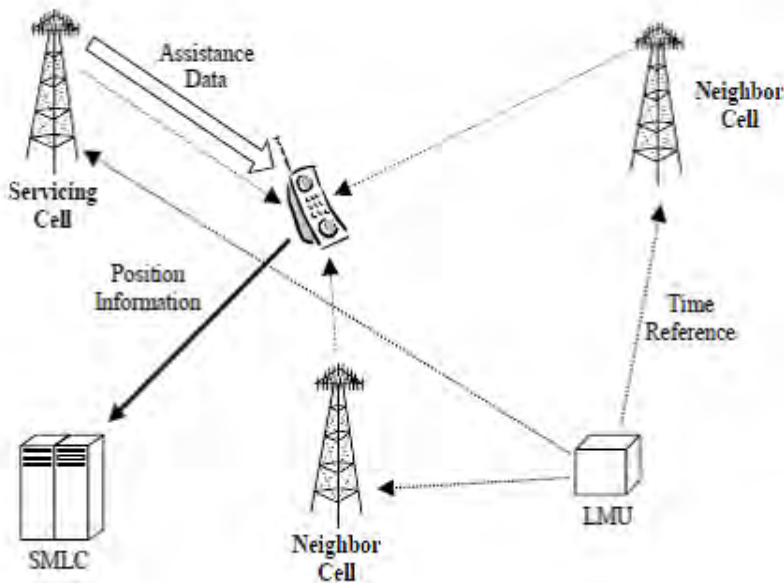


Figure 2.4: Enhanced observed time difference

Time based methods can be considered the best method when developing location service but it definitely is not the cheapest method. Time based methods have the advantage of signal travelling speed. The disadvantage of time based method is that it requires changes to network or both network and hand phone which will result in a higher investment.

2.4.3. Signal strength based Positioning

Here, signal strength is used to calculate the distance between BS and MS in order to identify the location of the MS. This technique utilizes Received Signal Strength (RSS) measurement based on the GSM mobile phone feature that can measure the signal strengths from a number of nearby base stations. The RSS measurement information is converted to geographical location by using propagation path loss model [49, 54, 56, 57, 67]. That is, the RSS from servicing and neighboring cell is used to calculate the distance between the MS and the each neighboring BS.

Signal strength is an easy and low-cost method to implement in GSM, because it does not require any changes to the handset and existing network infrastructure. Since RSSI information is readily available to the user's applications on almost all GSM phones, such systems have the potential of localizing 80-85% of today's cell phones, work all over the world, and consume minimal energy

in addition to the standard cell phone operation [66, 67]. RSS measurements are collected by the mobile devices as part of its standard functionality to assist in the handover process. However, the network type and topology influence the number of cells, from which the MS is capable of extracting RSS measurements [56, 57, 67]. Most prior work on GSM-based localization insist that the MS are able to store information about the currently serving cell, as well as up to six neighboring cells of which it has received the strongest signals [49, 56, 57, 67].

Even if Signal strength is an easy and low-cost method to implement, Location accuracy is dependent on the propagation path. Since signal strength is highly influenced by the propagation characteristics of intervening region (environment) between MS and the BSs. in most real environments, a number of impairments can occur such as absorption, refraction, shadowing, and reflection. Reflections of radio signal from nearby surfaces are very common in urban, mountainous, or indoor environments due to the existence of multiple obstructions. Multiple reflections can cause the reflected and delayed replicates of the transmitted signal to be combined at the receiver which is known as multipath distortion. Signals from different paths can add constructively or destructively that cause variations in amplitude which is known as fading [49, 54, 56, 57, 67]. Hence, to implement RSS as localizing techniques, it needs to understand the different error sources that might lower the quality of the signals. The most common are signal attenuation (or path loss), Shadowing, multi-path fading (slow and fast fading), and Time dispersion [49, 54, 56, 57, 67]. path loss will cause the radio signal to become weaker as the distance it travel increases, Shadowing and multi-path fading will cause random fluctuations in signal strength when it arrives at receiver due to obstacles such as tall buildings in urban area. Time dispersion will cause the bit stream from the direct signal may arrive several bit-times earlier than the reflected bits due to very large reflecting objects (such as Mountains), which is mainly caused in rural areas [49, 54, 56, 57, 67].

Because of these sources of error, it is expected that the accuracy of the location information using signal strength will vary depending on the environment. The field strength of a signal can be represented as a function of distance in space or as a function of time [67]. Hence, many researchers have tried to find a suitable relation between signal strength and distance. Since signal strength varies greatly according to terrain and due to multipath propagation, there is no

universal relation that can be used to calculate signal strengths for every location on the earth [49, 54, 56, 57, 67]. Therefore, an environment-dependent propagation model for the dependence of received signal level on BS-MS distance should be used. Thus, for each location, site specific relations must be formulated. For this reason, to implement RSS as localization, a proper propagation model (a propagation model calibrated to best fit the specific environment in the area of interest) is used to translate RSS values to distances from the respective neighboring BSs.

After solving for distance between the BS and MS using appropriate propagation model, it allows a circular area to be plotted around the location of the BS, using the distance as the radius. The location of the MS is believed to be somewhere on this circular plot [49, 54, 56, 57, 67]. The location accuracy can be further refine by performing standard trilateration techniques. Trilateration is the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres, or triangles [54, 55]. If signal levels from three different BSs are known, the location of the MS can be determined as the unique intersection point of the three circles. Figure 2.5 [67] shows how MS can be located using the signal strength measurements from multiple BS. The distance from each BS defines a circle around it, with radius equal to the distance calculated through the propagation model, on which the MS is possibly located. With the distances from the serving and the available neighboring cells known, a trilateration method is employed in order to determine the location of the terminal. However, errors occur regarding the radius of the circle, as the result of the variations in antenna orientation, local shadowing conditions around the MS (indoors, inside a vehicle etc.), fast fading, the employed propagation model and the number of available measurements [49, 54, 56, 57, 67].

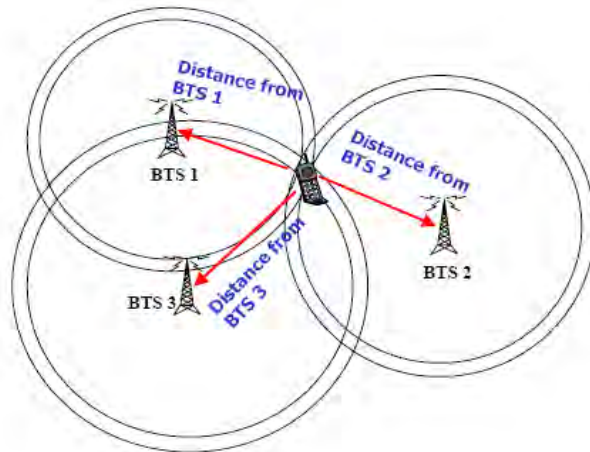
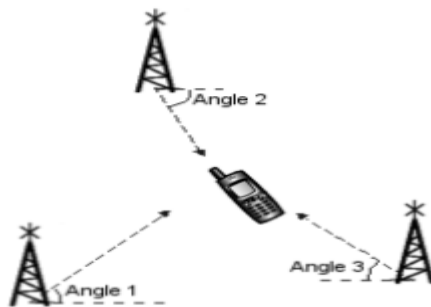


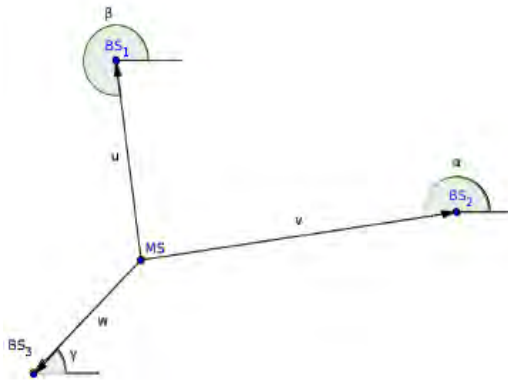
Figure 2.5: Positioning with RSS measurements using a propagation model

2.4.4. Angle Of Arrival (AOA) based Positioning

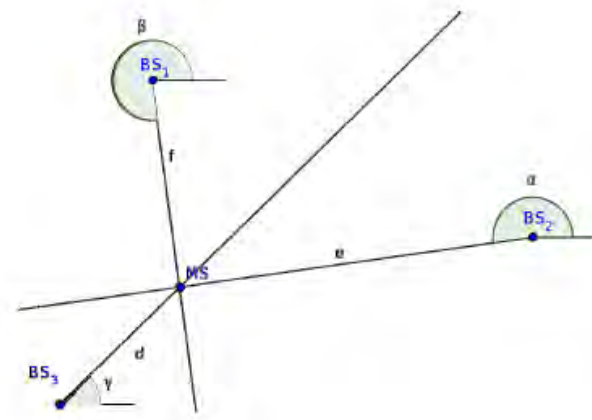
In this method, the angles of arrival of signals, which is measured at the BS, is used for positioning. In each BSs signal AOA (i.e. the direction of signal falling at BTS) is calculated. In order to measure the angles of arrival of signals, the BSs have to be equipped with antennas (antenna arrays) that are able to measure the angle under which they receive a signal from a MS [49, 54, 56, 57, 67]. That is, the angle in which the signal from the MS arrives to the BS is firstly measured by the BTS, and based on this measured angle an imaginary lines can be drawn from the BTS to the MS (see figure 2.6b). Hence, by measuring the angle at two or more different BSs an intersection of the lines can be calculated where the MS would be located as shown in fig. 2.6c [56].



a) Angle of Arrival



b) AoA - The MS sends out a signal that is received by the antenna arrays from the BS



c) AoA- The intersection of the lines from the BS in direction of the Angle of Arrival is the assumed position of the MS

Figure 2.6: Positioning with angle of arrival measurements

2.4.5. GPS Based Positioning

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites [49, 56, 57, 67]. It is the most widely used system for positioning. It was developed by the United States Government for its military. GPS relies on a network of 24 satellites circling the Earth and 5 monitoring station around the world that enable the satellites to broadcast a signal that can be used as a reference in determining the position of users [49, 56, 57, 67]. The satellites are positioned to cover the entire earth surface and at any given point on the earth surface there will be five satellites in view. GPS is the most accurate positioning system, with accuracy down to about 10m in best cases [57, 67].

In GPS localization techniques, the mobile telephone has to be provided with a GPS receiver to calculate its location in latitude and longitude coordinates based on the location information received from a satellite. The GPS positioning method uses the TOA principle to obtain the distance to the satellites.

To determine the position of MS, A GPS receiver needs the position of three satellites (four satellites are needed when positioning in four dimensions –X, Y, Z, and Time) and the distance between the GPS receiver and respective satellite. Since each satellite continually transmits specially coded signals (messages) that contains information about the time the signal was transmitted and the satellite position, the MS (GPS receiver) that received this signal measure the time difference (i.e. the time it took for the signal to travel between the satellite and the receiver) and computes the distance to each satellite using the speed of light. In addition to this it also computes the satellites' coordinates (X,Y,Z) [49, 56, 57, 67]. When time difference (travel time) value is multiplied with the speed of light gives the distance between MS and the satellite. These distances and satellites' locations are used to compute the location of the MS (receiver) through trilateration technique. Each of these distances and satellites' locations defines a sphere. GPS receiver needs at least 4 different satellites to locate its position in the earth surface by means of trilateration or triangulation.

2.5. Path Loss Prediction Model

Since the GSM system uses a radio interface to communicate between the BTSs and MSs, there will be different problems that might lower the strength of the signals. It has been observed that when signal propagates through an environment, its strength decreases [53, 54, 67]. This is due to the nature of the radio wave propagation because when the signal moves through the air in the form of radio waves it loses its power because of the existence of obstructions. The decreasing in strength of signal is known as path loss. Path loss is the loss of power of an RF signal travelling (propagating) through space. There are many factors which cause path loss such as free space absorption, reflection, refractions, human activities, diffraction and multipath signal losses [50,52, 53]. It is the largest and most variable quantity that depends on frequency, antenna

height, terrain irregularity, atmospheric conditions, the distance between the transmitter & receiver, and many other factors. It also depends on the condition of environment (urban, rural, dense urban, suburban, open, forest, sea etc.) and indoor/outdoor [50,52,53,57,67]. When calculating propagation path loss, all these factors have to be taken into account.

Several models have been developed to predict path loss in order to realize the propagation behavior in different conditions. These are categorized into three according to the principle approach used to develop propagation models. They are Empirical (Measured data), semi-empirical or Statistical (Probability), and Deterministic (Maxwell's Eq.). Each propagation model is valid in a specific scenario and specific frequency. If the model is not chosen correctly, model will either overestimate or underestimate the path loss.

The empirical models are derived from measurements and observations. It uses existing equations obtained from results of several measurement efforts. It is based on extensive measurement data. In empirical models, all the environment factors are implicitly considered. This model gives very accurate results, but the main problem with this type of model is computational complexity [53, 67]. On the other hand, empirical approaches offer less accurate, but simple prediction methods without the need for specific and detailed information on the terrain type.

The Statistical models Uses Probability analysis by finding the probability density function. Usually a statistical path loss model or prediction program is used to estimate the median propagation loss in dB. The estimate takes into account the situation: line of sight (LOS) or non-LOS and general terrain and environment using more or less detail, depending on the particular model [53].

The Deterministic model uses electromagnetic wave equations (Maxwell's equations) along with reflection and diffraction laws to determine the received signal power at a particular location. Deterministic models provide a reliable and thorough estimation of the path losses and the channel characteristics, but often require a complete three-dimensional map of the propagation environment. Since this model is based on theoretical analysis, it can be applied in different

scenarios without affecting its accuracy. However, the realization of theoretical model is based on large database on scenario features and accurate 3D digital map, which sometimes are impractical or even sometimes are impossible [53].

The most common widely used outdoor propagation path loss Empirical Models are Okumura Model, Hata Model, and COST 231 – Hata Model. These models are based on extensive measurements. The models vary in complexity and accuracy. Okumura Model is an Empirical model for irregular terrain. Hata Model is Analytical approximation to Okumura model. COST 231 Hata model is an extension to Hata Model that Extends Hata model to 2 GHZ and to lower mobile antenna heights [50, 52, 53, 67].

COST-231 Hata model

A model that is widely used for predicting path loss in mobile wireless system is the COST-231 Hata model [50, 52, 53, 69]. This model extends the Okumura-Hata model to a cover wider range of frequencies, and is used for medium to small cities to cover the 1500 to 2000 MHz band. The COST-231 Hata model is designed to be used in the frequency band from 500 MHz to 2000 MHz. It also contains corrections for urban, suburban and rural (flat) environments. Although its frequency range is outside that of the measurements, its simplicity and the availability of correction factors has seen it widely used for path loss prediction at this frequency band. The basic equation for path loss in dB [50, 52, 53, 67] is:

$$PL=46.3+33.9\log_{10}(f)-13.82\log_{10}(h_b)-ahm+(44.9-6.55\log_{10}(h_b))\log_{10}d+cm \quad (2.7)$$

Where, f is the frequency in MHz, d is the distance between Rx and Tx antennas in km, and h_b is the Tx antenna height above ground level in meters. The parameter cm is defined as 0 dB for suburban or open environments and 3 dB for urban environments.

The parameter ahm is defined for urban environments as.

$$ahm=3.20(\log_{10}(11.75hr))^2-4.97, \text{ for } f > 400 \text{ MHz} \quad (2.8)$$

For suburban or rural (flat) environments,

$$ahm=(1.1\log_{10}f-0.7)hr-(1.56\log_{10}f-0.8) \quad (2.9)$$

CHAPTER 3

RELATED WORKS

3.1. Overview

Context-aware applications take advantage of contextual information, such as location, time, etc. to offer services to users. For this reason, there is a growing number of context-aware system and need to use them that motivate most of the researchers to go towards this concept. Research on context-awareness has focused on supporting three main types of functionalities: presentation of information and services to a user, automatic execution of a service, and tagging of context to information for later retrieval [28]. Moreover, context awareness is often categorized into pull and push, where the first type is initiated by the user and the second is event-triggered and initiated.

A lot of work has been done on the development of context-aware applications that focus on enabling pervasive computing using mobile devices such as call forwarding, teleporting, active map, mobisaic web browser, shopping assistant, cyberguide, conference assistant, people and object pager, fieldwork, adaptive GSM phone and PDA, office assistant have been proposed and commercialized. Most of these systems are context-aware mobile systems which aim at delivering information and services tailored to the current user's context. Furthermore, several intelligent mobile marketing frameworks have been proposed and prototypes have been developed.

In this chapter, we survey previous research works about context awareness, pervasive, and mobile marketing applications that focus on market information delivery services. Hence, we discuss eight related works in two general sections (section 3.2 and 3.3) with emphasis on their application scenario, primary goals, and the issues they addressed. Section 3.2 deals with the previous works on market information service delivery system, and section 3.3 mobile marketing frameworks for delivering promotional information. Finally we present the summary of these research works with focusing on the gaps that we have identified in the works in comparison to our work.

3.2. An interactive market information service delivery System

3.2.1. An SMS Based Rural Application for Agricultural Consultancy and Commodity Booking Service

The work by Mitra et al. [58] proposed an SMS-based system for providing rural farmers information about market prices of agricultural commodities and advice about fertilizers and pesticides to be used for the particular crop being asked through their mobile phones. The system is designed in client-server architecture that connected over the Internet. It consists of three modules: Agricultural Database Server, SMS Application Interface Server that serves as an interface between the SMS requests from farmers through a GSM Modem and the Agricultural Database Server, and a database module as shown Figure 3.1. The Network Interface Application is responsible to build an HTTP request and send it to the Agricultural Database Server through the Internet. The Agricultural Database Interface Application makes a Query to the combined database module which is a relational database containing the necessary data. On receiving a query, the database module returns the appropriate result to the Agricultural Database Interface Application.

It is an interactive information and advisory service that can offer by combining variable factors such as the location, preferences and needs of the user at a particular time, through their mobile phones. The system incorporates local language interface for language conversion into local language. It uses Hypersonic SQL (HSQL), Java communication API, Java application, Java Servlet and HTTP protocol for its implementation.

In this system, the user (farmer) enquire market information such as recent prices of the agricultural products, and any consultancy service on crop-specific fertilizers and pesticides per quintal by sending an SMS query to the system in a predefined format. The system processes it and provides the necessary information back to the user via an SMS to his mobile phone. The user can also place advance bookings for purchasing agricultural commodities to the system.

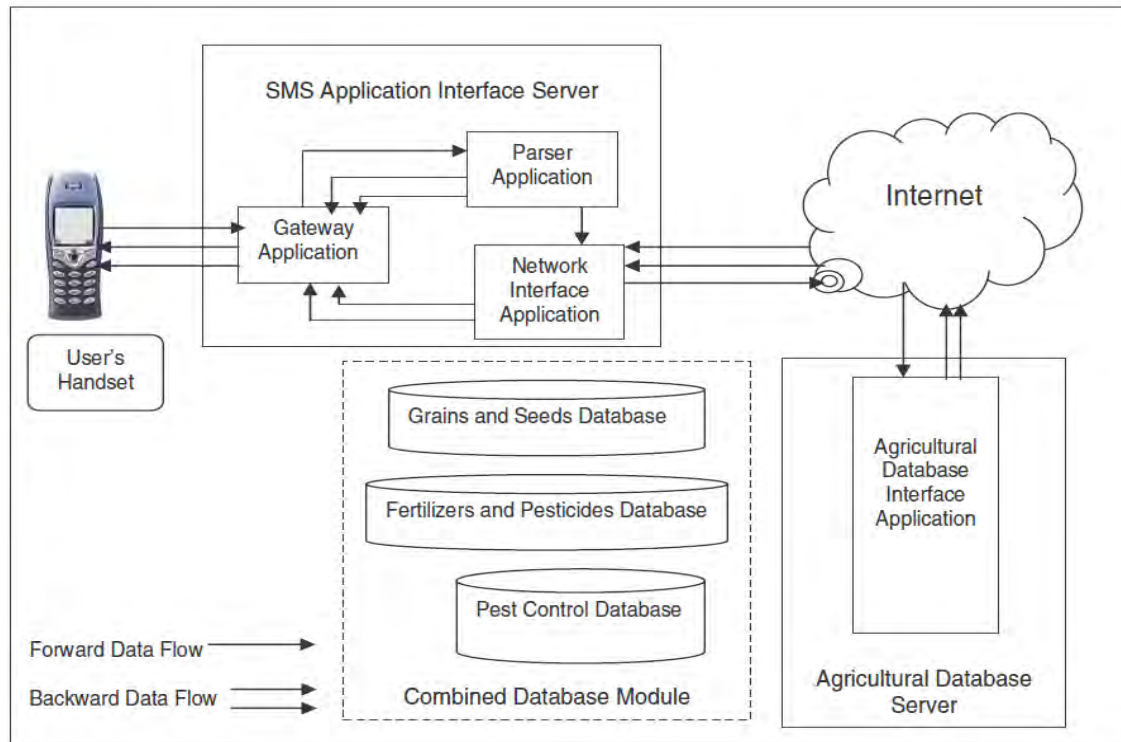


Figure 3.1: Architecture of „Agro-based Advice and Commodity Booking Service“

3.2.2. Context aware mobile service deployment model for AIS

The work by Chandrasekaran et al. [59] focuses on designing a context aware mobile service deployment model to deliver the needed information to the farmers in planning their agricultural activities. It emphasizes on providing Context Aware Mobile Services and designing Agriculture Information System (AIS) to assist the farmers. The proposed agricultural system is web based client – server architectural model where the client places the request and the distributed database present in the server responds to the client’s request according to its context as shown in figure 3.2. Server is designed using core java and mobile client application is developed using J2ME. The application developed based on this model utilizes the GSM networking of mobile devices to bring the details to the farmers using location awareness features.

