An Evaluation of Oracle Application Server Wireless as a Framework for Location-aware Applications

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Abstract

Today, much focus is put on adding location-awareness to mobile applications. This will lead to an improved user experience by enabling more relevant information to the user, depending on his location. However, location-aware applications are still in their early days. They are hard to develop, deploy and test. Every application developed is tailored for its specific needs, a difficult and time-consuming job.

To have a general framework for developing location-aware applications will make developing such applications easier, less expensive and less time-consuming. This will in turn lead to more applications and can lead to great value for both users and other stakeholders.

This project has evaluated Oracle Application Server as a framework for developing location-aware applications in general and location-aware guiding in particular. Oracle Application Server includes much of the functionality needed including for example positioning, privacy handling, adaption of content to different devices and development tools. However, Oracle Application Server introduces some challenges and has some shortcomings. Among the challenges is the fact that most APIs provided need to be implemented by external providers, and among the shortcomings we find some issues related to the privacy of the users.

Keywords: Oracle Application Server Wireless, Location-aware applications, Location-aware guiding, Evaluation
Preface

This report contains the documentation of a project in "TDT4735 Systemutvikling, fordyppning" by Stein Kåre Skytteren and Trond Marius Øvstetun. The title of this project is "An Evaluation of Oracle Application Server Wireless as a Framework for Location-aware Applications" and has been carried out at the Department of Computer and Information Science at the Norwegian University of Science and Technology. The project evaluates the Oracle 10g Application Server with respect to general location-aware application requirements and especially concerning location-aware guiding applications.

This report has been written under the supervision of Associate Professor PhD Alf Inge Wang. This project is part of the MOWAHS project, which is sponsored by the Norwegian Research Council.

We would like to thank our supervisors Alf Inge Wang from IDI, NTNU and Steinar Brede form Telenor R&D. They have given us invaluable feedback and council during this fall. We would also like to thank Per A. D. Jynge for valuable advice and interesting viewpoints.

Trondheim, November 24, 2004

Stein Kåre Skytteren  Trond Marius Øvstetun
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Part I

Introduction
This part is the background and foundation for the project. It starts out with a chapter about motivation before it focuses on the problem definition, the project context and the readers guide in next chapters. The final chapter is on the project’s process and method.
Chapter 1

Motivation

Today, mobile equipment has become increasingly common and has taken a major place in peoples’ lives. Mobile phones and Personal Digital Assistants are being used more and more frequently in many settings. As the use of this equipment increases, so does the need for applications tailored for them. A few successful applications have been seen in the past, but the need for something new and innovative is still there.

Many believe that location-aware services will be the next big thing, using the user’s location to provide relevant functionality and information for the user. In the past, all such services have been developed from scratch, as no generic way to acquire the user’s location has been available. Another problem has been the fact that several different localization techniques such as GPS and WLAN positioning exist. Each service has to choose which technique to use, and develop some sort of proprietary solution.

By providing a generic framework for location-aware services, the development of new services would be much easier. Such a application framework should handle concerns such as acquiring the location from different localization technologies as well as security, privacy and billing.

The motivation for this thesis is to explore different aspects needed in a general framework for location-aware services in general, and a location-aware guide application in particular. Tourist applications are challenging, as the users are mobile by definition. This also means that they need to have very user friendly design, as the users come from many different countries, cultures and understand different languages.
Chapter 2

Problem Definition

This project aims to investigate different aspects related to a framework for location-aware mobile applications. After an analysis of technologies, business possibilities and general concerns related to location-awareness and mobile computing, a set of requirements for a general framework for these applications must be captured.

These requirements shall be related to a specific usage scenario, *location-aware tourist guiding*.

Finally, the requirements shall be used to evaluate Oracle Application Server Wireless as a general framework for location-aware applications.
Chapter 3

Project Context

This project is part of the MOWAHS research project. The MOWAHS project, which is supported by the Norwegian Research Council in its IKT-2010 program, is carried out by the Software Engineering Group in cooperation with the Database Systems Group at the Department of Computer and Information Science (IDI) at the Norwegian University of Science and Technology (NTNU). Our project fits into the MOWAHS project as location-aware technology is important in supporting mobile work.