The proposed agricultural system is a multi-tier application consisting of mobile client application, resources, components and containers. The mobile client requests services from the web server using http protocol. Servlets are used to process the clients request and response back. In this work agriculture information space is represented as a concept cube with the vertices representing the various contexts of information retrieval.

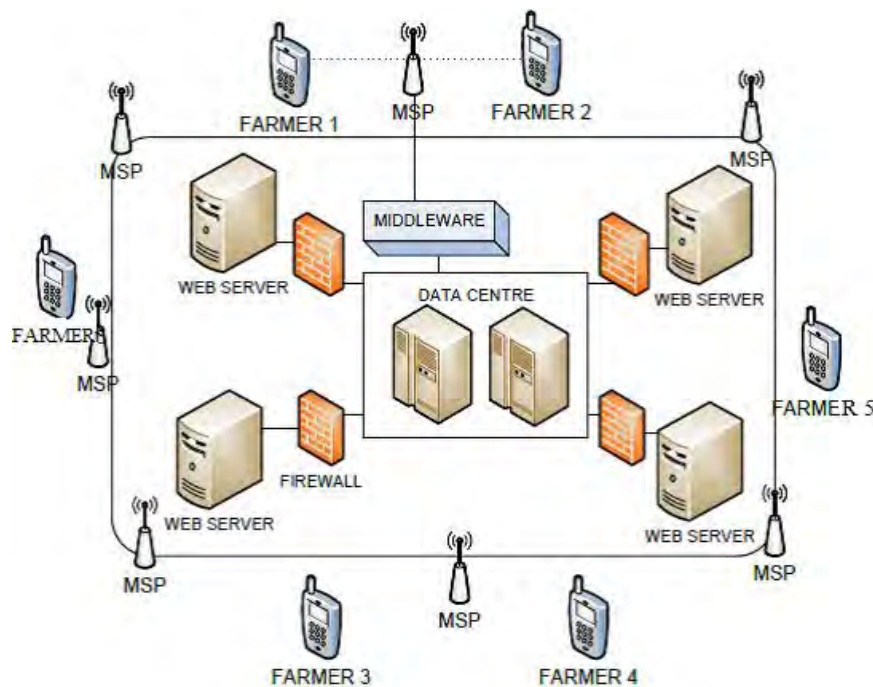


Figure 3.2: AIS architecture

3.2.3. An Intelligent Mobile Grocery Assistant

The work by Bhattacharya et al. [60] presents a framework of an intelligent mobile grocery assistant that capable of providing support for the customer during the entire shopping process. This work was designed around a shopping list paradigm where the shopping list serves as an entry point for users to access different resources that help them to carry out their everyday shopping practices. In this work shopping lists are created using natural language, and recommendations are based on the user's current shopping list entries instead the customer's purchase history. Furthermore, it combines recommendation techniques with positioning to enable location aware information delivery. In order to provide an indoor navigation system, the authors developed positioning system that assists customers in finding products within the store. The framework was designed in client-server architecture to deliver the intended service as shown in Figure. 3.3. In addition to supporting shopping list creation and management, the work was also focused on providing product recommendations, information about special offers, information and suggestions about recipes, targeted advertisements, and navigation information inside a store. This work has been developed as a web-based application that emulates a standalone application. As the target device they have used the Nokia N900 devices for the sake

of its full keyboard and a relatively large display. All communications between the client and the server take place over HTTP. In order to identify product, the work was employed WiFi tag such as barcodes, or RFID technology that communicates with wireless access points installed in the store.

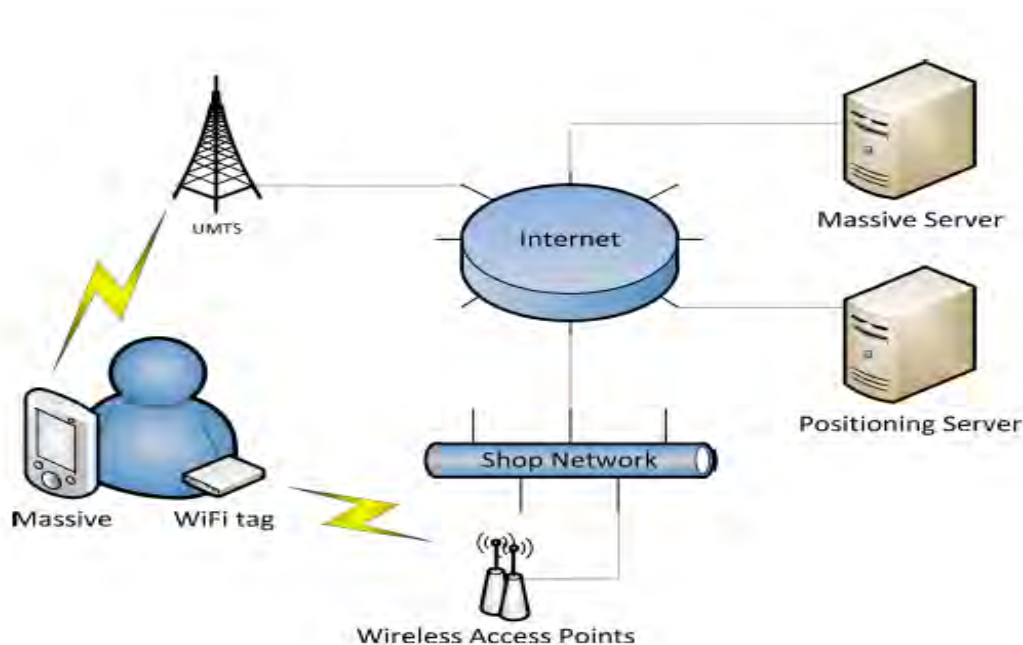


Figure 3.3: Architecture diagram

3.2.4. Personalized Shopping Assistant

The work by Asthana et al. [61] present indoor personalized shopping assistant service to a customer based on individual needs and a shopping profile accumulated over time without limiting his movement, or causing distractions for others in the shopping center through integrating wireless, video, speech and real-time data access technologies. The Personal Shopping Assistant (PSA) consists of two components: the PSA unit itself and the PSA server a computer responsible for controlling all of the PSAs in its domain. It is designed in client-server service based architecture that contains a very high volume hand-held wireless communications device, PSA unit that the customer owns (or may be provided to a customer by the retailer), and a centralized server located in the shopping center to which the customer communicates using the PSA over a *small area* wireless network. The centralized server maintains the customer database, the store database and provides audio/visual responses to inquiries from customers in

real-time. This work intend to guide the shoppers through the store, provide details of items, help locate items, point out items on sale, do a comparative price analysis, and so forth.

3.3. Mobile marketing frameworks for delivering promotional information

Mobile marketing and advertising applications deliver promotional information to consumers based on their preferences and location. Several intelligent mobile marketing frameworks have been designed and prototypes have been developed that deliver promotions based on location information and user preferences through user's mobile phones. We will examine the following four proposed mobile marketing frameworks.

3.3.1. eNcentive

The research work by O. Ratsimor et al. [63] is an agent based, context-aware, peer-to-peer marketing framework for mobile environments that was built using Java technology. This work employs an intelligent marketing scheme in which users capable of collecting as well as distributing sales information in the form of electronic coupons. The users are rewarded by the businesses depending on their distribution rates whereas the businesses attract more customers in this process, thereby being mutually beneficial. eNcentive works in both infrastructure and ad hoc wireless networks. In this framework there is no central user preference database because users required storing their profiles locally. The model is less intrusive on users' privacy thereby making it more appealing from a user point of view. eNcentive was built as an application on top of an in-house agent framework called Numi. However, eNcentive pushes all available coupons to its users regardless of their preferences. And it requires a large number of participating customers to be more effective.

3.3.2. Ad-me (Advertising for the Mobile E-Commerce user)

Ad-me [64] is a context-aware and personalized advertising system that is built on top of a mobile tourist guide. Ad-me uses user location as well as their profiles to deliver personalized advertisements. It also updates user profiles dynamically depending on user migration and activity. Ad-me is implemented using Java technology and uses a mix of both push and pull technologies in order to fulfill its objective. Ad-me has the ability to deliver multimedia presentations as well. However, Ad-me requires a GPS receiver in order to obtain the geographical information about the location of each user;

3.3.3. B-MAD (Bluetooth Mobile Advertising)

B-MAD developed by L. Aalto et al. [65] is a permission-based location - aware mobile advertising system that uses Bluetooth technology for positioning and Wireless Application Protocol (WAP) push for delivering messages (advertisements) to the users. B-MAD uses permission-based advertising wherein the server sends only those advertisements that is associated with the location of the client and which were not sent previously to the client. In order to deliver the message to the user The system first acquire the unique Bluetooth device address (BD-ADDR) of user's device using the Bluetooth sensors which was then compared with predefined entries in a user-database, and then the URL of advertisements that were deemed appropriate for the user were returned to the user's device. Due to the fact that only the URL or address of the advertisement was returned to the user via an SMS text message, the authors claimed the system was permission-based.

However, this framework generally does not consider the user's interests and push all available advertising information to them. It also requires Bluetooth sensors, GPRS capable end user devices with XHTML browser.

3.3.4. SMMART Framework

The work by S. Kurkovsky et al. [62] aimed at providing the users with a productive shopping experience. It is a context-aware, adaptive and personalized mobile marketing application that was designed to deliver targeted promotions to the users of mobile devices about the products they like. SMMART stands for System for Mobile Marketing, Adaptive, peRsonalized and Targeted. It was designed to deliver personalized promotional information based on context and the preferences of the user by matching the user's shopping interests to current promotions available at a retail store. Its main objective is to help the shopper navigate through many offers or promotions available at a given retail store by directing the user's attention to those products that match their interests. The framework is composed of two main modules as shown in figure 3.4, a SMMART Server that is installed at every participating store location and a SMMART Client that resides on the user's mobile device (typically a PDA) equipped with wireless network connectivity. It uses XML web services for client/server communication over a Wi-Fi wireless network. The proposed framework was designed to attain capability of analyzing the user's shopping habits and dynamically adapts to the changing interests of its user. Moreover, it is also

capable of not revealing any private information about the user to the store and does not require additional devices such as a GPS Receiver or a Bluetooth Sensor in order to work effectively.

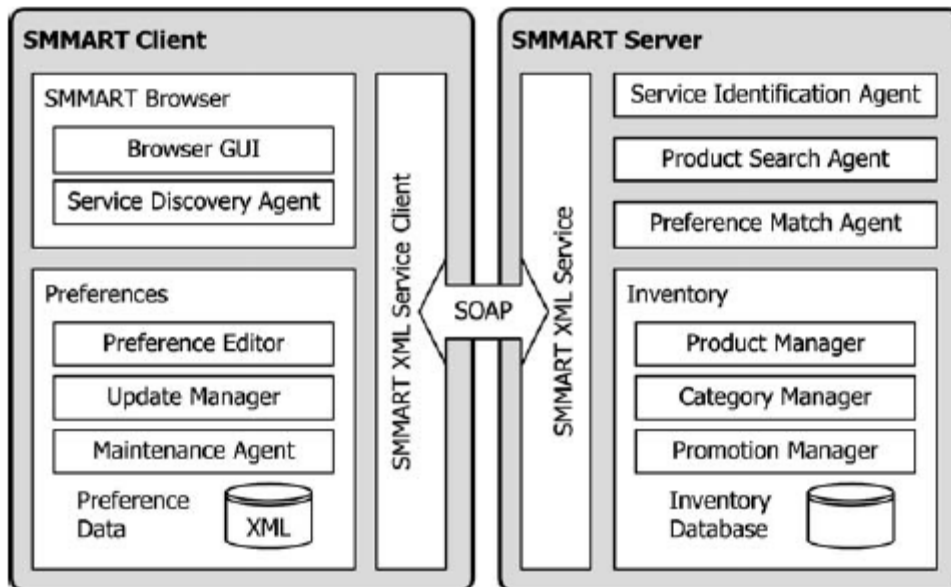


Figure 3.4: Architecture of SMMART framework

3.4. Summary

Most of the research works that we examined in this chapter were context-aware which offer market information to customers based on their context. All of these works except PSA that uses indoor guiding service use one of the two modes of information delivery: push (information is automatically sent to the consumers) or pull technology (information is sent at the consumer's request), and outdoor market information delivery services. More over most of the application except eNcentive are designed in client-server architectural base that are connection through wireless media using http protocol and web based on mobile devices. Most of the works were built applications on mobile devices and the server for their implementation to deliver the service to the user of mobile devices.

Although most of the related works are resembled to our work basically on delivering market information service to the user, all of them lack a means of acquiring raw market information data from the marketplaces. Instead, they simply provide information by inter-connecting information provider center. Moreover, even if these works were pervasive and context-aware,

the context representation modeling technique was non-ontological. Most of them, except [62] focused on delivering information without handling dynamic change of contexts. Relational database was used for storing context information, and SQL and XML for information access in most of them. In the work [59], context information was modeled based on data cube.

In our work we implement a different approach for providing the intended pervasive context aware agricultural marketing information service. That is, instead of using web service and the context aware services that are used in the related works, we provide the intended service through gathering raw context data using smart phone. Furthermore, in our proposed framework we implement ontology based context modeling for providing information to user's context. Ontology-based modeling are considered the most appropriate ones for modeling context data, since they permit formal representation, richness of information and interoperability among different applications and devices. The proposed framework can collect market information and dynamically updates context whenever there is changes, according to user's interest. It is also capable of providing information about the market place where agricultural produces sale with better price according to the interest of users. Our work targets in providing agricultural market information service to the user based on his current context (his interest, preference, location and time). Our work use smart phones (with built-in GPS receiver) for collecting local context data from local marketplaces. The market information is delivered to the end-user through the internet using pull or push mode without need of special devices for finding location not for advertisement purpose unlike the previous works [62, 63, 64, 65]. Our work also not web based service unlike the work of [59, 65]. Furthermore, unlike them, the user's location is determined using cell-ID and RSSI information that is fetched from the user's mobile phone. In our work, the push notification service is also provided based on the analysis of the user's profile data and a special event triggered. Moreover, in addition to java technology, we implement Android mobile phone development tool and TCP/IP internet protocol for client server communication unlike other related works. Besides this we also use ontology development tools for modeling concepts in the domain. We also use MySQL databases as a backend for persistence context data repository.

CHAPTER 4

PROPOSED FRAMEWORK

In this chapter, we present components of the proposed framework, and their detail description. To understand the service requirements, we have conducted a survey study through interview. The survey study was done for investigating market relation, the essential requirements to be satisfied by the service, the required information for service, and how currently existing marketing information service has been carried out. This was also done to obtain an insight for designing the intended service framework that supports for gathering, interpreting, storing and disseminating of contextual information. Moreover, this also helps for modeling the agricultural marketing concepts products in terms of their hierarchy and types to structure their relation to the user's context. The interview was conducted within the organization ECX, Ministry of Trade, Ministry of Agriculture, and Oromiya Agricultural Market. Having or getting this information helps us in designing the service framework and modeling its detail components. The functionality of components and the details description of the proposed framework are presented in the following sub-sections. Some of the major agricultural product classifications and their production trends are included in Appendix A.

4.1. General Overview of the Architecture of the proposed framework

The proposed agricultural marketing information service framework is designed in client-server architecture. It has four basic elements: the server (PC), the two clients that are the local market data provider (Smart phones with built-in GPS) and the end-user mobile device (Mobile phones without built-in GPS), and the existing wireless infrastructure (Internet) which are shown in figure 4.1.

The server is responsible for delivering the relevant information after identifying user's current location according to his context. It is also responsible for processing and managing user requests, and storing and handling user's and market context data. Furthermore, it is also responsible to maintain context repository and association rules that are used for reasoning out to deliver the intended context-aware market information service. The server delivers the relevant information to the user after analyzing the request and interest based on the user's environmental contexts (location, time, and preferences). In addition to this, the server determines the location

of user through GSM cellular positioning techniques and maintains cell tower location data in location database.

The local market data provider is responsible to provide local context data. This local context data includes, the location of market places, the current market data (price, availability, demand etc. of certain agricultural product, which are currently in the marketplace), and the time at which the current sell occur (i.e. the point of time the data was provided). These local context data are collected from the local market place and sent to server with stamped time and market place's location on regular base. Collecting and providing such context data from all over the places through mobile phone especially in the countries like Ethiopia that has poor infrastructure, requires high capability and GPS enabled mobile phone. Since smart phones have capability and flexibility to handle more data unlike ordinary mobile phones, they suit best to this work in collecting and providing local data to the server for delivering the intended service. For this reason, we use smart phone with built-in GPS. Hence, using smart phone we can easily identifies the market place location where agricultural commodities are currently sold through the GPS system and collect market data from all over the country even from rural market places. These collected local context data will be sent to the server to be stored in the context repository for later retrieval and reasoning in order to deliver the relevant market information to the user according to the current context (interest/preference).

The user mobile device is responsible for the interaction of user with the server in order to get (access) the proposed service in either pull or push mode. That is, it allows a user to query or receive personalized agricultural market information from the server. The user context data is acquired from the user's mobile phone explicitly through the provided user interface and implicitly through accessing the properties (features) of the mobile phones (devices). The context data that are collected explicitly from user's mobile phone includes his preferences (or request) for the type of service during pull scenario, and his profile data (such as: identity, name, address, phone No., e-mail address). The user explicitly provides these context data on the provided interface in his mobile phone. The context data that are collected implicitly from user's mobile phone includes location information (cell id and RSS) and time of request. Both of these context data are sent to server either to be stored or queried based on user current context, and for user

location determination. The server accepts user's location information and processes it to identify his current location. Besides identifying the user's current location, the server also checks context knowledgebase and AMIS ontology and rules to make a decision about user context based on the stored context data in the database and current context of a client. Hence, the server analyzes user's profiles, such as his identities, preference, trends (history of his last requests) and reacts according to his context by delivering the relevant market information.

All communications between the client and the server take place through the currently existing cellular phone infrastructure over the Internet. In order to handle the communication between these three major elements, we have developed a module that manages the interaction. The two clients communicate with the server via TCP/IP sockets through internet gateway.

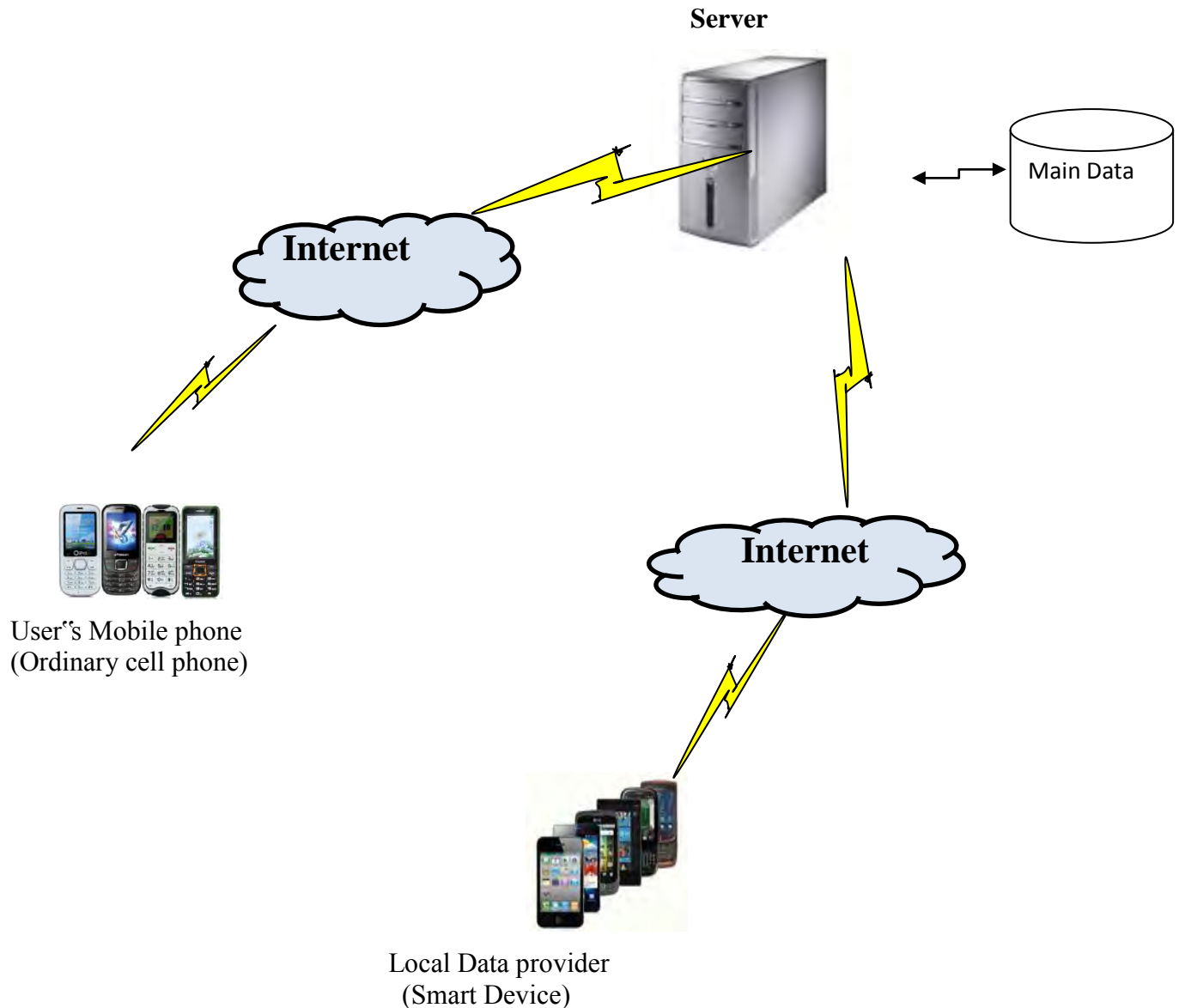


Figure 4.1: Elements of the proposed market information service framework.

The general overview of the architecture of the proposed framework is depicted in figure 4.2. It describes the three main elements in some detail, and the overall interaction between them. Furthermore, it also shows how to interact with the external services like the GPS and cellular network.

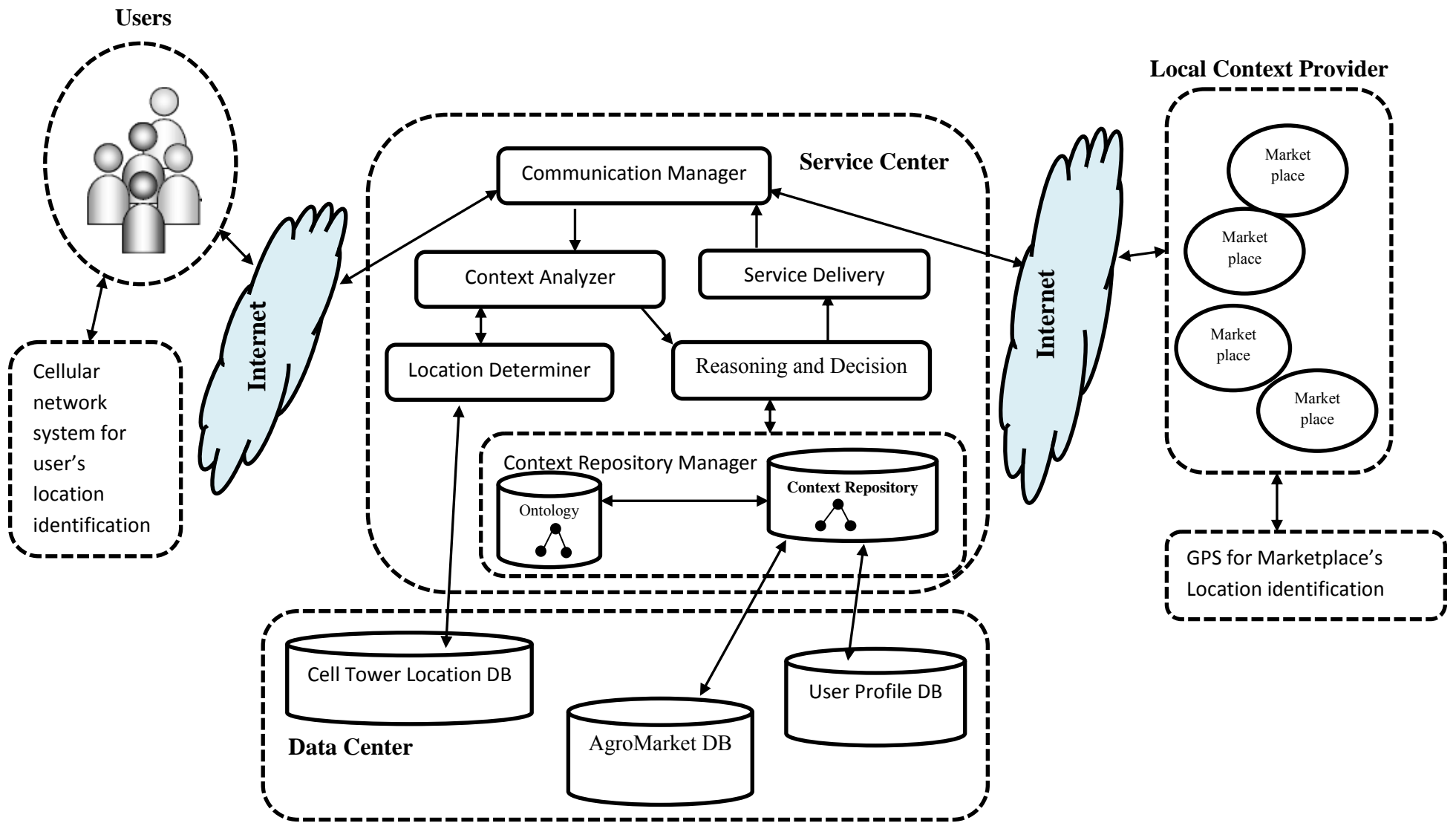


Figure 4.2: Architecture of the proposed framework

The proposed framework logically organized into six layers that are: Communication Handling Layer, Context Analyzing and Location Determining Layer, Context Reasoning and decision Layer, Context Sensing/Acquisition and communication Layer, Context Repository and Managing layer, and Service Delivery. This enables the system to be easily manageable and handles modularity. Furthermore, it allows flexibility and scalability. The proposed framework is designed to attain capability of analyzing the user's interest and preference, and dynamically provide relevant market information according to the users' context (i.e. their preference and interest). This enables a system to provide location-specific market information services to the users through their mobile phones. The proposed framework employs a central service center and data center. The central data center is responsible for storing, and maintaining context data. The communication between the two clients and the server is takes place via Internet (TCP/IP sockets).

The context acquisition/sensing/ layer is responsible to acquire raw context data from the client mobile devices explicitly when the user insert, and implicitly with fetching the user's mobile device system properties. Communication Handling Layer is responsible to handle the communication between the clients and the server. The Context Repository and Managing layer is responsible to store and manage context data. The Context Reasoning and Decision layer is responsible to take inference and decision about the context. Context Analyzing and Location Determining Layer is responsible to analyzed user's context and identifies his/her location. The Service Delivery and Communication layer is dedicated to provide the intended service and to handle communication between the server and the clients. The logical layered views of the proposed framework architecture are shown in Figure 4.3.

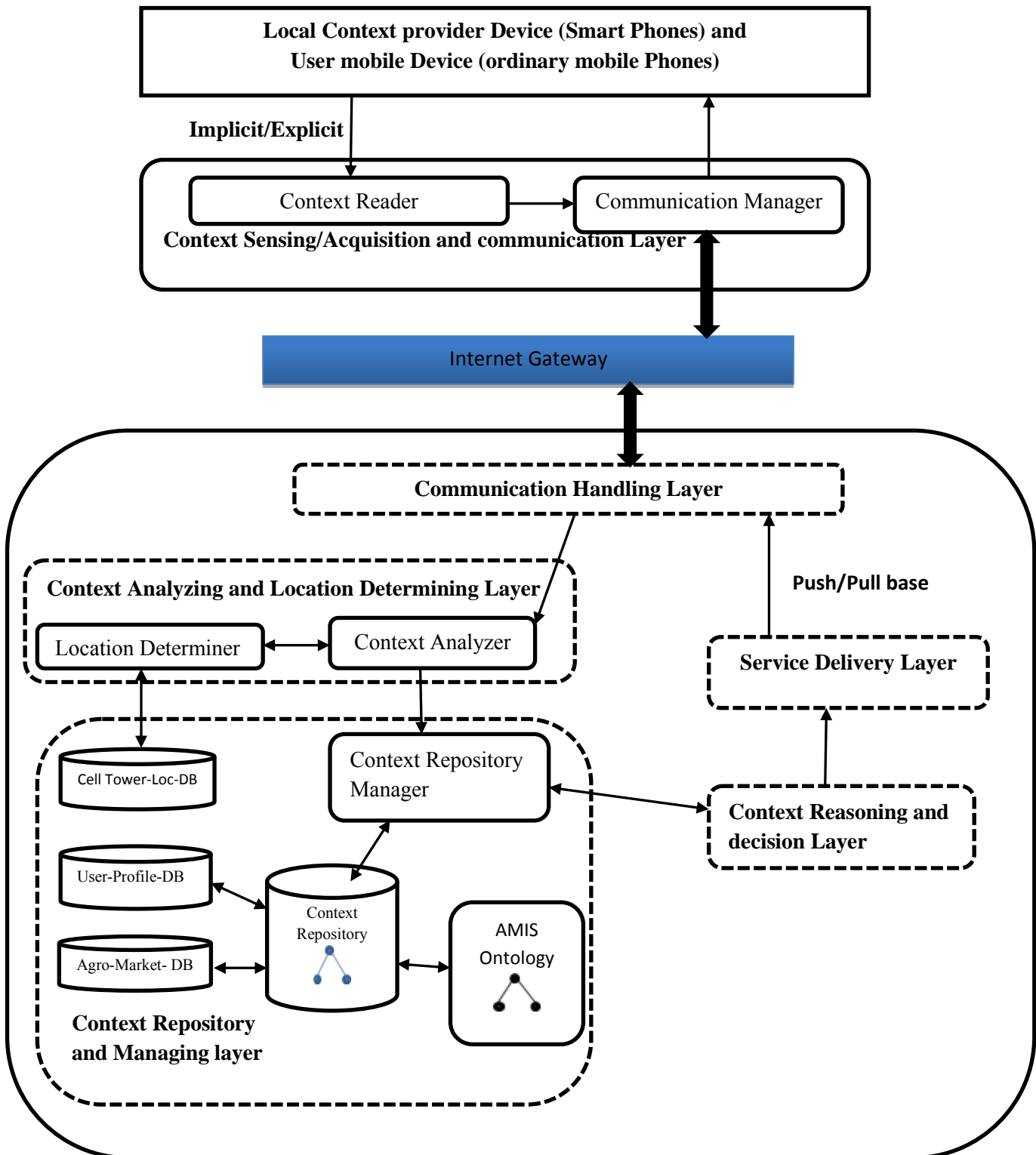


Figure 4.3: Layered architecture of proposed framework

4.2. Details of the Proposed Framework

The proposed framework consists of six major layers that reside on either on the server-side and/or the client-side which communicate via the Internet (TCP/IP). These are Context Data Acquisition and Display, Communication Manager, Context Analyzing, Reasoning and Decision, Context Data Repository, and Service Delivery. The component view of the proposed framework is shown in figure 4.4. These components cooperate and communicate in order to effectively assist the user in getting the right (relevant) information at the right time and place on his/her mobile device. Each of the major components is composed of several modules that are needed to carryout different tasks in the course of giving context aware agricultural market information service.

The components that reside on the client-side are Context Data Acquisition and Display, and Communication Manager. On the server-side are Communication Manager, Context Analyzing, Reasoning and Decision, Context Data Repository, and Service Delivery.

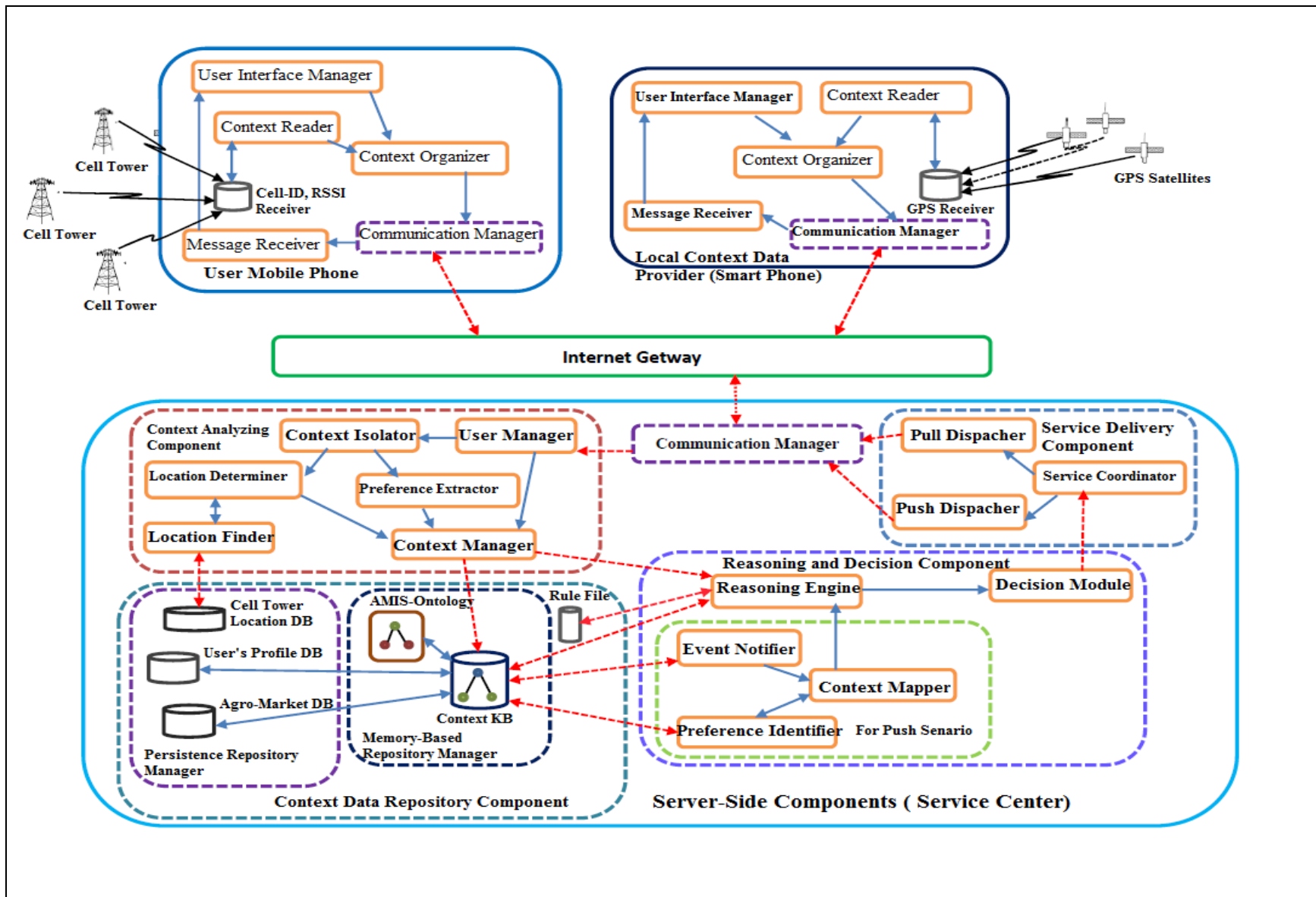


Figure 4.4: The component views of the Architecture of the proposed framework

4.2.1. Context acquisition and display component

This component resides on the two client mobile devices. Its main responsibility is similar for both clients, which is to capture and submit raw context data to the server, and display the server's response on the client's mobile devices. However, the raw context data that was collected from the two clients, and the way of acquiring location data, the reaction of the server to them is different. In the case of local data provider the raw context data are market place location, current time, and local market data that will be stored in context repository component for later retrieval. Whereas in the case of user, the local context data are user's profile data, his request (preference), current time and his location information. In addition to this, it is also responsible to display the server's response based on user's context that received from the server on the user's mobile phone. This component is composed of four modules that will be described in the following subsections.

4.2.1.1. User Interface Manager

This module resides on a handheld device that provides raw context data for the Context Organizer Module. Moreover, it also displays the context information that receives from receiver manager to the user. Its main responsibility is to provide an interface for the user in order to communicate with the system. In addition to this, it manages the user interface that is designed for the two users (Local context provider and End-User).

For target user, this module enables the user to explicitly input his interest, preference, and his profile data. Hence, through the provided interface, the module gathers the user's interest, preferences, and his profile data, and submits these raw context data to context organizer module. For local context provider, the module provides an interface to explicitly input local market data, and passes these local market data to context organizer module.

4.2.1.2. Context Reader

It is responsible to read implicitly raw context data (such location and time) from the user mobile device through using API. The module forwards this context data to the Context Organizer module in the client mobile phone. Context Reader perceives contextual information and transmits it to the Context Organizer module. The context information such as the marketplace's location information is acquired by GPS receiver in the smart phone (with built in an internal

GPS receiver). This location information acquired during the local context provider provides local market data to server. On the other hand, the user's location information (cell ID and RSSI) is acquired from the mobile phone (having no internal GPS receiver). As discussed in section 2.4.3, Cell ID and RSS of the servicing and neighboring cells can be obtained from MS at any given time. This information can be used in identifying mobile location. Thus, the module captures Cell IDs and RSSI (Received Signal Strength Indication) from mobile phone using phone APIs. The module forwards these fetched cell id and RSSI information to Context Organizer module to be sent to the server in order to provide localization computation.

4.2.1.3. Context Organizer

It is responsible to organize context information that receives from the User Interface Manager and Context Reader module. It organized these context data in the form of message and submits to the Communication Manager to be sent to the server. The format for context organizer is based on key value.

4.2.1.4. Message Receiver

It is responsible to accept all incoming messages, which held context information that sent from the server, and submit to the user interface to be displayed for the user. Thus, the module listens to incoming messages from the Communication Manager component and forwards the messages to the User Interface Manager. The messaging format that we implement here is the key value with new line indicator.

4.2.2. Communication Manager

This module resides in both client mobile device and server device that Manages communication between the client and the main server over the Internet.

On the client-side, the main task of this module is to establish communication between the client mobile device and the server. This module accepts data from Context Organizer module, and sends a request to the server; similarly the module receives context information that sent from the server, and forwards it to Message Receiver module to be displayed on the screen of client mobile phone. Moreover, the Communication manager handles the low-level socket communication. The transmitting protocol is TCP/IP for data transmission. It manages incoming and outgoing messages.

On the server-side, the main task of this module is to establish communication between the client mobile device and the server. This module accepts data from Service Delivery component, and sends a response message to the client; similarly the module receives context information that sent from the client, and forwards it to Context Analyzing component for further process. The Communication Manager continuously listens to user's initiated requests and accepts the request to react accordingly to the user request by giving the right context information.

4.2.3. Context Analyzing

Here different modules are interrelated (work together) to analyze the context data. Finally, hands over the analyzed context information to the Reasoning and Decision Component. This component comprises six modules that are presented in the following sub-sections.

4.2.2.1. User Manager

The module accepts the data from the communication manager, and identifies users and their request in order to forward to the responsible module for further process. In this study, there are two types of users, which are end-user (service requester) and content data provider (Local market data provider). Hence, the main responsibility of the modules is to manage these users and their requests based on their identity. The user's identity is tagged with the message when it was sent from the clients mobile devices. Hence, this module can easily identify the identity of the user by analyzing the tagged message.

For instance, if the user's identity is local data provider, which only send local market data to be stored in the database for later retrieval. This module simply forwards the content to Context Manager Module. Similarly, user's static profile data doesn't require further process, and the module also directly forwards the content to context manager module.

The context manager module builds an instance of these new context data using the domain ontology and submits the content to the Context Data Repository component to be stored into the responsible database. In another case, if the user identity is target user, and the user pass a request for service, the module forwards the user's request to Context Isolator Module for further process.

4.2.2.2. Context Isolator

The module accepts the context raw data from the User Manager, and separate location data from other context data. Then, it passes location data to Location Determiner module for the identification of user's location. And other context data to Preference Extractor to identify and manage user's preferences and to handle the user request based on his interest.

4.2.2.3. Location Determiner

The main task of this module is to determine the location of user that has a mobile phone (without built in GPS). This module implements mobile location determination algorithm. The algorithm is designed based on centroid algorithm with empirical propagation path loss model [50, 52, 53, 57, 67]. In section 2.4.3 we described that signal strength can be used to determine the location of MS. The signal strength and cell id information can be obtained from the mobile device. To know which cell the MS should communicate with, the MS constantly listens to the signals sent out from the different BTSs. Then, the MS stores information about the currently serving cell, as well as up to six other cells of which it has received the strongest signals, called neighbor cells [54,55, 67]. This information is the Network Measurement Result (NMR). NMR contains cell information such as the Base transceiver Station Identity Code (BSIC), serving cell ID, received signal strength and the Timing Advance (TA) parameters. The mobile device regularly forwards the NMR to the serving cell to assist the network to make handoff decisions. Through retrieving NMR, it is possible to obtain users' location using trilateration based on the retrieved cell- ID's and received signal strengths from three or more BTS. This can be done by approximating the user's distance from three or more locations on the basis of the signal strength received. [54,55,67]

Based on these facts, we design location determination algorithm to determine the location of Ms using cell Id and RSS based mobile positioning technique. The algorithm was designed by taking the following assumptions into consideration:

- The number of BS is one and more than one,
- Signals from one and more than one BSs are measured at MS,
- Received Signal Strength from each BS is independent to each other.
- All cells in the system are deployed with non-omni directional antennas.