Telenor R&D and Klipp og Lim Media have also supported this project with time, effort, resources and guidelines. Telenor R&D supports the project as a step towards the implementation of location-aware applications as part of their overall application portfolio. It also enables the possibility of providing location-aware information to other application providers. Klipp og Lim Media strives to provide new kinds of services for their customers. Location-aware applications are an important part of this work.
Chapter 4

Readers Guide

This chapter contains a brief overview of the entire document, giving a short description of each part.

Part I - Introduction

This part sets the frame for the rest of the document. It contains the motivation, problem definition and project context before it finishes with this readers guide, and an overview of the project’s process and method.

Part II - Prestudy

The prestudy contains general information on topics that are related to location-aware applications and frameworks. These topics are positioning techniques, devices, performance, privacy, business possibilities, future location-aware applications and finally the Oracle Application Server.

Part III - Contribution

This part contains a scenario for location-aware applications with emphasis on different stakeholder views. Further it contains requirements for such applications, before it evaluates the Oracle Application Server with respect to the requirements.

Part IV - Conclusion

This part sums it all up and has the chapters on discussion, conclusion and further work.
Chapter 5

Project Process and Method

The purpose of this chapter is to present an overview of the project’s process, which this document is based upon. After starting with the prestudy, this process will go through several steps before it evaluates the Oracle 10g Wireless Application Server and end up with a conclusion as shown in Figure 5.1.

This project will start out wide using an exploratory approach, trying to capture all important issues from many different fields concerning location-aware applications. The use of secondary sources will be dominant in this part as it focuses on prior and ongoing work. The purpose of addressing many fields is to have a great variety of requirements for evaluating a location-aware application framework, not just the developers’ view that easily can be emphasized. Some issues like business concerns, is especially important for some of the project’s stakeholders as they are commercial actors. The business issues will also be a foundation for this thesis’ stakeholder views.

A scenario of a location-aware guidance application will be adopted. This will be based upon the different stakeholder views and will together with the other topics addressed in the prestudy be a basis for requirements for the framework. These requirements should as a result incorporate many different aspects, which can be important for the evaluation of the Oracle Application Server Wireless as a location-aware application framework. The evaluation will end up in a discussion and a conclusion used to indicate future work.

These phases could be done in strict step by step manner, however there are some activities that overlap somewhat naturally, and thereby can improve the project’s overall efficiency. This is natural as there are two people collaborating in this project. However the process will be close to the one outlined in Figure 5.1.
Figure 5.1: Project Process
Part II

Prestudy
The prestudy is a broad survey of important topics concerning location-aware applications. The purpose of this part is to get an overview as well as a detailed description of these topics. The topics addressed are positioning, devices, performance, privacy, business possibilities, future applications and finally the Oracle Application Server.
Chapter 6

Positioning techniques

This chapter will present some of the most commonly available positioning techniques. All systems discussed are capable of locating some sort of mobile device (see Chapter 7), with a given degree of accuracy.

6.1 GPS – Global Positioning System

GPS [15] is a satellite-based positioning system. It was originally started by the U.S. Department of Defense, but is now publicly available. The system consists of 24 satellites orbiting the earth. These satellites transmit a signal, allowing GPS-enabled devices to be positioned in 2D (latitude and longitude) anywhere on the face of the earth, given a line-of-sight to at least three satellites. If the receiver is able to get signals from a fourth satellite, the position will be given in 3D, including altitude. An illustration of the satellite system is shown in Figure 6.1.

The most common GPS-enabled devices have accuracy of approximately 15 meters. A newer kind of receivers using a technology called Differential GPS (DGPS) can increase the accuracy to 3-5 meters. This system use a correction signal received from a base station on the ground, and the device corrects the original signal received from the satellites. An extra receiver is needed to be able to take advantage of this correction signal.

Another addition to GPS is Wide Area Augmentation System (WAAS) [16]. By using WAAS, the accuracy is improved to less than 3 meters. This technology also relies on base stations on the ground, but one is not dependant of extra equipment or receivers to use it. WAAS has only been implemented in North America.

European Geostationary Navigation Overlay Service (EGNOS) [1] is the European counterpart of WAAS. The technology is basically the same as for WAAS, and EGNOS is available in most of Europe.