- The variation in altitude among different neighboring BS and MS are assumed to be insignificant.

In addition to these, Location determination takes place for urban, suburban and rural environments. For simplification, we consider the location determination in 2D plane neglecting the altitude effect.

The inputs are cell ID along with their respective accurate positions and location area, the number of BSs (or cells) and RSS measurement, and typical parameters pertaining to the COST - 231-Hata's path loss model. The main logic behind this localization algorithm is through retrieving cell Id and RSS value of the serving and neighboring Base Station (BS) from mobile device, and the BSs actual position from cell tower database using propagation path loss model, estimate the position of the MS.

The general steps involved in the location determination algorithm for MS are three. The first step is receiving the cell id and signal strength values of active and neighboring BSs that were sent from the client mobile phone. In addition to this, at this step, the actual geo-location of the received cell id is acquired through look up cell tower location database. This is done in order to get the actual geo-location of the received cell towers (BSs).

The second step involves determination of the distances between MS and the corresponding BSs based on the received signal strength (RSS) with the help of the general accepted method of calculating RSS, and COST -231-Hata 's model. The final step involves estimation of location of the MS (mobile device) using either trilateration techniques in the case when RSS from 2 or more BTS or geometric calculation based on cell-ID and cell sector measurement technique in the case when RSS from one BS. The general flow diagrams of the steps involved in the location determination algorithm is shown in Figure 4.5.

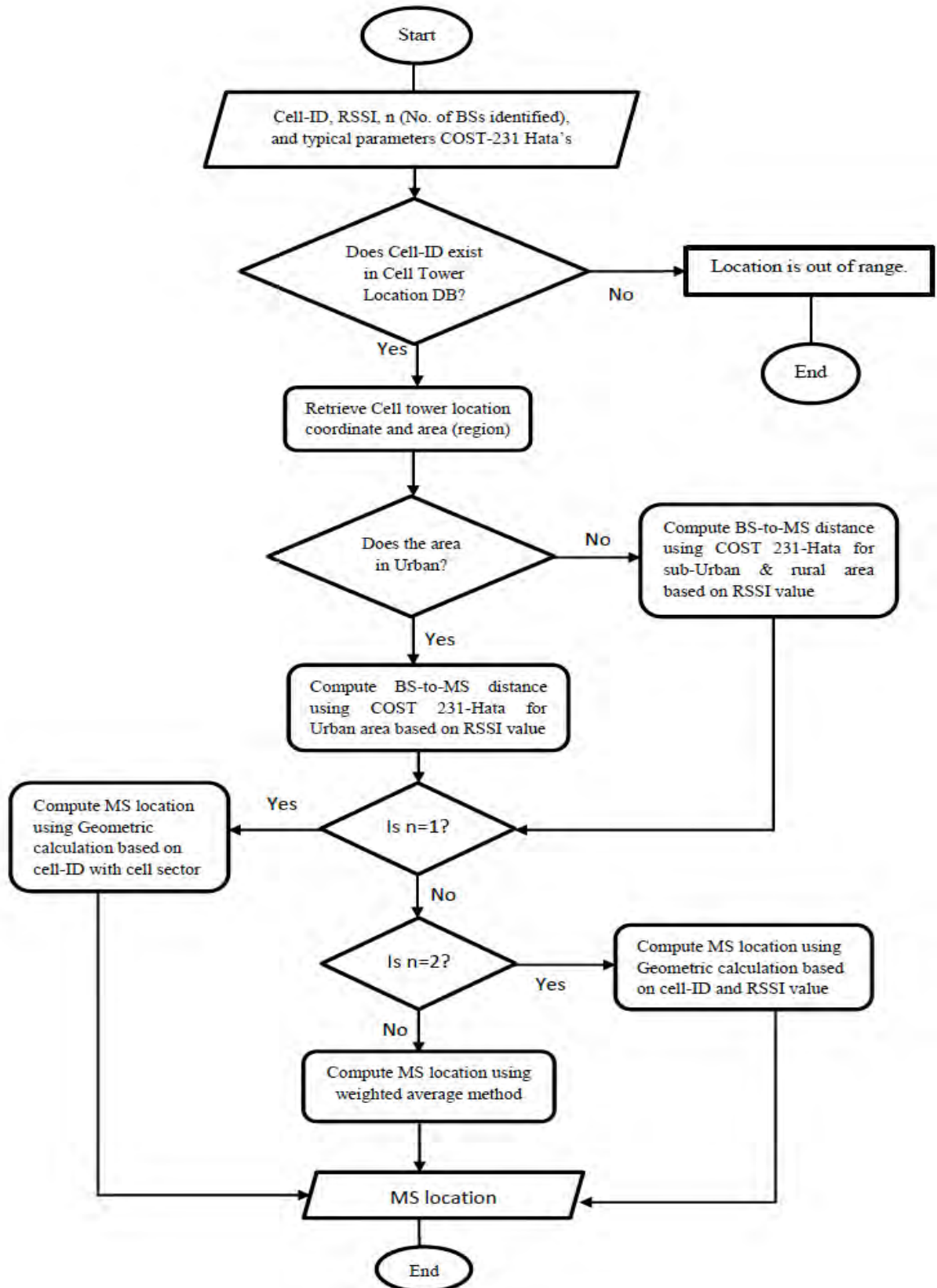


Figure 4.5: Location determination algorithm Flowchart

The detail description of the major steps that are involved in the Location determination algorithm is described in the following three steps:

Step 1: Accept Cell ID and Signal Strength Information (RSSI) from Context Isolator module.

The first step in this algorithm is accepting Cell IDs and RSSI from Context Isolator module. After, received the cell id and RSSI information, the cell ID is forward to Location Finder module to obtain the actual location coordinates and region of the cell IDs through looked up in an existing cell towers" location database.

Step -2: BS-MS Distance Estimation

The power level of the signal or RSS at the MS propagated is depends on various factors. The main factors are a BS transmitted power and antenna gain, MS antenna gain, and the transmission path (environment) between the BS and MS. The transmission path between the BS and MS is one of the main factors that influence on the signal strength (power level). Hence, we should have to implement an appropriate pass loss prediction model. However, this work doesn"t not require fine grained location accuracy, we select COST -231-Hata"s model to implement as pass loss prediction model, because of its simplicity and use of correction factors for all environments that suits to this work. The appropriateness (or validity) checking of COST -231-Hata"s model for the selected environment is beyond the scope of this study. We only use COST -231-Hata model on its theoretical based. Hence, in COST -231-Hata"s model [50, 52,53] , the path loss is expressed as [in dB] :

$$PL(\text{dB}) = 46.3 + 33.9 \log_{10}(f_c) - 13.82 \log_{10}(hb) - ah_m + (44.9 - 6.55 \log_{10}(hb)) \log_{10} d + C_m \dots\dots\dots(4.1)$$

Where: PL : median path loss in decibel (dB),

f : frequency of Transmission in MHz,

h_B : Base Station Antenna effective height in meter (m),

d: distance between base station and mobile station (km),

h_m : mobile station antenna effective height in meter (m),

$a(h_m)$:mobile station antenna height correction factor which is a function of the size of the coverage area, and

The correction parameter, C_m is equal to 3dB for urban area and 0 dB for suburban & rural environments [50,52,53].

$$a(hm) = 3.20 (\log (11.75 h_b))^2 - 4.97 \dots\dots\dots (\text{Urban}) \quad (4.2)$$

$$a(hm) = (1.1 \log f - 0.7) h_b - (1.56 \log f - 0.8) \dots\dots\dots(\text{suburban and rural}) \quad (4.3)$$

Hence, the distance d for each environment is used proper COST -231-Hata "s model, for urban environment (4.2), for suburban and rural environment (4.3).

$$d = \text{antilog} \left[\frac{(\text{PL} + (13.82 \log h_b + 3.20 (\log (11.75 h_b))^2 - 4.97) - (46.3 + 33.9 \log f_c + 3))}{(44.9 - 6.55 \log h_b)} \dots \right] \quad (4.4)$$

$$d = \text{antilog} \left[\frac{(\text{PL} + (13.82 \log h_b + (1.1 \log f_c - 0.7) h_b - (1.56 \log f_c - 0.8)) - (46.3 + 33.9 \log f_c))}{(44.9 - 6.55 \log h_b)} \dots \right] \dots\dots(4.5)$$

With known quantities of transmit power, path loss, antenna gain, and cable losses, the value of RSS is determined by [43]:

$$\text{RSS} = T - \text{LossT} + \text{GainT} - \text{PL} + \text{GainR} - \text{LossR} \dots\dots\dots (4.6)$$

Where: RSS is the detected receive signal strength in dB.

T is the transmitter output power in dB.

LossT is the sum of all transmit-side cable and connector losses in dB.

GainT is the transmit-side antenna gain in dBi.

LossR is the sum of all receive-side cable and connector losses in dB.

GainR is the receive-side antenna gain in dBi.

From equation (4.6), PL is calculated as:

$$\text{PL} = T + (\text{GainT} + \text{GainR}) - \text{RSS} - (\text{LossT} + \text{LossR})$$

For simplicity,

$$PL = T + G_T - RSS - C_L \quad \dots\dots\dots(4.7)$$

Where: $G_T = \text{Gain}_T + \text{Gain}_R$ is total antenna gain, and

$C_L = \text{Loss}_T + \text{Loss}_R$ is total connection loss

The transmitter power (T), antenna gains (Gain_T & Gain_R), and connection losses (Loss_T & Loss_R) of a GSM tower and a MS are constants.

Substitute equation (4.7) into equation (4.4 and 4.5), the distance (d) between MS and BS for urban environment (4.8), for suburban and rural environment (4.9) is:

$$d = \text{antilog} \left[\frac{(T + G_T - RSS - C_L + (13.82 \log h_b + 3.20 (\log (11.75 h_b))^2 - 4.97) - (46.3 + 33.9 \log f_c + 3))}{(44.9 - 6.55 \log h_b)} \right] \quad \dots\dots (4.8)$$

$$d = \text{antilog} \left[\frac{(T + G_T - RSS - C_L + (13.82 \log h_b + (1.1 \log f_c - 0.7) h_b - (1.56 \log f_c - 0.8)) - (46.3 + 33.9 \log f_c))}{(44.9 - 6.55 \log h_b)} \right] \quad \dots\dots (4.9)$$

Step -3: MS Location Determination

Solving for the distance d between BSs and MS allows a circular area to be plotted around the location of the BS, using the distance d as the radius. The location of the MS is believed to be somewhere on this circular plot. With the distances from the serving and the available neighboring cells known, a trilateration method is employed in order to determine the location of the MS. Trilateration method is used to further refine location accuracy.

The Different way of estimations of MS location: In general, two approaches can be used for solving MS location on the basis of signal strength measurements [51, 54, 55]. The straightforward approach is to use a geometric interpretation of the measurements and to compute the intersection of the lines of position. The second approach is weighted average estimation approach.

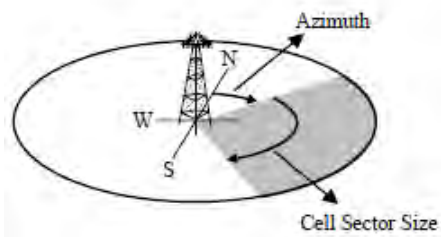
(1) Location Estimation with Geometric Interpretation (Geometric Calculation)

Since the MS stores information about the currently serving cell, as well as up to six neighbor cells, we may have a number of position-distance pairs which correspond to a set of circles, each centered at a BS. The position and the distance fields of the position-distance pair define the circle center and circle radius respectively. The region of possible positions is the area formed by intersection of the circles [54, 55]. At a course of time MS can get cell id and RSS information either from a single cell (BS) or from 2 up to 6 nearby cells on its network [54,55], we have to consider different scenarios (cases).

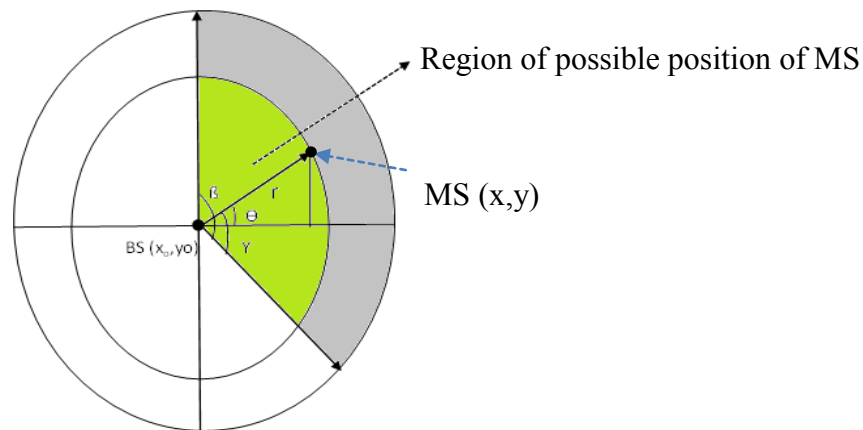
Case 1: when the MS receives cell id and signal strength information of a single BS.

The simplest case is when the MS receives cell id and signal strength information from only one single BS. That is, when MS only communicate with a single cell- tower at a time. It is clear that MS is located within a circle centered at BS, of radius d . To express this more generally, MS's *Region of Possible Positions* is the circle centered at MS, with radius d . To improve the accuracy of this type of location Cell sectors can be used. Normally in cell arrangement there is more than one antenna radiating different direction. Separate antennas radiate in different direction around the base station to cover the full circle around it [54, 55, 67]. Therefore if the antenna that the MS is connected is known then it will be possible to narrow down the MS location to one sector of the cell coverage area.

Typically one BTS can handle several cells. Common patterns are a one BTS covering a circular area with one round-radiating antenna or a three-sector BTS which covers three cells with sector-radiating antennas. One cell can only be handed by one BTS at a time [54, 57, 67]. Figure 4.6a shows the basic concept of using the CI and cell sector information to narrow down the MS location. In case of Omni-directional antennas, cell sector method will not be applicable since it is one single antenna that covers 360° . In such cases this method can locate MS within the whole cell coverage area [67].



(a)



(b)

Figure 4.6: Region of possible position for MS in angle BS within a sector

We can find the coordinates of any point on the circle if we know the radius and the subtended angle. An antenna is designed to radiate either at 120° or 60° [67]. As shown in the figure 4.5b the BS cell antenna is radiated at an angle β (the sectore size) to cover the circular region of radius R . If a MS recived signal from this cell at a distance r , which is determined by COST 123 Hata model by using the RSS from this BS, then we can determin its location with a simple matimatical calculation as follows. Since, the cell radiated at an angle β , the mean angle is taken to be θ ($\beta / 2$) to minimize the error of position estamiation of MS. Then θ will be $\theta / 2$ to simlefy the calculation. Hence, the posible estimated position of MS that recived signal only from one BS will be:

$$x = x_0 + r \cos(\theta)$$

$$y = y_0 + r \sin(\theta)$$

Case 2:- When the MS receives cell id and RSS information from 2 up to 6 nearby cells on its network.

In this case, the region of possible positions is the area formed by intersection of the circles [54, 55,57]. Each mobile tower is the center of a circle. The size of the circle is relative to the signal strength of that tower. In the case of two intersecting circles the region of possible positions is the region between the two intersection points (curved edges) of the circles. For three intersecting circles, the region of possible positions could be loosely described as a triangle with curved edges as shown in fig. 4.7. For more than three intersecting circles, the region of possible positions could be described as a polygon with curved edges.

The best calculation of position would be to evaluate the center of gravity of the region of possible positions [54, 55]. A pragmatic and fairly straightforward estimate of this is simply to determine the mean position of the points of corners of the (curved) triangle or polygon forming the Region of Possible Positions. Here, we will see for two and more than two intersecting circles.

(a) For two intersecting circles

For two intersecting circles the location of MS is determined by geometrical interpretation of the two intersecting circles. A common chord L1 is passes through the two intersection points P3 as in fig. 4.7. Since the region of possible positions is the region between the two intersection points, the location of the MS can be determined by the midpoint of the common chord L1 that lies between p3 at point p2.

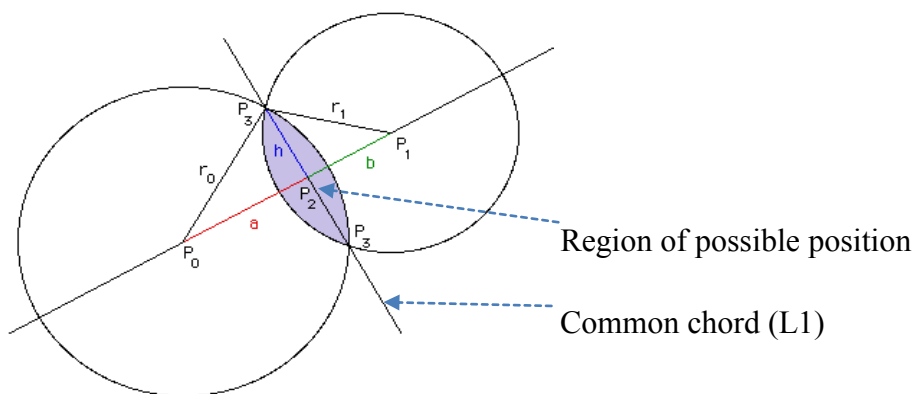


Figure 4.7: Region of possible position for two Interesecting circles

The distance d between the centers of the circles $P_0(x_0, y_0)$ and $P_1(x_1, y_1)$.

$$d = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2} \dots\dots\dots(4.10)$$

- If $d > r_0 + r_1$ then there are no solutions, the circles are separate.
- If $d < |r_0 - r_1|$ then there are no solutions because one circle is contained within the other.
- If $d = 0$ and $r_0 = r_1$ then the circles are coincident and there are an infinite number of solutions.
- If $d = r_0 + r_1$ then there is only one solution, the circles are met at one point. Using the mid-point formula, the coordinates of the intersection point will be the location of MS which is:

$$x = \frac{x_0 + x_1}{2} \quad \text{and} \quad y = \frac{y_0 + y_1}{2} \dots\dots\dots(4.11)$$

By considering the two triangles $P_0P_2P_3$ and $P_1P_2P_3$ we can write

$$a^2 + h^2 = r_0^2 \quad \text{and} \quad b^2 + h^2 = r_1^2 \dots\dots\dots(4.12)$$

Using $d = a + b$ we can solve for a ,

$$a = (r_0^2 - r_1^2 + d^2) / (2d)$$

It can be readily shown that this reduces to r_0 when the two circles touch at one point, i.e.,

$$d = r_0 + r_1$$

Solve for h by substituting a into the equation (4.12), $h^2 = r_0^2 - a^2$

So, the estimated location of MS will be:

$$P_2 = P_0 + a (P_1 - P_0) / d \dots\dots\dots(4.13)$$

And hence, the two intersection points $P_3(x, y)$ in terms of $P_0(x_0, y_0)$, $P_1(x_1, y_1)$ and $P_2(x_2, y_2)$, is

$$x = x_2 \pm h (y_1 - y_0) / d, \quad \text{and} \quad y = y_2 \pm h (x_1 - x_0) / d \dots\dots\dots(4.13)$$

(b) For three and more than three intersecting circles

For three and more than three intersecting circles, in ideal case, the circles are intersected in one point and MS location is uniquely defined. In real environment we can't assume previous case and there are three relevant intersections, but algorithm has to calculate one point. The center of gravity of the region of possible positions is done in a simple two-stage process [54, 55, 69]. Firstly the set of all of the intersections of pairs of circles is calculated. Secondly a subset of interior intersections is created in the following way. If an intersection point of a pair of circles is inside all of the other circles (i.e. all of the circles not involved in the intersection), then it is defined as being in the subset of interior intersections. Otherwise, it is not included in the subset of interior intersections. This evaluation involves a simple calculation of the distance from the point of intersect to the center of a circle and comparing it to the circle radius [54, 55].

To illustrate this logic, we assume a MS received cell ID and signal strength information from three BSs as in figure 4.7. Hence In the first stage of the process, each pair intersection point of the (respective pairs of) circles is calculated, so in this case the coordinates of the 6 points a, b, c, d, e and f are calculated. In the second stage, each of these 6 points is evaluated whether they are an interior intersection point of the remaining circles or not. Once this simple calculation is made for each of the 6 intersect points, 3 intersections - a,b and c – are found to be interior intersections. The mean of these 3 points of interior intersection is defined as the estimate of the position of the device [54, 55].