GPS will normally deliver high accuracy, as mentioned in the previous paragraphs. One of its weaknesses is the fact that one has to have a free line-of-sight to at least three satellites. This means that in areas with many obstacles (such as tall buildings, ...
trees and mountains) and inside buildings, GPS accuracy is low if it works at all. A GPS receiver has to be included in a mobile device in order to position it using GPS. Many devices, including mobile phones and PDAs do not have such a receiver.

6.2 WLAN positioning

Traditionally, WLAN (Wireless Local Area Network) positioning has shown a low degree of accuracy, as it has not been possible to determine location more precise than to say that a device is in the proximity of a given access point. This method is called the proximity model. Lately, several solutions have arisen that improve this situation considerably. These solutions can generally be placed in two categories, namely the empirical model and the propagation model.

The empirical model relies on a pre-recorded map of signal strengths from the area to be considered. Systems in this category must be calibrated in order to record these values. Based on these values, the location of a device is estimated.

The propagation model estimates the location of a device on-the-fly. Using advanced equations, the location is determined based on the strength of the received signal at the different access points.

6.2.1 Ekahau

The Finnish company Ekahau delivers a location system called the Ekahau Positioning Engine [13]. Ekahau is an example of a system using the empirical model.
It is purely a software-based system, and uses the access points already present in a WLAN environment. It requires at least three access points to work, giving an accuracy of 2-3 meters on average. If 5-7 access points are available, accuracy will be as good as 1-2 meters on average.

Ekahau requires calibration, approximately one hour per 1000 m². After this calibration has been done, it can locate more than 50 devices per second with 90-95% accuracy. Ekahau works in any 802.11a/b/g WLAN environment.

6.2.2 Cordis RadioEye

Cordis RadioEye is a system developed by the Norwegian company Radionor Communications. It is based on the propagation model, which means that it calculates the device's location on-the-fly. The system consists of the RadioEye, which is integrated into an already existing WLAN (802.11b) environment.

The RadioEye is basically an advanced antenna array with an integrated computer. It can calculate the position of wireless devices with an accuracy of about 1 meter, and can cover an area of 2-3000 m². It is able to deliver close to 1000 location updates per second.

The technology used in the RadioEye is applicable to all kinds of wireless technologies, including GSM, GPRS, UMTS, all WLAN devices (802.11a/b/g) and Bluetooth. Today, the system only support devices using the 802.11b technology, but future releases of the system will include more of the different communication technologies.

6.3 GSM and GPRS positioning

Most mobile phones in Europe today use the GSM network. Several techniques for positioning in this network exist, we will look closer at three of them.

6.3.1 Cell ID

Cell ID is a standard available in both GSM/GPRS and UMTS networks. This is the simplest way to say something about the location of a mobile phone. This method identifies the base station where the phone is connected, and finds the location of this base station. The device is then known to be within the proximity of the particular base station.

The accuracy of this method is depending on the size of the cell – the coverage area of the base station. A typical cell has a diameter of 2-20 km. The more dense the network is, the smaller the cells will be and thus improving accuracy. This is typically the case in urban areas. If micro-cells are used, accuracy can be within to 400–500 m.
6.3.2 Enhanced Observed Time Difference

Enhanced Observed Time Difference (E-OTD) use signal bursts from at least three neighboring base stations. The location of the mobile device is then calculated based on these bursts. Both the arrival time of each burst, the time difference between them and the coordinates of the base stations is used to triangulate the location of the device.

This method does not require hardware modifications of the handsets, only a software upgrade to be able to perform the calculation and measure the timing differences precisely. Because of the need for precise timing information, the network has to be extended with Location Measurement Units (LMUs). The LMU is responsible for delivering the precise timing information to the GSM devices.

E-OTD has an accuracy of 50–100 m, making it much better than Cell ID, but the addition of LMUs makes it a far more expensive solution.

6.3.3 Wireless Assisted GPS

Wireless Assisted GPS (A-GPS) use the GPS technology discussed in Section 6.1. Devices supporting A-GPS has a GPS receiver integrated within it. A-GPS use some of the characteristics of the DGPS system, and has approximately the same performance. Reference base stations with known locations receive information from the GPS satellites, and calculate a correction to the signal.