If the true location of MS is (x,y) and the coordinates of the i^{th} BS is (x_i, y_i) , then the distance between MS and the i^{th} BS, denoted by d_i , is given by

$$d_i = \sqrt{(x_i - x)^2 + (y_i - y)^2} \quad , \quad i = 1,2, \dots, N \quad \dots\dots\dots(4.14)$$

The distance d_i is radius of circle with equation:

$$(x_i - x)^2 + (y_i - y)^2 = r_i^2 \quad , \quad I = 1,2, \dots, N \quad \dots\dots\dots(4.15)$$

Since, the coordinates of circles centers (BSs) and circles radiuses (d_i) are known, it is possible to determine intersections of circles as in case-2 above. After calculating intersections between couple of circles, we are acquired the following set of coordinates of intersections points I :

$$I = [(x_1,y_1), (x_2,y_2),(x_3,y_3),\dots, (x_n,y_n)] \quad \dots\dots\dots (4.16)$$

Where n is the numbers of intersection point

From these intersection points it is necessary to choose the relevant points, because not all points are appropriate for final determination of MS location (i.e. the outlier has to be removed). Since we know coordinates of intersections, the second step is identifying a subset of interior intersections. To identify whether the intersection point is interior or not, first we calculate the distance between the center of the first circle and each intersection points, and compare each distance with the radius of the circle iteratively. If the distance is greater than the radius of the circle, the intersection point is consider as exterior point and excluded from next computation. This distance computation is continued (repeated) for the remaining circles with excluding the identified exterior point. For every elimination of the exterior point, the distance computation decrease by one. Finally, the remaining non-eliminated intersection points are interior points [54,55]. This is, if the coordinates of the center of j^{th} circle and the i^{th} intersection point is (x_j,y_j) and (x_i,y_i) respectively, then the distance d_i between the center of the j^{th} circle (x_j,y_j) and the i^{th} intersection point is:

$$d_i = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \quad \dots\dots\dots(4.17)$$

if $d_i > r_j$, then the point (x_i,y_i) is an exterior point and it is outlier. Where r_j is the radius of j^{th} circle.

After calculating and comparing the distance d_i with the radius of each circles iteratively, we get the subset of the relevant intersection point I_r :

$$I_r = [(x_1,y_1), (x_2,y_2),(x_3,y_3),\dots, (x_k,y_k)] \quad \dots\dots\dots(4.18)$$

where k is the number of relevant intersection point.

Hence, as in fig.4.8. there are known three points (b, c and a) and consequently we have to calculate mean value of these correct points. The mean of these N - relevant intersection points is defined as the coordinates of MS position estimate, it is calculated as

$$x = \frac{1}{N} \sum_{l=1}^N x_l, \quad y = \frac{1}{N} \sum_{l=1}^N y_l, \quad l = 1, 2, \dots, K$$

.....(4.19)

where N is the number of BSs and K is number of relevant intersections.

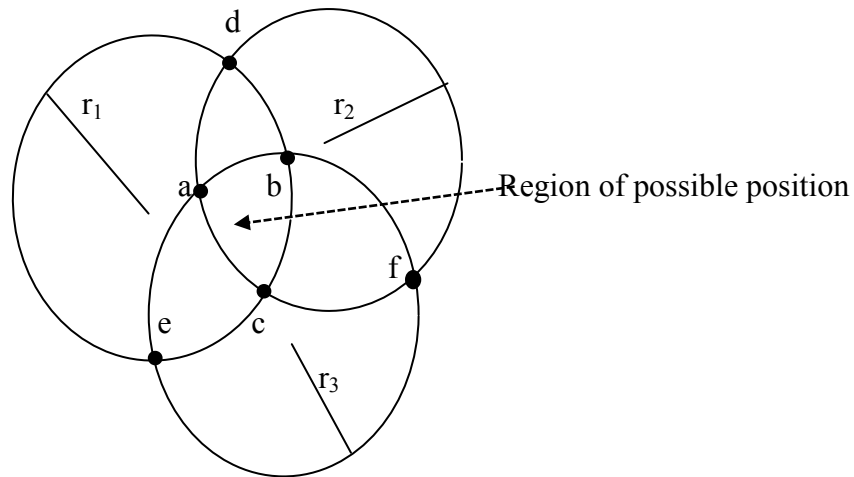


Figure 4.8: The Region of Possible Positions formed by the Intersection of Circles

(2) Location Estimation with Weighted Average

Another possible method of performing a calculation of a best estimate of position is through a simple direct numerical calculation by weighted average estimation, rather than performing a computational algorithm [51,55]. Since we know that the coordinates of BSs and the distance between the BSs and MS that was determined in step-2 based on RSS measurement, we can easily estimate the location of MS by weighted average estimation as in equation (4.20), where d_i is the distance between i^{th} BS and the MS [51,55].

If (x_i, y_i) , c_i and d_i are the coordinates, its weighted factor, and its distance from MS of i^{th} BS respectively, then MS location coordinates with weighted average estimate will be:

$$x = \frac{c_1x_1 + c_2x_2 + \dots + c_nx_n}{c_1 + c_2 + \dots + c_n}, \quad \text{and} \quad y = \frac{c_1y_1 + c_2y_2 + \dots + c_ny_n}{c_1 + c_2 + \dots + c_n} \dots\dots\dots(4.20)$$

Where: n is the number of base stations (cell towers), and

c_i is the weighting factor of a BS, which is determined in terms of the distance values of the respective BS-MS position-distance pairs, and in the environments tested, the most promising simple definition appeared be [55]

$$c_i = \frac{1}{d_i^2}$$

In the other way, if we take the received signal strength s_i from BS_i as a weighting factor, the location of MS can also be determined based on centroid algorithm. The centroid algorithm estimates the MS's position to be the geometric center of all the cells that are seen in a measurement [58]. Weighting the received signal strength observed by a MS, its location coordinates with weighted average estimate will be:

$$x = \frac{s_1x_1 + s_2x_2 + \dots + s_nx_n}{s_1 + s_2 + \dots + s_n}, \quad \text{and} \quad y = \frac{s_1y_1 + s_2y_2 + \dots + s_ny_n}{s_1 + s_2 + \dots + s_n} \dots\dots\dots(4.21)$$

or

$$X = (w_1 * x_1 + w_2 * x_2 + \dots + w_n * x_n), \text{ and}$$

$$Y = (w_1 * y_1 + w_2 * y_2 + \dots + w_n * y_n) \dots\dots\dots(4.22)$$

where: n is the number of base stations(cell towers), and

w_i is Weighted signal as the weighting factor of a BS, which is determined in terms of the received signal strength values of the respective BS-MS pairs,

$$w_i = s_i / (s_1 + s_2 + \dots + s_n)$$

4.2.2.4. Location Finder

The main responsibility of this module is to acquire actual geographical location of a given cell tower through look up the Cell-Tower-Location database. Cell-Tower-Location database stores cell IDs corresponding with their actual geographical location. Hence, the module checks the existence of the cell ID that accepts from the Location Determiner module in Cell-Tower-Location database. If the cell ID exists in the database, then it retrieves its actual geographic location, and returns this geographical location to Location Determiner module. Otherwise, it returns the geographical location of this cell can't find for time being. This indicates that the databases need to be updated. Thus, the module is also responsible to maintain the Cell-Tower-Location database.

4.2.2.5. Preference Extractor

The main responsibility of this module is to extract user's interest and preferences from the raw context data that is received from context filter module. It passes the identified user's preference and interest to the context manager module for further process. List of possible request and preference that a user can explicitly ask (request) the system to get market information to his nearest location are provided in the client mobile device through the user interface. The list is prepared by taking user's context into consideration. Hence, a user can specify his interest and preference through the provided list. The module extracts these specified users' interest and preference, and it forwards to Context Manager Module. For instance a user may want to get price information of a certain agricultural product at nearest market place; he specifies his request (price information) and his preference of market place location at some distance from his current location (within the specified distance range from his current location). Then the module extracts the user's interest and preference and forward to context manager module to get the respective response by consulting Agricultural Market database.

4.2.2.6. Context Manager

The Context Manager (CM) is the module in charge of delivering analyzed context data to the Reasoning and Decision component for further processing and action taking. CM accepts the user's preference and interest from the Preference Extractor module and current user's location from the location determiner module, and it combines the two information and tag with the

current date. At the same time, it also forwards the user's preference and interest to the Context Repository to be stored in user Profile Database. Based on the user preference distance range, the module determines the location of the possible market places.

For instance, if a user needs to know the availability of certain agricultural product at different market places which are 5km far from his current location. Here, the user specifies his need that is market information at 5km far from his current location. To deliver this required market information to the user based on his preference distance (5km), the module passes into four steps. Firstly, the module receives the user's preference distance range (5km) from the Preference Extractor module, and current user's location from the Location Determiner module. Secondly, it calculates the location of market places that are within 5km radius (distance range) around the user's current location based on the existing market place location data in Agro-Market database. Thirdly, it identifies the range of the nearest market place location to the user's location within 5km radius. Finally, it submits this possible market location range with other context data to the Reasoning and Decision component. The module is also responsible to store these context data in the user profile database that helps to analyze the user's interest and preference history during push notification based on the user's profile history.

4.2.4. Reasoning and Decision

The main responsibility of this component is to make decisions by examining contextual information or user requests against the existing context instance of data in the context repository. That is, the component is dedicated to drive a new knowledge based on the collected context information, by consulting AMIS ontology, the Context Repository, and the predefined existing AMIS-rules. Then, it submits this knowledge to the Service Delivery Component. It performs ontology supported rule-based reasoning over context information that gets from the context analyzing and the Context Repository components. The component comprises of five modules as presented in Figure 4.4: Reasoning Engine, Event Notifier, Decision module, Preference Identifier, and Context Mapper. These modules together are able to carry on the context reasoning process.

This component infers new knowledge for both cases either in pull scenario or push scenario. For this reason, it treats them separately. The modules that work for pull scenario are Decision Module and Inference Engine. Whereas, the modules that work for push scenario are all of the five modules. Many approaches have been developed and employed for context reasoning such as formal logic-driven reasoning and ontology-driven reasoning. In our work we employed ontology-driven reasoning.

4.2.4.1. Reasoning Engine

Reasoning Engine (RE) is the core module of the Reasoning and Decision component. Its main responsibility is to infer the suitable information to be dispatched to the user based on his current context. To do this, the module performs reasoning about the context, and then passes decisions about the actions to be performed. The RE works for both pull and push scenarios. In order to perform reasoning and drive new context knowledge, RE applies reasoning rules. In other word, it performs rule-based reasoning over the context.

It combines facts from the raw context data that receive either from Context Analyzing component (during pull scenario) or from Preference Mapper (during push scenario), the Rules files, and the AMIS ontology in order to assert new facts or to identify specific contexts. Then, it derives conclusions from the interpreted facts. Finally, it hands over the interpreted and the derived context information with the delivery mode type (push or pull) to the Decision module. The reasoning process is carried out in Working Memory in order to simplify the querying process and minimizing the interaction to the backend database. The reasoning rule that this module uses are the user defined rules and Ontology rules.

The reasoning rules can be ontology reasoning rules, which define constraints on the relationship of properties of concepts in the agricultural market domain or user-defined reasoning rules, which associate specific actions to a combination of various conditions. While deriving new context knowledge, it may need to access the responsible backed database to enrich the semantics of the derived context information that in turn enhances the usability of the context information for decision making. The example of user defined reasoning rules is presented in Table-1 below.

Table 1. Examples of Reasoning Rules

Example for User-defined Reasoning Rules	Description
[UserLocationRule: (?U AMIS:own ?D) (?device AMIS:isLocatedIn ?L) -> (?U AMIS:isLocatedIn ?L)]	If a user U own a device D, and the device D is located in location L, then the user U is located in L.
[UserServiceRequestRule: (?U AMIS:request ?S) (?S AMIS:isAbout ?M) -> (?U AMIS:request ?M)]	If a user U request a service S, and the service S is about market Information M, then the user U requests about market information M.

4.2.4.2. Decision Module

This module is responsible for accepting the context information with the delivery mode type that has been prepared by the Inference Engine module and reach to the final decision on selecting the mode of delivery (pull or push) of this derived context information. After it tag the context information with the delivery mode, and it submit the tagged context information to the Service Delivery component.

4.2.4.3. Event Notifier

It is responsible to notify the occurrence of a new event based on the monitored context. The monitored contexts are event parameters where the module periodically checks their current changes in the Agro-Market database as compared to the past history. The event parameters that used by the module includes: price with location, demand with location, availability with location, and stored time with location. These parameters describes price, demand, availability of a certain agricultural product that exists in Agro-Market database. These parameters fluctuate seasonally or periodically depending on the environmental situation and location, and the level of production condition. Furthermore, the module also uses event parameter (stored time with location) to notify the existence of outdated context data at certain location in Agro-Market database in order to be updated.

Hence, the module periodically analyzes the change on these parameters by contacting Agro-Market database, and it notifies if there is a change on them to the Context Mapper module.

The reason that the module uses the monitored context (or event parameters) is that for identifying and navigating of the occurrence of new event (i.e. any new change on these parameters). For instance, if currently: the price of certain agro-product falls or rises at certain

location; or the product is highly demanded at certain location; or the product's availability shows excess or deficit at certain location, then it notifies this to the Context Mapper module.

4.2.4.4. Preference Identifier

The module is responsible to analyze and dispatch the user's preferences and interests either based on the occurred event that accept from Context Mapper module, or through periodically navigate the users profile histories from the User Profile database. Then, the module analyses and identifies the user's preference, interests, and trends from his profile data, and submits these findings to Context Mapper module.

4.2.4.5. Context Mapper

The module performs its tasks based on two cases, one is during Event Notifier modules notifies the occurrence of special event, the other one is during Preference Discovery module submit context information to be dispatched to a user based on his profile history.

In the first case, the module accepts the notified event and contacts Preference Discovery module in order to identifies whether the notified event match with the user profile or not. If it matches, then the module submits to IE module. Otherwise it ignores. For instance during the production season the availability of certain agro-product shows excess at certain market place. The Event Notifier module notifies this. The Context Mapper contacts the Preference Discovery module. A user profiles shows that he requests the availability of this product at different market places every time during the production season. The module checks this match and forward to the RE.

In the second case, Preference Discovery module every time traces the users profile history and identifies their interest and preference. Then, it forwards the identified user's interest and preference to IE. For instance, a user every three month needs to know the price information of a product at market places that are 3km far from his current location. The module identifies his interest (price information) and his preference distance range of market place (3km). Then it forward this to RE in order to prepare context information based on his interest and preference.

4.2.5. Context Data Repository

The Context Data Repository is responsible to store ontology based context data instances into the responsible backend databases for future reference. Because historical context information can be used to establish trends and predict future context values. It manages the interaction of other components with the backend databases and AMIS ontology. It comprises two modules Memory-Base Repository Manager and Persistence Repository Manager.

4.2.5.1. Memory-Base Repository Manager

This module is responsible to manage the interaction of other components with the backend databases and AMIS ontology. It is also responsible to analyze and dispatch the context data to Persistence Layer to be stored into a responsible backend database based on the received context from other components. It acts as a mediator between other components and Persistence Repository module. The module temporarily holds ontology-based context data instances that received from either Context Analyzing or Reasoning components to facilitate the context analyzing and reasoning process. According to [41] using this module not only makes resource utilization to be efficient and effective, but also increases the performance of retrieving and storing operation. Since every retrieving and storing operation on context data is done by this module (with the help) through communicating with Persistence Repository.

4.2.5.2. Persistence Repository Manager

This module is responsible to manage the data store and access to the underlying relational database system and provides an abstraction for data access and retrieving operations. The module interacts with three databases which are used to store context data instances permanently. The user profile database stores and maintains the details of the user profile both static (his name, identity, phone number, e-mail address etc.) and dynamic (his interest, preference, location, service request time etc.). This database is updated every time whenever the user pass a request based on his preference and interest. The Agro-Market database is a repository of all instances of Agro-Market context data that is provided by local context data providers. This database is updated any time whenever the local Data provider sends new market data from the local market place. The Cell-Tower-Location Database is a repository of the cell towers (Cell IDs) corresponding with their actual geographical location. This database record and maintains the geographical location of the BSs (cell towers) and cells, and Cell Sector coverage angle for

each antenna (Sector Size). This database is developed and updated with the help of consultation from the EtioTelecom Company.

4.2.6. Service Delivery

The main responsibility of this module is to submit the received context information from Reasoning and Decision Component to the Communication Manager Component in the form of message either in pull or push scenario. Since this component handles the two scenarios, it comprises three modules, which are Service Coordinator, Information Dispatcher, and Notification Manager. The context information here is to mean that the responses to the user's interest and preference. We used this term in the subsequent three modules.

4.2.6.1. Service Coordinator

The module is responsible to decide the type of action to be taken, and submit this to the responsible module for the action to be performed. It coordinates and manages the two service scenarios. In order to identify which type of scenario will be carried out, it receives flag parameter with context information from Reasoning Component. The flag parameter holds the type of action that is going to be carried out. Hence, the module identifies the content of the flag parameter and decides to submit the context information to the responsible module for the action to take place.

4.2.6.2. Pull Dispatcher

The module is responsible to submit the required context information that received from service coordinator module to communication manager component to be sent to the client during pull scenario. Before submitting the context information, the module creates a message that holds the context information. Then, it submits the message to the communication Manager component.

4.2.6.3. Push Dispatcher

Its main responsibility is to submit the context information that accepts from Service Coordinator module, and passes the way of dispatching mechanism (either SMS or e-mail) to the Communication Manager component. Before submitting the context information, the module creates a message that holds the context information and the dispatching mechanism. If the dispatching mechanism is SMS, the module provided user's registered phone number. If it is e-mail, the module provided user's e-mail address. It decides how the notified message is sent to

the user through either SMS or using the user's e-mail address. Hence the communication manager is responsible to deliver the message to the client mobile devices.

4.3. Agricultural Marketing Information Service (AMIS) Ontology Design and Model

All core components of the described architecture require a common theory on how to formally represent context. This theory is called context ontology. To manage the context information systematically, the framework entities must have a common structure for representing information. Context modeling is the process for the abstract description of concepts and their relations. At the context modeling stage, context information is interpreted and structured in a holistic, coherent, and systematic way.

Among the different approaches for context modeling (Key-Value Models, Markup Scheme Models, Object-Oriented Models, Logic-Based Models, and Ontology-Based Models [36, 37, 38, 39]), we preferred to use Ontology-Based Models for modeling the concepts and relationships in the application domain of agricultural market information service (AMIS). In addition to providing an expressive formalism for representing complex context data, ontologies are well-suited for knowledge sharing, because they provide a formal specification of the semantics of context data. Using ontologies, context-aware services are able to semi- automatically or automatically matching users with content/services that are relevant to their context such as locations, activities and other contextual attributes [42]. An ontology based context modeling is used for context representation, context management and semantic interoperability that describe concepts, concept hierarchies and their relationships.

We therefore designed AMIS-Ontology for representing context information for the domain. AMIS-Ontology is where all the terms (concepts), properties of concepts, relationship between concepts and constraints on the properties of concepts in the pervasive agricultural marketing information service domain are modeled. The AMIS Ontology consists of a schema which represents the structure and the properties for all the AMIS-ontology's concepts and vocabulary that presents the terms for describing context information. The purpose of the AMIS ontology is to describe and formalize all major concepts involved in agricultural market domain, such as agricultural commodities, user (consumer, farmer, sailor, etc.), mobile devices, marketplaces,

etc. In AMIS-ontology, we have semantics about all components and related concepts. It also defines relations between the components and the concepts. For example, a user can be defined as an *own* a device and the device isLocatedAt certain place, then the relation islocatedAt is automatically granted to the transitive relation because both concepts are defined, in the ontology, as being the transitive of one another. One example of such context instance data can be given as: *Andarge own PhoneA001, and PhoneA001 isLocatedAt AratKilo*. This means, a user known as Andarge own a mobile phone called PhoneA001, which isLocatedAt AratKilo. From this, the ontology reasoner can easily deduce that Andarge isLocatedAt AratKilo. Figure 4.9 shows the class hierarchy and relationships of the concepts modeled by the ontology.