For the mobile phones, two modes of operation is possible. In the network based mode, the phone is only responsible for receiving signals from the satellites and forwarding this information to a location server. This server is then responsible for calculating the actual position and sending it back to the phone.

In network assisted mode, the phone performs the calculation itself after receiving corrections from the network. This method requires more work to be done on the phone itself, and also more correction data to be sent to the phone from the location servers.

6.4 UMTS positioning

UMTS is the next generation standard for mobile telephony. The techniques for positioning phones in this system are similar to the ones used in GSM networks, presented in Section 6.3. In this section we show three possibilities for positioning in UMTS networks.

6.4.1 Cell ID

The Cell ID method for use in UMTS networks works is the same way as in GSM/GPRS networks, as presented in Section 6.3.1. The difference is that UMTS cells generally are smaller than GSM cells, due to differences in the technology and
CHAPTER 6. POSITIONING TECHNIQUES

the fact that UMTS uses a higher frequency for transmitting signals. The accuracy in UMTS networks is approximately 100 m – 5 km.

6.4.2 Observed Time Difference of Arrival

Observed Time Difference of Arrival (OTDOA) is considered a UMTS version of the E-OTD method. It has approximately the same performance as E-OTD, the same need for LMUs and signal from at least three base stations. Since the signal strength is lower in UMTS networks than in GSM networks, the ability for a mobile device to receive signals from at least three base stations is severely limited.

6.4.3 Wireless Assisted GPS

A-GPS can be used in UMTS networks as well as in GSM networks. The properties of this method are exactly the same as those discussed in Section 6.3.3.

6.5 Bluetooth positioning

Many mobile devices include a Bluetooth module. Bluetooth comes in several forms. The most common are the Class 3 devices, and has a transmission range of approximately 10 meters. Most attempts of using Bluetooth as a positioning technique are based on the proximity model, saying that a mobile device is inside the range of another (stationary) device with a known location. Thus the mobile device can be positioned with an accuracy of 10 meters.

There have been made some attempts to improve the accuracy by using triangulation with several stationary devices, but none have been very successful.

6.6 Ultrasound positioning

The Norwegian company Sonitor [4] delivers an indoor positioning system based on ultrasound. Ultrasound is sound with frequency higher than audible for the human ear, in the range of 25–45 kHz. The system uses a tag that emits sound, and can be attached to just about any device, person or equipment. The sound signal is then received by one or more microphones, and the id of the tag is forwarded to a central server.

The Sonitor system has two granularities. Using a single microphone in each room, a tag can be positioned to the correct room. This is the basic Sonitor IPS (Indoor Positioning System) system. By using more microphones in a limited area, as in the Sonitor 3DPsos system, a much greater accuracy is achieved. With eight microphones covering an area of 5x5x3 meters, the accuracy can be as good as 2–3 cm.
CHAPTER 6. POSITIONING TECHNIQUES

One of the advantages of using sound as a signaling medium is that it does not interfere with other radio-based systems. Technologies using radio-signals, such as for example WLAN and Bluetooth, do interfere.

6.7 Positioning using RFID

Positioning can also be done using RFID (Radio Frequency ID) tags. These tags come in two different forms, passive and active. The most common is the passive tag, without a battery. This tag gathers electricity from the radio waves sent from a receiver and sends back information based on these signals. These tags have a very short range of 5–25 cm, but are very inexpensive. Due to its short range, the tag must be held up close to a receiver, which detects the tag and collects its unique ID. If we know the location of the receiver, we will also know the location of the tag.

Active tags have an active transmitter to send information. Most active tags also have a battery, but some gather electricity from other sources. An active tag has a range of up to 100 meters, but is much more expensive than the passive one.

6.8 Summary

As we have discussed in this chapter, several technologies for positioning mobile devices exist. These technologies differ in capabilities, both in accuracy, scale and availability and we classify them in three different levels, Macro, Micro and Touch.

**Macro** is the least accurate level. It represents a rough estimate of the location of a device or user. This level will include any positioning with accuracy less than 15 meters. The technologies that fall into this category include the GSM- and UMTS-based technologies. This accuracy will probably be available anywhere, as most users “always” carry their mobile phone with them, and will function outdoors as well as indoors.