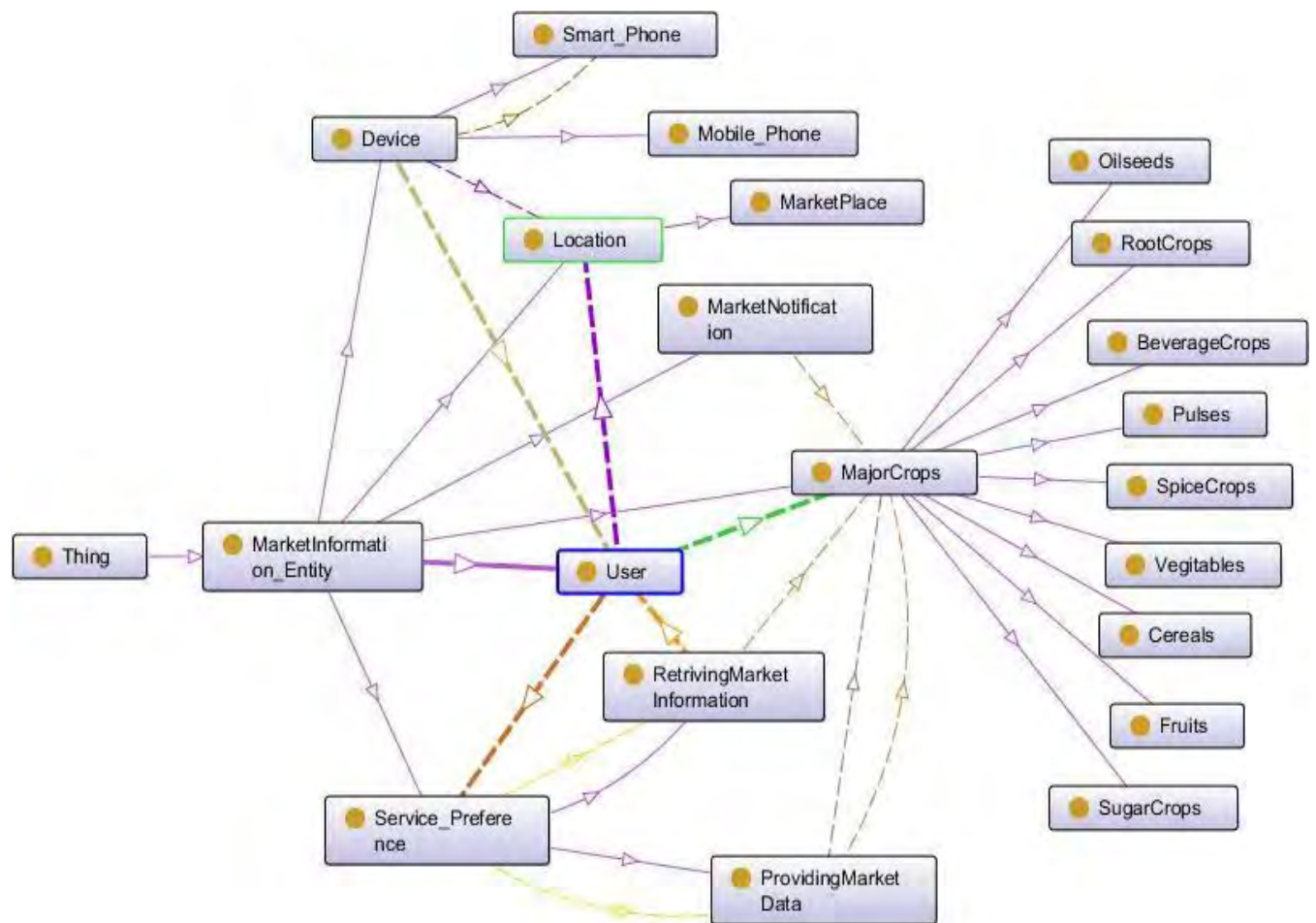


Figure 4.9: The class hierarchy and relationships of the concepts in AMIS ontology.

—————▶————— : Class Hierarchy

-----▶----- : Relationships

Table 2: AMIS Ontology Object Properties

No	Property Name	Domain	Range	Inverse of
1	isAbout	Service_Preference	ProvidingMarketData, RetriveMarketInformation	
2	ofCrop	MajorCrops	CropPrice,CropAvaliability, CropDemand	
3	isLocatedIn (hasLatitude, hasLongitude)	Device, User	Location	
4	isNotifiedTo	MarketNotification	User	
5	isOwnedBy	Device	User	own
6	isRegardingTo	ProvidingMarketData, RetriveMarketInformation, MarketNotification	MajorCrops	
7	request	User	Service_Preference	isRequestedBy

Table 3: AMIS Ontology Data type Properties

No	Property Name	Domain	Range	Description
1	AvailabilityLevel	MajorCrops	String	Crop's Availability level
2	CropColor	MajorCrops	String	
3	CropId	MajorCrops	String	
4	CropIdentity	MajorCrops	String	
5	CropName	MajorCrops	String	
6	CropQuality	MajorCrops	String	
7	CropType	MajorCrops	String	
8	DemandLevel	MajorCrops	String	
9	DeviceId	Device	String	
10	DeviceName	Device	String	
11	DeviceType	Device	String	
12	HasEducation	User	String	
13	HasEmail	User	String	
14	HasIdentity	User	String	
15	HasMobilePhoneNumber	User	String	
16	HasName	User	String	
17	HasPrice	MajorCrops	double	
18	SailedAtLocation(hasLatitude, hasLongitude)	MajorCrops	double	Market Location
19	SailedDate	MajorCrops	dateTime	Crop's sale date
20	DistancePreference	User	String	
21	RequestType	User	String	
22	RequestDate	User	dateTime	User's service request date

CHAPTER 5

PROTOTYPE IMPLEMENTATION

In this chapter, we present prototype implementation detail of the proposed framework, and their detail description. Here, we describe the development of the prototype, which is implemented for demonstrating and validating some of the concepts we have proposed during the design of the proposed framework architecture in the previous chapter. The main goal of the prototype implementation is to prove these concepts. A proof of concept implementation has been constructed using Java technologies. Besides this, we have used Android mobile application development platform tools and technologies, and JAVA programming language that runs on Eclipse Integrated Development Kit for implementing the prototype.

The majority of the components in the framework have been implemented as per the theoretical specifications formulated for each component. The implementation has been done for the two scenarios (push and pull). The communication between the client mobile phone and the Server PC is carried out with java socket programming interface through Internet Gateway.

The chapter is organized into four sections. Section 5.1 provides list of tools and technologies utilized; section 5.2 will give implementation detail of the major module that are implemented in the proposed architecture and algorithmic description of major modules there. Section 5.3 is to show implementation scenario and demonstration will be on section 5.4.

5.1. Tools and Technologies Used for Prototype

Several tools and technologies were utilized for the purpose of developing the prototype of the proposed framework. Programming, communication, database management, context representation, context reasoning and operating environment used in the prototype implementation are listed as follows:

- ADT Bundle version v22.0.5-757759 that includes the essential Android SDK components and a version of the Eclipse IDE with built-in ADT (Android Developer Tools) to streamline the Android application development.

- MY SQL database server version 5.0.22 is used for persistent data management on the server side.
- Protégé Ontology Editor Version 4.3 is used for developing AMIS ontology. It is an ontology development tools.
- Apache-Jena Semantic Web framework version 2.11.0 is used for generating an RDF model and implementing the ontology and user-defined reasoning rules.
- Microsoft Windows 8 operating system is used for the server.
- IEEE 802.11 wireless LAN (Wi-Fi) is used as a communication infrastructure between the mobile device and the server.

5.2. Implementation Detail

Since the main objective of the prototype implementation is to demonstrate and prove the concepts with respect to the framework components interactions, we have implemented the following modules in client-side and server side. The detail of implementation for the major components is outlined in the following sub-sections.

5.2.1. Modules on Client-Side

5.2.1.1. User Interface Manager

It is responsible to manage and monitor a user interfaces that will be displayed to the user. Besides this, it is also responsible to collect user's context data (his interest and preference) by providing a list of possible requests and preferences for user to selectively enter his interest. To do this, this manager provides an appropriate user interface to the user. Through the displayed user interface, a user can explicitly enter his request, and this manager collects his preference and interest. Then it submits this to Context Organizer module. It is implemented as an android main activity class that runs when the user initiate AMIS application.

5.2.1.2. Context Reader

It is responsible to capture and collect implicitly either raw location information (i.e. cell ID and RSSI) of currently servicing and neighboring cells for the mobile phone without built in GPS, or the location coordinates for smart phone with built in GPS receiver during local market data

collected, and submit this information to Context Organizer. It is implemented as an android java class that runs when the user initiate AMIS application. Its main duty in the prototype is to track the location information of the user, and to capture these context data. Then, it submits to the Context Organizer module. The source code for this module is included in Appendix C.

5.2.1.3. Communication Manager

On Client-Side: It is responsible to establish a TCP/IP socket connection through binding itself to a particular port, and then sends user's context information that received from Context Organizer module to the server. It is implemented as an android java class using java socket programming that runs when the user initiate AMIS application. Besides sending context information, this module is also responsible to continuously listens to the incoming messages from the server. And, it delivers the incoming message to the Context Receiver module to be displayed to the use on his mobile phone screen.

On Server-Side: It is responsible to establish a TCP/IP socket connection to listen a particular port and accepts connection of a client that binds itself to a particular port. Then accept user's context information that sent from the client mobile phone. It is implemented as java class using java socket programming that continually runs when it is instantiated. This module is responsible to continuously listens to the incoming requests from the client. And it delivers the coming message to the Context Analyzing component to be processed further. This process is during pull scenario.

During push scenario, this component is responsible to send the notification message either through SMS or e-mail to the client when it receive a notification message from Service Delivery component.

5.2.2. Modules on Server-Side

5.2.2.1. Pull Scenario

The major modules that are implemented during pull scenario are outlined in the following sub-sections.

5.2.2.1.1. Location Determiner

The main task of this module is to determine the location of user with a mobile phone (without built in –GPS). This module implements mobile location determination algorithm which is described in fig 5.1. It is implemented as a java class.

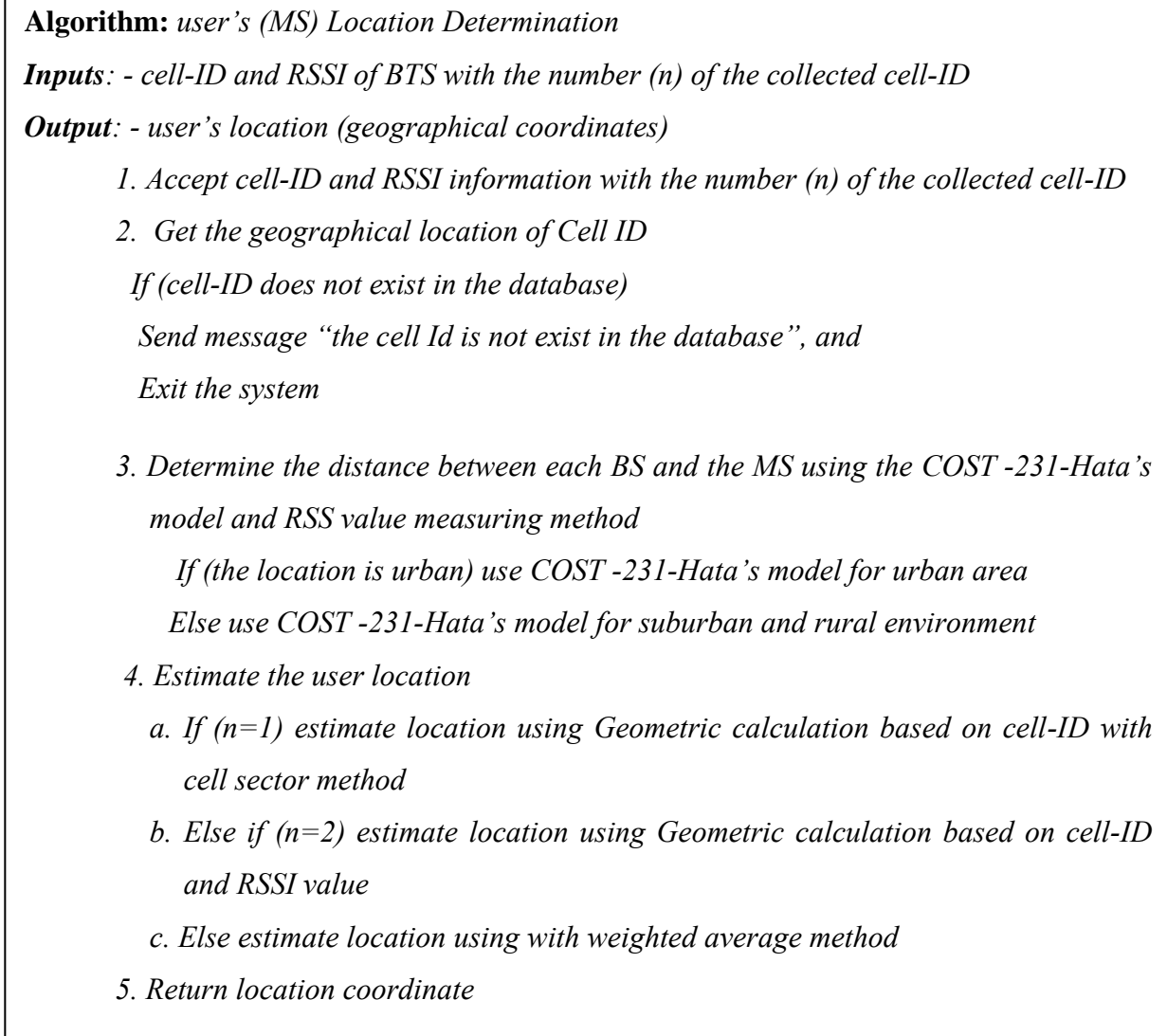


Figure 5.1: Location determination algorithm

5.2.2.1.2. Context Manager

The Context Manager (CM) is the module in charge of delivering analyzed context data to the Reasoning and Decision component for further processing and action taking. CM accepts the user's preference and interest from the Preference Extractor module and current user's location from the location determiner module, and it combines the two information and tag with the

current date. At the same time, it also forwards the user's preference and interest to the Context Repository to be stored in user Profile Database. Based on the user preference distance range, the module determines the location of the possible market places. It is implemented a java class and Jena API.

Algorithm: *Context Manager Module*

Inputs: *user's interest and preference*

Output: *current date tagged user's preference, interest, and location*

1. *Accept user's location, preference, interest, name, and identity*
2. *Get the current date*
3. *Concatenate user's preference with location and current date*
4. *Store user's preference, location, interest, and current date into context repository*
5. *Return current date tagged user's preference, interest, and location*

Figure 5.2: Context Manager mod determination algorithm

5.2.2.1.3. Information Dispatcher

The module is responsible to submit the required context information that received from service coordinator module to communication manager component to be sent to the client during pull scenario. Before submitting the context information, the module creates a message that holds the context information. Then, it submits the message to the communication Manager component. It is implemented a java class.

5.2.2.2. Push Scenario

The major modules that are implemented during push scenario are outlined in the following sub-sections

5.2.2.2.1. Preference Identifier

The module is responsible to analyze and dispatch the user's preferences and interests through periodically navigate the users profile histories from the User Profile database. Then, the module

analyses and identifies the user's preference, interests, and trends from his profile data, and submits these findings to Context Mapper module. It is implemented a java class.

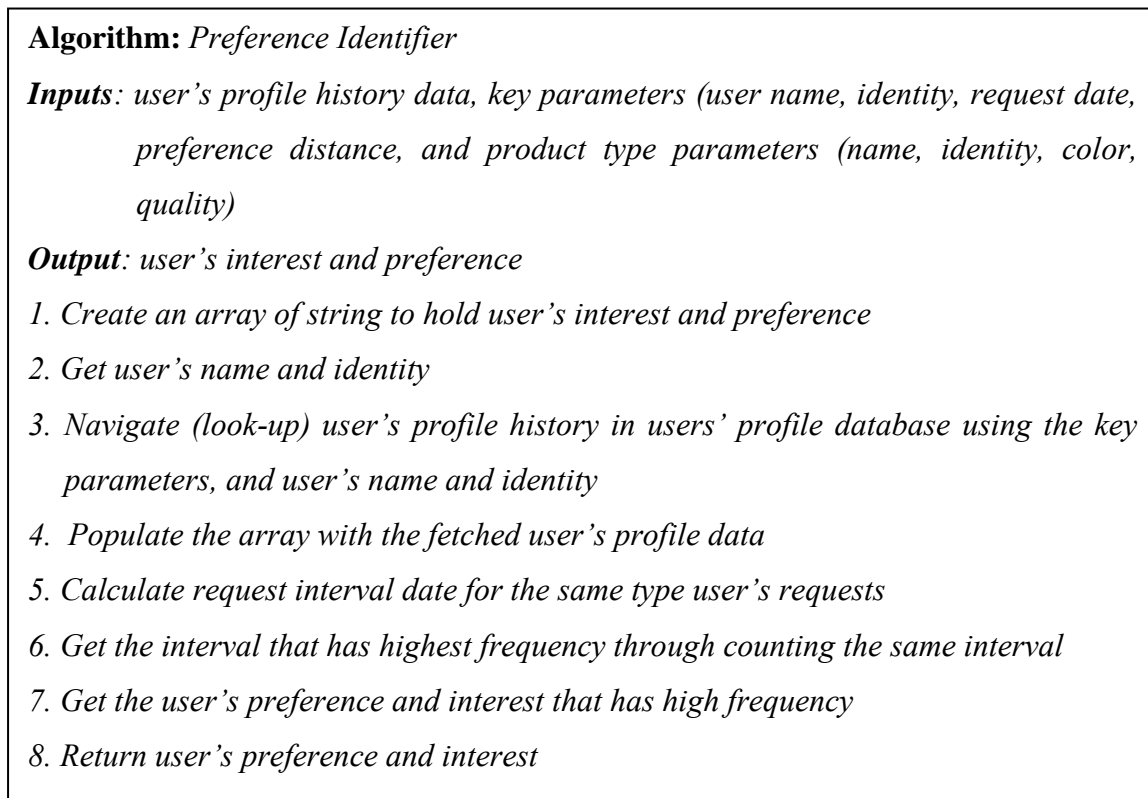


Figure 5.3: Preference Identifier Algorithm

5.2.2.2.2. Notification Manager

Its main responsible is to submit the context information that accepts from Service Coordinator module, and passes the way of dispatching mechanism (either SMS or e-mail) to the Communication Manager component. Before submitting the context information, the module creates a message that holds the context information and the dispatching mechanism. It is implemented a java class.

5.2.2.3. Reasoning and Decision

The component has two modules: the Reasoning Engine (RE) module and the Decision module, which are Java classes. It is implemented for both pull and push scenario. The module first receives the user's context information from either the Context Analyzer Component or Context Mapper module, and invokes the AMIS-ontology, the Context Repository (context knowledgebase), and the predefined existing AMIS-rules for undertaking a reasoning task.

Protégé [13] ontology development tools and Jena framework [14] API's are used to implement reasoning and decision process. Besides this, the reasoning process takes places by Combining Generic and OWL Reasoners. The inference engine accepts a set of context data, rules and their semantics, and changes it into concrete knowledge necessary for reasoning and decisions. After semantically combining together data from AMIS-ontology, context instance data and the predefined rules, the IE generate an RDF model that can be queried to get the required context information which match to the user interest and preference. In this prototype implementation, we use query tools SPARQL (Simple Protocol and RDF Query Language) that are supported by the Jena framework, to query the generated RDF model. Based on the responses returned by the query, the IE-module develops the context information. Then, it hands over the context information to the Decision module. Then, the Decision module tags the derived context information with the delivery mode, and submits to Service Delivery component. The source code is included in Appendix C.

Figure 5.4 shows a java code that uses Jena API to put together all the major components of the proposed frame work for reasoning, inferences and decisions. It also indicates how SPARQL queries are used to draw parameters for action triggering.

```

OntModel schema =
ModelFactory.createOntologyModel(OntModelSpec.OWL_DL_MEM_TRANS_INF);
schema.read("file:./Documents/OWLFiles/AgroMarket.owl");
Model data = FileManager.get().loadModel("file:./Documents/OWLFiles/AMISdata-
instance.owl");
Reasoner owlReasoner = ReasonerRegistry.getOWLReasoner();
InfModel owlInfModel = ModelFactory.createInfModel(owlReasoner, schema, data);
GenericRuleReasoner reasoner =
    New GenericRuleReasoner(Rule.rulesFromURL("file:./Documents/OWLFiles/
/myrule.rule"));
reasoner.setDerivationLogging(true);
InfModel infModel = ModelFactory.createInfModel(reasoner, owlInfModel);

```

Figure 5.4: Java code that uses Jena API to put together all the major components

5.2.2.4. Context Data Repository

It is responsible to store and provide context data from/to the responsible component. It serves as a repository where the context knowledge that is accumulated overtime will be stored. The Reasoning and Decision, and Context Analyzing component mainly accesses it. It is implemented as an ontology instance data. It is implemented as Jena SDB backend with MySQL database.

In order to manage the user profile and context profile, MySQL is used in the Entry Server.

The context knowledgebase and the context ontology are implemented as RDF schema and OWL ontology document respectively. The EMR and the Service Parameters Database are implemented as MySQL relational databases.

5.2.2.5. The AMIS Ontology

This is where all the terms (concepts), properties of concepts, relationship between concepts and constraints on the properties of concepts in AMIS are modeled. It is implemented as a protégé OWL ontology document. The RDF/OWL version of part of the context ontology for the AMIS is given in Appendix B.

5.3. Implementation Scenario

For purposes of demonstrating the usability of the prototype, we present two scenarios for the two cases: pull scenario and push scenario.

Pull Scenario:

Selamawit is a consumer whom lives somewhere in Addis Ababa city. Currently, she is at home, and wants to buy wheat for her consumption. However, she doesn't know the nearest marketplace where the wheat is currently sold with better price. She initiates the AMIS application that was deployed in her mobile phone. The application provides welcome message and provides an interface to login in the system. Since she is already registered user, she entered to the system as a member. After her login, an interface that helps her to insert explicitly her interests and preferences is displayed in her mobile phone. Then, she explicitly insert her interest (price information), and her preference the market place distance range (within 10km radius from her current location). The system captures her interest and preference. In addition to this, the system also implicitly captures her location information and time from her mobile phone through accessing the device system property. And then, it organizes these raw context data in the form of message, and sends the message to the server through internet gateway.