**Micro** is the next level. This level represents an accuracy ranging from 20 cm to 15 meters. This group will include GPS, WLAN, ultrasound, Bluetooth and active RFID. This level of accuracy will be available at locations where an application needs more reliable information of the position of a device, probably most indoor, as in hospitals and museums.

**Touch** is the most accurate classification. The accuracy will be up to 20 cm. This level is a bit different than the others, in that a user will have to perform an active action, moving his device into the (short) range of a predefined point, hence the name *touch*. This level will primarily include passive RFID, and be available at particular points of interest, for example next to a specific item on display in a museum, where one can access more precise information about the item.
Chapter 7

Devices

This chapter describes some mobile devices that can be used in location-aware computing. The different devices have very different characteristics, from variations in computing capacity and memory to display quality, portability and available communication technologies.

Different devices can be positioned using the techniques from Chapter 6 depending on the capabilities of the device. The technique applicable for each device type will be highlighted here, as well as how applications can be developed for the devices.

7.1 PDA

A PDA (Personal Digital Assistant) is a small handheld computer. They typically include part of the functionality found in a normal desktop computer, such as web-browsing, e-mail, calendar and management of personal contacts. The device has a small touch-sensitive screen, which will display information to the user. Some devices have a small keyboard for the user to give input, while other solely rely on the touch screen, and use a form of hand-writing recognition to record the input. An example of each type is given in Figure 7.1

The connectivity of these devices has been limited in the past, as they had to use a cable to connect to a desktop computer. Lately, this situation has changed. Today, many devices come with WLAN (mostly 802.11b), IRDA and Bluetooth as standard. Some PDAs also include a GSM module; making it capable of connecting to the GSM network in the same manner as GSM phones, see Section 7.2. A PDA with phone characteristics (or a phone with PDA characteristics) is often referred to as a smartphone.

Some PDAs even incorporate a GPS receiver (see Section 7.5), or such a receiver can be added as an extension. These devices then are capable of receiving and decoding the GPS positioning signals.

Most PDAs are programmable and it is possible to develop new applications to be deployed on them. These applications have to be developed using a programming
language supported by the PDA. The languages available on a PDA is mainly given by the type of operating system (OS) running on the device. Today, four main flavors of operating systems are available:

- **Palm OS** [39] is the operating system for the palmOne [38] handheld devices. Software development can be done directly on the API included in the OS, or J2ME [46] applications can be deployed if there is a Java Virtual Machine installed on the devices.

- **Windows Mobile** [10] is Microsoft’s [31] attempt to gain market shares in the handheld market. It is found in many devices from different vendors, including Dell [1] and Hewlett-Packard [2]. Development of applications for this OS can be done either by using Microsoft’s native languages found in the .NET Compact Framework [32], or through the use of J2ME [46].

- **Linux** is an open source operating system primarily developed for stationary devices. None the less, it is also available for use on a few handheld devices. Handhelds [3] is an organization working for implementing Linux for handheld devices such as PDAs.

- **Symbian OS** [28] is mostly found in smartphones. Development for Symbian OS is done either through a native C++ SDK (Software Development Kit), with J2ME or a language called OPL (Open Programming language) [27].

PalmOS and Windows Mobile are by far the most common, but more and more
devices come with Linux and Symbian. In particular, as more smartphones appear on the market, Symbian is gaining a considerable market share.

Pros & Cons

PDAs have moderate computing power, and have in general good capabilities for showing multimedia content. Several well known programming languages are available, making application development relatively easy. They support standard communication channels using WLAN or Bluetooth, giving high performance both for communication and positioning when available.

However, most PDAs lack the ability to use the GSM network for communication. Thus they cannot be positioned or have communication in most areas without an external module. Not many people own a PDA, so the access to such a device for a location-aware application must be provided by for example renting them to potential users. This imposes a great administration effort as well as the economical risk associated with this scheme.

7.2 GSM phone

The most common mobile phones in Europe today use the GSM network. These phones vary in capacity, functionality, size, prize etc. Almost all devices have the capability of sending and receiving SMS (Short Message Service) messages, and most new devices also have the capability of handling MMS (Multimedia Messaging Service) messages. SMS messages contain text, up to 160 characters in one message, while the MMS messages also can contain multimedia content such as pictures, video streams and sound in addition to text.

Many of the newest devices have extended connectivity options beyond that of the GSM network. Integrated Bluetooth is becoming more and more common, in particular in the more expensive phones. As is the case with some PDAs, a few GSM phones include a GPS receiver, or have the capability of adding such receivers as an extension.

As stated, GSM phones differ much, physically and in terms of functionality. One of the most obvious differences is size and display. While some phones have large displays with full color capabilities, other phones have smaller displays only capable of showing black and white. The numeric pad is basically the same on every phone, but the form of navigation vary. They range from simple up-and-down arrows with one select-button to devices with a two-dimensional arrow-set and several buttons and methods for selecting. Two different phones are shown in Figure 7.2.

This difference in capabilities in the different devices put constraints on how to develop services for these devices. The most advanced services will not work (at least to their best) on the most primitive devices, and services developed for the limited devices will not be able to utilize the full potential in the more advanced ones.
Development of an application for GSM phones is mostly done the same way as for PDAs. Different phones support different programming languages, but most phones support J2ME \cite{46} in some flavor. In addition, phones running the Symbian OS (smartphones) can be programmed using all languages supported by the OS \cite{27}, as mentioned in Section \ref{sec:7.1}.

**Pros & Cons**

The greatest advantage of using GSM phones is the availability. The greater part of the population has such a phone, and virtually always carry their phone with them. They can always be reached and positioned through the GSM network. Text, images and sound-based multimedia can be used on most modern phones, but video is rarely available.

The performance of using the GSM network for transferring data is generally a bit too low for multimedia content. Positioning of GSM phones has a too low accuracy for most indoor applications, but outdoors the accuracy might be as good as required for many applications.

### 7.3 UMTS phone

UMTS phones are the phones used in the next generation mobile network (3G), in Europe the UMTS network. They have many of the characteristics found in GSM phones, but have in general higher computational power and better displays. The data rate such a phone can handle through the network is also much higher than in the GSM network. This makes it possible to create applications relying more on use of multimedia content. Two phones are shown as an example in Figure \ref{fig:7.3}.
Application development for UMTS phones is basically the same as for GSM phones, see the discussion in Section 7.2.

![Two 3G phones](image)

**Pros & Cons**

UMTS phones are in many ways similar to GSM phones. Their advantages and disadvantages are mostly the same, but multimedia possibility is better: use of video is greatly improved due to both better computing capabilities, displays and higher bandwidth. Positioning is slightly more accurate than GSM, but still not accurate enough for indoor use requiring a very accurate position.

Some UMTS phones have been criticized for having inadequate battery capacity. As the computing power and display size and quality has increased, the battery-life has become a bigger challenge. Not many people have made the transition from a GSM phone to the new UMTS standard. However this will change in the near future. The availability will likely be as good as for GSM phones today. UMTS phones are more expensive than GSM phones, but in the future the cost of these devices will drop.

### 7.4 Tablet PC

A tablet PC is a mix between a portable PC and a paper notebook. It is a (possibly) small and light portable PC, with a special display and requires no keyboard or mouse. Instead, user input is given through the special display system. This system
includes a small pen-like unit, which is used for giving input. The screen records the movement of the pen when held close to or touching the screen, much like a touch-screen but using a magnetic field.

Such a device will have all the same properties as a normal portable PC, including possibilities to have integrated WLAN, Bluetooth and GPS receivers. An example of a Tablet PC is shown in Figure 7.4.

![Figure 7.4: Tablet PC. Source: [21](#)](image)

**Pros & Cons**

Tablet PCs have very good computing power, and can display any form of multimedia content without problems. Communications with WLAN or Bluetooth allow for high bandwidth, as well as accurate positioning.

There are two major problems with Tablet PCs in location-aware systems in general. The first is that they are rather large and too heavy to carry around compared to for example PDAs. The second is the price and durability. They are expensive, fragile devices, and will probably break if dropped to the floor from waist-height. As PDAs, they cannot be positioned in an area without WLAN or Bluetooth without an additional module.