The server accepts the message, and analyzes it. Then it identifies her interest, preference, and her current location. Based on these raw context data, the system performs reasoning with contacting the AMIS-Ontology, the context repository and backend database. Before performing reasoning the system store her interests and preferences in the user profile database that used for later reference in the discovery of her interest and preferences during push notification. The server prepare message that holds inferred result that match with her preference and interest. Then it sends the message to her mobile phone. AMIS application in her mobile phone accepts the server response and displays a list of wheat current prices corresponding with the geographical location (the name) of market places within 10km radius where the wheat is currently sold. She navigates through the list, and she has a chance to identify and knows the marketplace where the wheat is currently sold with the least price. Then, she may be go to that market place, and buy the wheat. This saves her time and

money in searching a market place where the wheat is sold with better price, and protect her from deceives.

Push Notification Scenario:

Seifu is a trader whom lives somewhere in Addis Ababa city. He is basically sales wheat. He has agricultural commodities sale shop in “Berenda”. Every time, he wants to know the availability or price of Teff at different marketplace 20km far from his location especially from marketplaces: Sebeta, Alemgena, Sendafa, Asko, and Gefersa.

He is an already registered user to the AMIS system. Every week, he initiates the AMIS application that was deployed in his mobile phone. Then, he login to the AMIS system, and request the availability or price of wheat at a marketplace within 20km radius.

The system regularly checks the user’s profile history to discover his interest, and preferences. When the system traverses through user’s profile history using the parameters such as: user’s name (Seifu), his identity (trader), his interest (price of Teff), his preference (within 20km radius), number of requests (n weeks), and time interval (weekly), it found and understand that Seifu needs to know every week the price of Teff at marketplaces within 20km radius. Before Seifu pass the request to the system when six days elapsed from his current request, the system forwards the list of current price of Teff with the corresponding marketplace’s location to Seifu to notify him through his e-mail address. From this on continually, every week the system notify Seifu by sending the list of price of Teff with the corresponding marketplace’s location through his e-mail address.

5.4. Prototype Demonstration

In pull scenario:

When a user first initiates PCAAMIS application that installed in his mobile phone figure 5.5, the system displays the welcome window as shown in figure 5.6. If the user is an already registered, he selects a “member” from drop down list. As he selected “member” from drop down list, an interface is displayed to insert explicitly his identity as shown in figure 5.7. When the user click “Ok” button, an interface is displayed based on his identity. Since the user identity is “Local Context Data Provider”, the system displays an interface that helps the user to insert explicitly local market data as shown in figure 5.8. Similarly, for any user that is different from

local data provider, an interface is displayed that helps the user to insert explicitly his preference and interest as shown in figure 5.9. Immediately this interface is displayed to the user, the system capture implicitly the user’s location information. Then the user submits his request to the server. The server analyzes his interest, and preferences, as well as identifying his location. Then, it sends the relevant information to the user according to his current location with consulting the context repository as in figure 5.10.

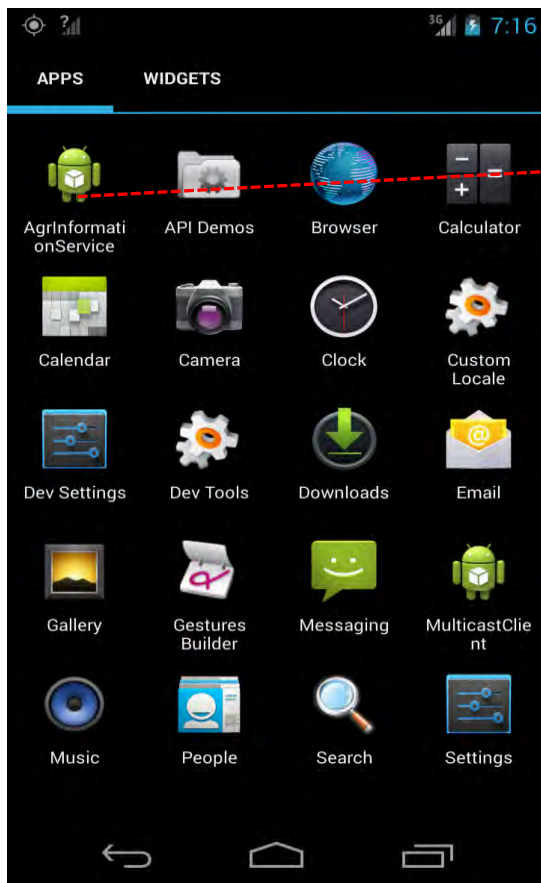


Figure 5.5: Snapshot of AMIS deployed in the user’s mobile phone

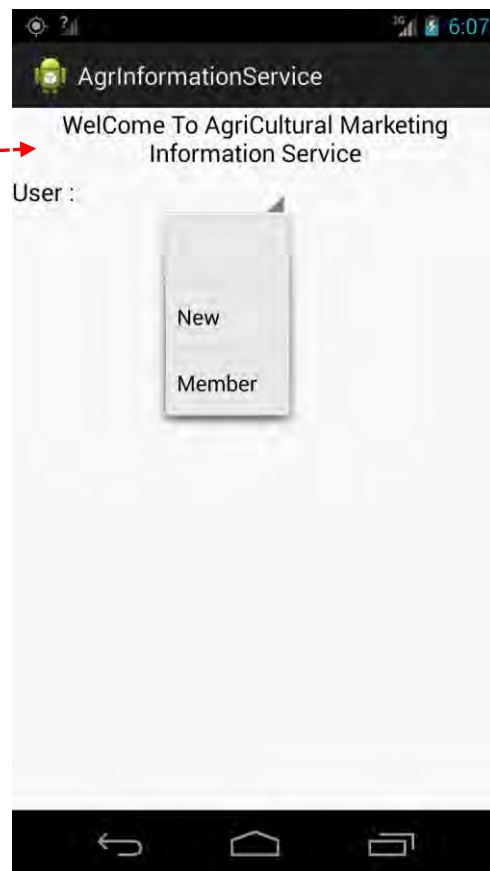


Figure 5.6: Snapshot during AMIS initiated

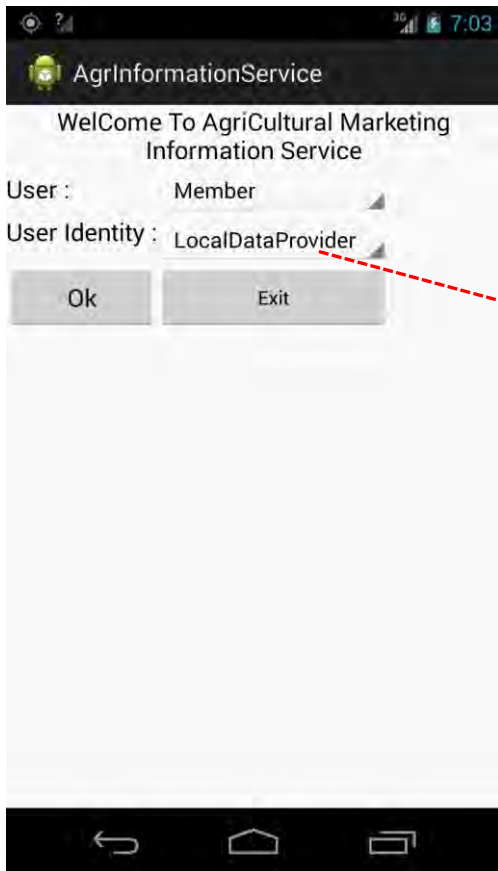


Figure 5.7: Snapshot during user selects "Member"

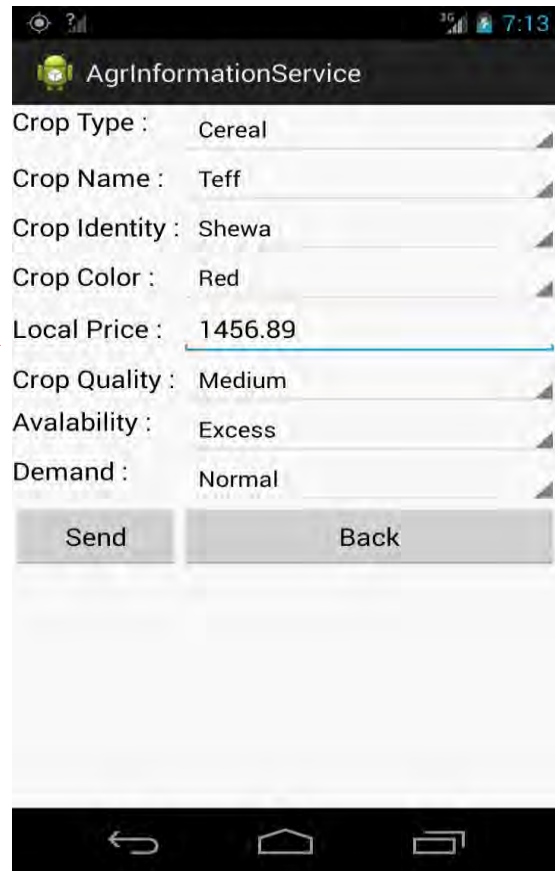


Figure 5.8: Snapshot for collecting local market data

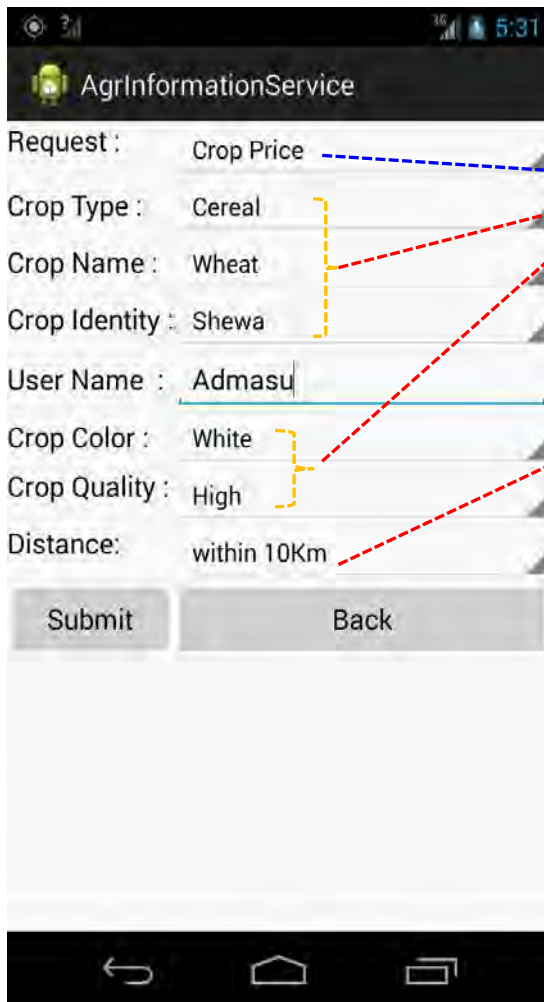


Figure 5.9: Snapshot to capture user's interest and preference



Figure 5.10: Snapshot of the response to the user's interest and preference

The figure 5.10 shows the result of a user's request based on his interest (crop price with the description of the type of crop) and his preference marketplaces (within 10km distance). The user's current identified location is Lideta.

In Push Scenario: The figure 5.11 shows that a user received a notification message in his e-mail address. The server sends a notification message to the user through his/her e-mail address, after discovered his/her preference and interest from his/her profile history.

The screenshot shows a Gmail interface with the following elements:

- Header:** Google logo, search bar, and navigation icons (+Yared, Share, profile icon).
- Navigation:** Gmail logo, back, forward, and other icons.
- Left Sidebar:**
 - COMPOSE
 - Inbox (3)
 - Starred
 - Important
 - Sent Mail
 - Drafts
 - Circles
 - More
 - Yared
 - New Hangout
- Top Ad:** Fluke Calibration - flukecal.com/Official_Site - High Quality Electric Calibration Products. Get Free Quote Today!
- Email Content:**
 - From:** abebekara@gmail.com
 - Subject:** Current Price
 - Time:** 2:58 AM (14 hours ago)
 - To:** me
 - Body:**
 - [1]. Teff , Gojam , White , High-Quality , Price:1456.34 , Location :Gefersa , Date:22-Feb-2014
 - [2]. Teff , Gojam , White , High-Quality , Price:1342.54 , Location :Asko , Date:22-Feb-2014
 - [3]. Teff , Gojam , White , High-Quality , Price:1098.56 , Location :Sebeta , Date:22-Feb-2014
 - [4]. Teff , Gojam , White , High-Quality , Price:1234.65 , Location :AlemGena , Date:22-Feb-2014
- Right Sidebar:**
 - Abebe kara
 - Job vacancies
 - Watch Live Football
 - Facebook Account Sign Up
 - Download For Free Movies
- Bottom Ad:** Fluke Calibration - High Quality Electric Calibration Products. Get Free Quote Today! flukecal.com/Official_Site
- Footer:** URL: https://mail.google.com/mail/?shva=1#inbox1446dd845c53ba59

Figure 5.11: snapshot when the user receives the notification message through his e-mail address

CHAPTER 6

CONCLUSIONS AND FUTURE WORK

This work presents a framework for provision of pervasive context-aware agricultural market information service (PCAAMIS) to mobile users by collecting local market data from local marketplaces. Unlike other related works, this work uses a different approach, incorporating the following three important things: firstly, we tried to show the possibility of gathering market data information from the diversified marketplaces all over the country using the mobile phone. Based on this collected context data, we provide the required services to the end user according to his current context (interest, preferences, time and location). The possibility of collecting market data from different marketplaces using mobile phone has a great contribution in the process of collecting context data in other domain especially for the country that has poor infrastructure. Secondly, we also describe how the intended service is delivered to the end user using the two basic delivery modes the pull and push. We describe this in scenario during the prototype implementation of the proposed framework. Finally, we use an algorithm that is used to identify the user location from the fetched cell-ID and RSSI information from the user mobile phone. This also contributes to the user to access the service using mobile phone without built in GPS receiver. Since most of the user especially the rural farmer in the country can't afford smart phone, this work supports them to access the service using an ordinary phone.

Furthermore, we discussed the architecture of the proposed framework and the proof of concept implementation. The prototype implementation of the proposed framework has been built using Java technologies and Android mobile phone development platform tool. The Java code for reasoning on the three components (ontology, instance contexts data and rules) and the SPARQL query is given as a demonstration. The ontology based context model with the parsing and interfacing mechanism of rules and context instances play an important role for reasoning and decisions involved to provide the intended context-aware agricultural market information services. Usability of the system can be greatly enhanced by utilizing contextual factors to display only the needed information and to provide optimized data entry screens, in accordance with the user preference and interest. We also discuss on developing context-aware information

services for agricultural market information applications. Despite the fact that our primary application domain is agricultural market, we expect that many concepts discussed here can be transferred to other application domains. The use of ontologies to specify a context model has as the main advantage the possibility of specifying the correct meaning and relationship between the terms, and avoiding ambiguous interpretations of the domain being modeled. Preliminary results from the prototype implementation show that the proposed PCAAMIS framework is a promising service that provides proactive context-aware market information services in pervasive environment.

Because of lack of collaboration from telecom organization, which is the only company that provides telecommunication service in the country, we are unable to get GSM network information including cell id information to look up cell tower location. For this reason, in the prototype implementation we use GPS simulated geographical location data for the identification of user's location instead of cell-ID and RSSI fetched measurement. This is the limitation of this work. However, the user location determination using cell-ID and RSSI is conducted by Ayenew [68] whom face the same problem like us, but he conduct the study through manually collecting cell tower (BS) geographical location using GPS device. His finding is good enough to become an evidence for the applicability of our work in the user's location determination using cell-ID and RSSI.

Regarding the future work, the privacy and security issue is one aspect that needs to be enhanced from the users' perspective. Moreover, since the main focus of this work is on providing market information service, this service can be enhanced by including context aware market recommendation and market prediction service based on the user current context using datamining facility. Besides this, the usability of the service increases, if the multi lingual capability is incorporated in the service, because in Ethiopia there is diversity of languages. Incorporating the multilingual capability helps the user especially rural farmers to access the service with their own language. Even if it is beyond the scope of this work in validating the appropriateness of COST -231-Hata's model for the selected environment, it has to be proofed. This will be performed in the future work.

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APENDECIES

Appendix A: Major agricultural products

Major Crops	TOTAL AREA IN HECTARES						TOTAL PROD. IN QUINTALS						Yield(Qts/Ha)			
	Estimates of		Forecast of 2012/13	% Change Of 2012/13 over		Estimates of		Forecast of 2012/13	% Change Of 2012/13 over		Estimates of		Forecast of 2012/13	% Change Of 2012/13 over		
	2010/11	2011/12		2010/11	2011/12	2010/11	2011/12		2010/11	2011/12	2010/11	2011/12		2010/11	2011/12	
	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12		
Pulses	1,357,522.68	1,616,809.37	1,609,053.05	18.53	-0.48	19,532,003.53	23,162,012.43	22,747,021.19	16.46	-1.79						
Faba Beans	459,183.51	457,559.94	583,821.71	27.14	27.59	6,978,008.30	7,147,960.23	9,394,740.07	34.63	31.43	15.20	15.62	16.09	5.87	3.02	
Field Peas	203,990.64	212,890.15	259,095.43	27.01	21.70	2,570,321.92	2,632,663.87	3,250,165.82	26.45	23.46	12.60	12.37	12.54	-0.44	1.41	
Haricot beans	237,366.39	331,708.15	359,235.58	51.34	8.30	3,402,814.00	3,878,023.01	4,127,345.88	21.29	6.43	14.34	11.69	11.49	-19.88	-1.72	
Chick-Peas	208,388.62	231,298.54	132,724.61	-36.31	-42.62	3,228,392.62	4,002,077.19	2,254,218.12	-30.18	-43.67	15.49	17.30	16.98	9.65	-1.83	
Lentils	77,334.22	109,895.27	114,114.61	47.56	3.84	809,521.98	1,280,087.87	1,401,902.82	73.18	9.52	10.47	11.65	12.29	17.34	5.45	
Grass Peas	131,043.99	179,866.13	74,923.77	-42.83	-58.34	2,009,490.22	3,055,753.10	1,330,901.23	-33.77	-56.45	15.33	16.99	17.76	15.87	4.55	
Soya Beans	11,261.12	19,397.16	25,320.88	124.85	30.54	158,244.45	358,802.94	380,896.94	140.70	6.16	14.05	18.50	15.04	7.07	-18.69	
Fenugreek	14,670.04	39,964.58	30,697.17	109.25	-23.19	179,055.13	362,939.17	282,742.63	57.91	-22.10	12.21	9.08	9.21	-24.56	1.44	
Gibto	14,284.15	34,229.45	29,119.30	103.86	-14.93	196,154.92	443,705.05	324,107.68	65.23	-26.95	13.73	12.96	11.13	-18.93	-14.12	
Oilseeds	774,529.55	880,870.81	852,460.89	10.06	-3.23	6,340,005.07	7,308,800.29	7,370,529.84	16.25	0.84						
Neug	247,611.17	309,010.72	304,735.94	23.07	-1.38	1,448,479.59	1,863,205.76	1,954,218.82	34.92	4.88	5.85	6.03	6.41	9.62	6.35	
Linseed	73,687.70	116,541.40	128,497.61	74.38	10.26	654,210.37	1,127,607.00	1,296,998.01	98.25	15.02	8.88	9.68	10.09	13.67	4.27	
Groundnut	49,602.97	64,476.52	92,242.77	85.96	43.06	716,069.62	1,034,787.88	1,247,682.19	74.24	20.57	14.44	16.05	13.53	-6.33	-15.73	
Sufflower	5,489.79	8,168.96	11,892.34	116.63	45.58	50,668.64	88,702.51	124,234.27	145.19	40.06	9.23	10.86	10.45	13.18	-3.81	
Sesame	384,682.79	337,505.41	271,717.60	-29.37	-19.49	3,277,413.35	2,447,833.59	1,982,460.67	-39.51	-19.01	8.52	7.25	7.30	-14.37	0.63	
Rapeseed	13,455.12	45,167.81	43,374.61	222.37	-3.97	193,163.49	746,663.56	764,935.89	296.00	2.45	14.36	16.53	17.64	22.81	6.69	

በኢትዮጵያ የታሪክ መረት ስፋትና የዋና ዋና ስብሰታ ምርት ግምት (መዝገር) 1998 - 2000 ዓ.ም
 AREA UNDER CULTIVATION, YIELD AND PRODUCTION OF MAJOR CROPS FOR 2005/06- 2007/08 MAIN (MEHER) SEASON ETHIOPIA**

ሠንጠረዥ መ.1.1

TABLE D.1.1

የስብል ዓይነት	1998 ዓ.ም.			1999 ዓ.ም.			2000 ዓ.ም.			CROP TYPE
	የታሪክ መረት ስፋት (በሂክታር)	የአያንዳንዱ ሂሳብ ምርት (በኩንታል)	ጠቅላላ ምርት (በኩንታል)	የታሪክ መረት ስፋት (በሂክታር)	የአያንዳንዱ ሂሳብ ምርት (በኩንታል)	ጠቅላላ ምርት (በኩንታል)	የታሪክ መረት ስፋት (በሂክታር)	የአያንዳንዱ ሂሳብ ምርት (በኩንታል)	ጠቅላላ ምርት (በኩንታል)	
የዘርፍ ስጋ ስህተት	8,081,292		116,241,561	8,471,919.72		128,797,925.96	8,730,001.31		137,699,066.6	CEREALS
ገብስ	997,868	12.73	12,706,798	1,019,313.77	13.27	13,521,480.05	984,942.72	13.8	13,548,070.55	BARLEY
ቡቱ	1,526,125	21.87	33,367,952	1,694,521.55	22.29	37,764,397.06	1,767,388.91	21.2	37,497,490.62	MAIZE
ማዝ	1,468,070	14.81	21,735,987	1,464,318.17	15.82	23,160,409.33	1,533,537.26	17.3	26,591,292.20	SORGHUM
ጸጉላ	333,029	11.92	3,970,017	374,071.57	12.95	4,844,089.15	399,267.90	13.5	5,379,914.64	FINGER MILLET
ቤፍ	2,246,017	9.69	21,755,977	2,404,674.00	10.14	24,377,494.60	2,565,155.22	11.7	29,929,234.99	TEFF
ስገዳ	1,459,540	15.20	22,190,754	1,473,917.31	16.71	24,630,638.52	1,424,719.03	16.3	23,144,885.23	WHEAT
አጃ	44,401	9.05	401,634	32,798.34	11.05	362,432.14	30,556.21	12.0	365,857.75	OATS
ሩዝ	6,241	18.02	112,443	*	*	*	24,434.07	29.2	713,160.65	RICE
የቅባት ስህተት	796,473		4,863,553	741,790.98		4,970,839.57	707,059.29		6,169,279.99	OIL SEEDS
የተለባ ፍራ	215,107	5.85	1,259,072	174,108.46	6.22	1,082,215.82	152,129.29	11.2	1,698,550.75	LINSEED(FLAX)
ጉግ	306,877	4.79	1,471,286	274,720.21	5.38	1,477,588.40	285,236.53	5.6	1,598,197.41	NEUG
ሰሊጥ	205,153	7.26	1,488,610	211,311.86	7.07	1,493,867.43	185,912.33	10.1	1,867,727.31	SESAME
ሰሙዝ	35,468	9.65	341,501	37,126.32	13.76	510,801.36	40,198.03	11.1	446,850.29	GROUND NUTS
ሱፍ	8,867	6.72	59,572	13,019.05	8.58	111,759.74	8,999.48	9.0	80,744.67	SUFFLOWER
ጎመንዘር	25,001	9.74	243,512	30,637.06	9.53	292,060.82	34,583.62	13.8	477,209.55	RAPESEED
ጥሬ ጥሬ ስህተት	1,292,169		12,712,469	1,379,045.77		15,786,215.39	1,517,661.93		17,827,387.94	PULSES
ግሙብራ	201,010	10.48	2,105,851	200,066.05	12.69	2,538,713.21	226,785.39	12.7	2,868,202.41	CHICK-PEAS
አተር	233,087	7.82	1,822,676	221,715.39	9.48	2,100,948.79	211,798.28	11.0	2,319,343.10	FIELD PEAS
አድንገራ	163,688	8.46	1,384,216	223,356.66	9.97	2,227,007.96	231,443.06	10.4	2,414,176.41	HARICOT BEANS
ባቄላ	456,919	11.22	5,127,970	459,201.57	12.55	5,761,562.97	520,519.72	13.2	6,886,670.09	FABA BEANS
ምሥር	84,895	6.79	576,033	97,110.32	8.35	810,494.22	107,427.59	8.8	941,027.30	LENTILS
ጓያ	123,464	11.82	1,459,448	124,954.05	14.71	1,837,839.76	147,171.56	12.6	1,854,900.23	GRASS PEA
አኩራ አተር	3,327	11.46	38,119	6,352.46	9.21	58,489.47	7,807.40	10.8	84,006.39	SOYA BEANS
አብሽ	11,845	6.32	74,839	20,762.03	7.90	163,985.87	38,310.10	7.7	293,520.42	FENUGREEK
ግብፅ	13,936	8.85	123,318	25,526.23	11.25	287,173.14	26,398.84	6.3	165,541.58	GIBTO
ሌሎች አዝርዕት										OTHER CROPS
ሽንጥራ አገጻ	43,555	427.82	18,638,318	42,995.37	319.73	13,747,115.00	21,482.25	363.9	7,817,336.53	SUGAR CANE
	AREA (ha)	YIELD (qt/ha)	PRODUCTION (qt)	AREA (ha)	YIELD (qt/ha)	PRODUCTION (qt)	AREA (ha)	YIELD (qt/ha)	PRODUCTION (qt)	
	2005/2006			2006/2007			2007/2008.			

** Excluding Nomadic Areas

NOTE: Data is for private holdings only

- መረጃ አልተገኘም
 - Data not available.

Appendix B: RDF generated Code of part of the AMIS ontology

<rdf:RDF

xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">

xmlns:AMIS="http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#">

<rdf:Description

rdf:about="http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#USER7">

<AMIS:own>

<rdf:Description

rdf:about="http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#0000000000000002">

<AMIS:DeviceId>0000000000000002</AMIS:DeviceId>

</rdf:Description>

</AMIS:own>

<AMIS:request>

<rdf:Description

rdf:about="http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#Service">

<AMIS:isAbout>

<rdf:Description

rdf:about="http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#RetriveMarketInformation">

<AMIS:isRegardingTo>

<rdf:Description

rdf:about="http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#Crop Price">

<AMIS:ofCrop>

<rdf:Description

rdf:about="http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#Teff">

<AMIS:CropName>Teff</AMIS:CropName>

<AMIS:CropColor>White</AMIS:CropColor>

<AMIS:CropIdentity>Gojam</AMIS:CropIdentity>

<AMIS:CropQuality>High</AMIS:CropQuality>

</rdf:Description>

```

        </AMIS:ofCrop>
    </rdf:Description>
</AMIS:isRegardingTo>
</rdf:Description>
</AMIS:isAbout>
</rdf:Description>
</AMIS:request>

```

Appendix C: Java codes of some of the module

```

/ **** Nearest Market Identifier ****/
public static String PreferenceMarketPlaceIdentifier(Double latitude, Double longitude, String distPref)
{
    String distancePref=distPref;
    Double clatitude=latitude;
    Double clongitude=longitude;
    int distance, distPref = 3;

    String queryId = "PREFIX PCAAMIS:
<http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#>" +
        "PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>"
+
        "SELECT ?CropId ?HasLatitude ?HasLongitude " +
        "WHERE { " + " ?x PCAAMIS:CropId ?CropId . " +
        "?x PCAAMIS:HasLatitude ?HasLatitude." +
        "?x PCAAMIS:HasLongitude ?HasLongitude." +
        "}" +
        "ORDER BY ASC(?CropId)";
    Query queryId1 = QueryFactory.create(queryId) ;
    QueryExecution qeId = QueryExecutionFactory.create(queryId1,m1) ;
    ResultSet results = qeId.execSelect() ;

    if (distancePref.equals("within 5Km")) distPref=5;
    else if (distancePref.equals("within 10Km")) distPref=10;

```

```

else if (distancePref.equals("within 15Km")) distPref=15;
else if (distancePref.equals("within 20Km")) distPref=20;

int k=0;
String[] qryResult=new String[1000];
String[] qryDate=new String[1000];
double [] lat = new double [1000];
double [] lon = new double [1000];
double [] lat1 = new double [1000];
double [] lon2 = new double [1000];
int [] dis = new int [1000];
for ( ; results.hasNext() ; )
{
    QuerySolution res = results.nextSolution() ;
    lat[k]=Double.parseDouble(res.get("?HasLatitude").toString());
    lon[k]=Double.parseDouble(res.get("?HasLongitude").toString());
    k++;
}

```

```

double a, c;
int j=0;

double dLat, dLon;
for ( int i=0; i<= lat.length ;i++ )
{
    if(lat[i] !=0.0 && lon[i]!=0.0) {
        dLat = Radians(lat[i]- clatitude);
        dLon = Radians(lon[i]- clongitude);
        a = Math.sin(dLat/2) * Math.sin(dLat/2) +
            Math.cos(Radians(clatitude)) * Math.cos(Radians(lat[i])) *
            Math.sin(dLon/2) * Math.sin(dLon/2);
        c = 2 * Math.atan2(Math.sqrt(a), Math.sqrt(1-a));
        distance= (int) (6371 * c); // Distance in km

        if (distance<=distPref) {

```

```

        lat1[j]=lat[i];
        lon2[j]=lon[i];
        j++;
    }
}
else i=99999;
}

double LatMin, LatMax,LonMin,LonMax;
LatMin=lat1[0];
LatMax=lat1[0];
LonMin=lon2[0];
LonMax=lon2[0];
for ( int i=1; i<= lon2.length ;i++ )
{
    if(lat1[i] !=0.0 && lon2[i]!=0.0) {
        if (lat1[i] <= LatMin ) {
            LatMin=lat1[i];
        }
        else if(lat1[i] >= LatMax ) {
            LatMax=lat1[i];
        }

        if ( lon2[i] <= LonMin) {
            LonMin=lon2[i];
        }
        else if(lon2[i] >= LonMax) {
            LonMax=lon2[i];
        }
    }

    else i=99999;
}

qeId.close();

```

```

        return LatMin + "," + LonMin + ";" + LatMax + "," + LonMax;
    }

    public static double Radians(double x)
    {
        return x * 3.141592653589793/ 180;
    }

    /***** Reasoning and Decision Code *****/
    public class ContextReasoning {

        static final String inputFileNames = "C:/Users/yaredb/Documents/OWLFiles/AgroMarket.owl";
        String NS =
            "http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#";
        private static String className = "com.mysql.jdbc.Driver";
        private static String DB_URL = "jdbc:mysql://localhost:3306/agrimarket"; //agrimarketinfo
        private static String DB_USER = "root";
        private static String DB_PASSWD = "root";
        static final String ontologySchemaFileName =
            "C:/Users/yaredb/Documents/OWLFiles/AgroMarket.owl";
        static final String ruleFile = "C:/Users/yaredb/Documents/OWLFiles/AMISRules.txt";
        private MulticastingServer mServer;

        @SuppressWarnings("static-access")
        void ReadValue ( String userName, String userIdentity, String device_id, String type, String name, String
            identity, String color, String quality, String requestType, String dist, Double latitude, Double
            longitude)
        {
            String cuserName=userName;
            String cuserIdentity=userIdentity;
            String cdevice_id=device_id;
            String ctype=type;
            String cname=name;
            String cidentity=identity;
            String ccolor=color;

```

```

String cquality=quality;
String crequestType=requestType;
String distancePref=dist;
Double clatitude=latitude;
                Double clongitude=longitude;
                String messageText = null;
                Calendar cal = Calendar.getInstance();
                cal.add(Calendar.DATE, -2);
                XSDDateTime date1;
                date1= new XSDDateTime(cal);
                mServer = new MulticastingServer();

// create store description
StoreDesc storeDesc = new StoreDesc(LayoutType.LayoutTripleNodesHash,DatabaseType.MySQL);

// load database driver
try {
                Class.forName(className);
                System.out.println("JDBC driver load successfully!");
        } catch (Exception e) {
                e.printStackTrace();
        }
        // create SDBConnection
SDBConnection sdbConnection = new SDBConnection(DB_URL,DB_USER,DB_PASSWD);
                // connect to store

Store store = SDBFactory.connectStore(sdbConnection,storeDesc);

                // connect store to dataset
// Dataset dataset = SDBFactory.connectDataset(store);

                Model model = SDBFactory.connectDefaultModel(store) ;

OntModel onto = ModelFactory.createOntologyModel(OntModelSpec.OWL_MEM, null);
Model m1 = ModelFactory.createDefaultModel();

```

```

InputStream in = FileManager.get().open( inputFileName );
        if (in == null) {
throw new IllegalArgumentException( "File: " + inputFileName + " not found");
        }
        // To read an ontology in a Java application with Jena:
try {

        onto.read(new File(inputFileName).toURL().toString());
        }
catch (Exception je) {
        System.out.println("ERROR");
        je.printStackTrace();
        onto = null;
        System.exit(0);
        }
}

```

```

String queryUserId = "PREFIX PCAAMIS:
<http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#>" +
        "SELECT ?userId " +
"WHERE {" +
        " ?u PCAAMIS:HasName ?userId. " +
        "}" +
        "ORDER BY ASC(?userId)";
Query queryUserId1 = QueryFactory.create(queryUserId);
// Execute the query and obtain results
QueryExecution qeUserId = QueryExecutionFactory.create(queryUserId1, model);
//ResultSet resultId = qeId.execSelect();
String userId="";
com.hp.hpl.jena.query.ResultSet resultId = qeUserId .execSelect();
        ResultSetFormatter.out(resultId) ;
int l= ((com.hp.hpl.jena.query.ResultSet) resultId).getRowIndex();
        System.out.println(l);
        l++;
        userId="USER"+ l;

```

```
qeUserId.close();
```

```
String st=userId;
```

```
Resource r1= m1.getResource(NS + st );
```

```
String st1="Service";
```

```
Resource r2= m1.getResource(NS + st1 );
```

```
String st2="RetriveMarketInformation";
```

```
Resource r3= m1.getResource(NS + st2 );
```

```
String st3=cdevice_id;
```

```
Resource r4= m1.getResource(NS + st3 );
```

```
String st4=crequestType;
```

```
Resource r5= m1.getResource(NS + st4 );
```

```
String st5=cname;
```

```
Resource r6= m1.getResource(NS + st5 );
```

```
//to get Datatype properties
```

```
ExtendedIterator<DatatypeProperty> Datatypeproperties =onto.listDatatypeProperties();
```

```
while(Datatypeproperties.hasNext())
```

```
{
```

```
String str= (Datatypeproperties.next().getLocalName().toString());
```

```
if (str.equals("HasName")) {
```

```
    r1.addProperty(onto.getProperty(NS,str),cuserName );
```

```
    }
```

```
else if (str.equals("HasIdentity")) {
```

```
    r1.addProperty(onto.getProperty(NS,str),cuserIdentity );
```

```
    }
```

```
else if (str.equals("UserId")) {
```

```
    r1.addProperty(onto.getProperty(NS,str),userId );
```

```
    }
```

```
else if (str.equals("RequestDate")) {
```

```
    r1.addProperty(onto.getProperty(NS,str),date1.toString());
```

```

    }
else if (str.equals("DeviceId")) {

    r4.addProperty(onto.getProperty(NS,str),cdevice_id );
    }
else if (str.equals("CropName")) {
    r6.addProperty(onto.getProperty(NS,str),cname );
    }
else if (str.equals("CropIdentity")) {
    r6.addProperty(onto.getProperty(NS,str),cidentity );
    }
else if (str.equals("CropColor")) {
    r6.addProperty(onto.getProperty(NS,str),ccolor );
else if (str.equals("CropQuality")) {
    r6.addProperty(onto.getProperty(NS,str),cquality );
    }
else if (str.equals("DistancePreference")) {
    r1.addProperty(onto.getProperty(NS,str),distancePref);
    }

    }

//to get object properties
ExtendedIterator<ObjectProperty> objectproperties =onto.listObjectProperties();
while(objectproperties.hasNext())
{
String str= (objectproperties.next().getLocalName().toString());

    if (str.equals("request")) {
m1.add(r1, onto.getProperty(NS,str), r2);
    }
else if (str.equals("isAbout"))
m1.add(r2, onto.getProperty(NS,str), r3);
    }
else if (str.equals("isRegardingTo")) {

```

```

        m1.add(r3, onto.getProperty(NS,str), r5);
    }
    else if (str.equals("ofCrop")) {
        m1.add(r5, onto.getProperty(NS,str), r6);
    }
    else if (str.equals("own")) {
        m1.add(r1, onto.getProperty(NS,str), r4);
    }
}
}

```

```

m1.setNsPrefix( "AMIS", NS );
m1.add(model);

```

```

OntModel schema =
ModelFactory.createOntologyModel(OntModelSpec.OWL_DL_MEM_TRANS_INF);
    try {
        //To read an ontology in a Java application with Jena:
        schema.read(new File(ontologySchemaFileName).toURL().toString());
    }
    catch (Exception je) {
        System.out.println("ERROR");
        je.printStackTrace();
        schema = null;
        System.exit(0);
    }
    Reasoner owlReasoner = ReasonerRegistry.getOWLReasoner();
    InfModel owlInfModel = ModelFactory.createInfModel(owlReasoner, schema, m1);// data);
    GenericRuleReasoner reasoner = new GenericRuleReasoner(Rule.rulesFromURL(ruleFile));
        reasoner.setDerivationLogging(true);
        InfModel infModel = ModelFactory.createInfModel(reasoner, owlInfModel);
    String queryId = "PREFIX PCAAMIS:
<http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#>" + "PREFIX
xsd: <http://www.w3.org/2001/XMLSchema#>" +
        double LatMin, LatMax,LonMin,LonMax;
        String location= PreferenceMarketPlaceIdentifier(latitude, longitude, distPref)
        // LatMin= str(location, ",",location.size -10 );

```

```

        // LatMax= str(location, ",",location.size -10);
        // LonMin= str(location, ",",location.size -10);
        // LonMax= str(location, ",",location.size -10);
String queryMesege = null;

if (crequestType.equals("Crop Price")){
queryMesege = "PREFIX PCAAMIS:
<http://www.semanticweb.org/preferredcustomer/ontologies/2013/8/MarketInformation/#>" +
"PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>" +
"SELECT ?CropId ?CropName ?CropType ?CropIdentity ?CropColor ?CropQuality ?HasPrice
?SailedDate ?LocationName ?HasLatitude ?HasLongitude " +
"WHERE {" + "?x PCAAMIS:CropId ?CropId . " +
" ?x PCAAMIS:CropName ?CropName . " +
" ?x PCAAMIS:CropType ?CropType . " +
" ?x PCAAMIS:CropIdentity ?CropIdentity . " +
" ?x PCAAMIS:CropColor ?CropColor . " +
" ?x PCAAMIS:CropQuality ?CropQuality . " +
" ?x PCAAMIS:HasPrice ?HasPrice . " +
"?x PCAAMIS:SailedDate ?SailedDate." +
" BIND (xsd:dateTime(?SailedDate) as ?Date)" +
"?x PCAAMIS:HasLatitude ?HasLatitude." +
" BIND (xsd:double(?HasLatitude) as ?Latitude)" +
"?x PCAAMIS:HasLongitude ?HasLongitude." +
" BIND (xsd:double(?HasLongitude) as ?Longitude)" +
"?x PCAAMIS:HasLocationName ?LocationName." +
"FILTER (?Latitude >= "+ LatMin +" && ?Latitude <= "+LatMax+" )" +
"FILTER (?Longitude >= "+ LonMin +" && ?Longitude <= "+LonMax+" )" +
"FILTER (xsd:dateTime(?SailedDate) >= xsd:dateTime("+ date1
+"))" +
"FILTER (str(?CropName) = "+ cname +" && str(?CropIdentity)=" +cidentity+" &&
str(?CropColor)=" +ccolor+" && str(?CropQuality) ="+cquality+" )" +
"}" +
"ORDER BY ASC(?CropId) LIMIT 6";
}

```

```
/***** cell-Id and RSSI Acquisition *****/
```

```
public String CellLocationReader(){

this.TelephonyManager telephonyManager =
(TelephonyManager) getSystemService(Context.TELEPHONY_SERVICE);
this.phoneStateListener = setupPhoneStateListener();
this.telephonyManager.listen(phoneStateListener, PhoneStateListener.LISTEN_CELL_LOCATION);
this.telephonyManager.listen(phoneStateListener,
PhoneStateListener.LISTEN_DATA_CONNECTION_STATE);
this.telephonyManager.listen(phoneStateListener,
PhoneStateListener.LISTEN_SIGNAL_STRENGTHS);

// This part is used to listen for properties of the neighboring cells
List<NeighboringCellInfo> NeighboringList = telephonyManager.getNeighboringCellInfo();
String stringCellInfo= Null;
for (int i=0; i < cellInfos.size(); i++){

    String dBm;
    int rssi = NeighboringList.get(i).getRssi();

    if(rssi == NeighboringCellInfo.UNKNOWN_RSSI){
        dBm = "Unknown RSSI";
    }
    else{
        dBm = String.valueOf(-113 + 2 * rssi) + " dBm";
    }

    stringCellInfo = stringNeighboring
        + String.valueOf(NeighboringList.get(i).getCid()) + " : "
        + dBm + "\n";
    }

public PhoneStateListener setupPhoneStateListener()
{
return new PhoneStateListener() {

    /** Callback invoked when device cell location changes. */
    @SuppressWarnings("NewApi")
    public void onCellLocationChanged(CellLocation location)
    {
        GsmCellLocation gsmCellLocation = (GsmCellLocation) location;
        gsmCellLocation.getCid();

        Log.d("cellp", "registered: "+gsmCellLocation.toString());
    }
}
}
}
```

```
}
/** invoked when data connection state changes (only way to get the network type) */
public void onDataConnectionStateChanged(int state, int networkType)
{
    Log.d("cellp", "registered: "+networkType);
}

/** Callback invoked when network signal strengths changes. */
public void onSignalStrengthsChanged(SignalStrength signalStrength)
{
    Log.d("cellp", "registered: "+signalStrength.getGsmSignalStrength());
}

};
}

return stringCellInfo;

}
```