### 7.5 GPS receivers

GPS receivers are devices who receive and decode the signals sent from the GPS satellites. They have a screen capable of showing the current location on a pre-
loaded map, to show a planned route, the actual route (tracking) etc. Many GPS receivers have the capability to connect to other devices, either using a cable (such as USB) or some sort of wireless connection (such as Bluetooth).

For more information on the GPS system, see Section 6.1.

### Pros & Cons

A GPS receiver is a rather small device, and can be positioned with a high accuracy in most areas. They are not very expensive either. Most of them have a standard interface for communicating with other devices such as PDAs.

The negative sides of GPS receivers are the fact that they are only receivers. They have no other functionality than positioning. Another issue is the fact that they are not very common, as mobile phones are.

### Tags

A tag is a small unit, emitting a signal that can be received by a nearby base station. Examples of tags are RFID tags, ultrasound tags and WLAN tags. These tags will not be able to receive information, but can emit their id to the surroundings. Thus they can be positioned as described in Chapter 6.

As these tags cannot receive information or perform calculations, their use is a bit different than other devices. They can either be used to find or track equipment or people without any other device, or they can be used as a form of support for
other devices. For example, if an area has a precise WLAN positioning system like Cordis RadioEye and a service using this system, a user with a mobile phone can be equipped with a WLAN tag. His phone can then receive information from the system based on the position of the tag.

Pros & Cons

Like GPS receivers, tags have no other functionality than positioning. The difference between them is that tags are passive devices in that the position must be calculated outside of the tag itself. They need special infrastructure in order to work.

Tags can be a helpful addition to other devices, such as using a WLAN tag with a mobile phone to achieve higher accuracy in indoor positioning.

7.7 Combination of different devices

When it comes to combining different devices, two different strategies are the most applicable. One is to integrate several different devices into one unit, for example to add a GPS receiver into a mobile phone. The other is to make the different devices communicate without physically making them fit into one unit.

Many people think the first strategy is the one most likely to succeed in the future. Several GSM phones have integrated GPS receivers. By using this strategy, the future will bring more integrated devices, but they are likely to be larger, more expensive and more power consuming.

The other strategy allows each device to be more and more specialized. They will only need to have an interface to connect to other devices to work together. This will result in smaller, cheaper devices using less power. The different devices can then be combined to suit the needs of each end user.

From a positioning point of view, both strategies will work towards the same end. Different technologies can be used in different environments, depending on the needs of the user. For example, GSM technology can be used outdoors, giving the position of a device roughly. If the same device (or an attached device) has GPS, the accuracy will be improved. As the user moves indoor, where WLAN positioning is available, this can be enabled, and when even more accuracy or user action is needed, RFID can be used.

Pros & Cons

Using combinations of devices, one can take advantages of the good qualities of each device. An example is the combination of a mobile phone with a WLAN tag attached to the mobile phone or the user. This will result in a unit having the good qualities of the phone such as high availability, and coverage in almost all areas combined with the high positioning accuracy indoors with a WLAN positioning system.
The disadvantage of this solution is that combining the different devices is not always straightforward and easy. Issues to consider are battery-life, cost and portability when joining devices. It is important to not make the additions too intrusive.
Chapter 8

Performance

There are different ways for managing performance in mobile applications. It is important as there are many limitations to mobile devices. Different aspects for improving performance on mobile devices are presented in this chapter. The first sections in this chapter will focus on balancing of performance, energy and quality by using a system that supports remote execution, before a general section on prefetching is presented. An algorithm for prefetching is addressed in Section 8.3. The last section will address different ways of adapting to the available resources.

8.1 A Way of Balancing Performance, Energy, and Quality

Balancing performance, energy and quality is a challenge that needs to be addressed in order to maximize the usability of mobile applications. In [22], Smith et al. uses Spectra, a remote executions system, as a framework and reference for offering a possible solution to this challenge. There are some requirements that need focus in order to cooperate with a server to balancing the performance, energy and quality of a mobile application with the mobile device. The requirements are:

- **Resource monitors:** Measure local and remote resource availability. This is the basis for dynamic adaption to changes in the environment.

- **Self-tuning operations:** There are different ways of predicting which procedures to execute where, but Spectra generates and uses models of resource consumption to predict future demand. There needs to be a service that provides resources matching those required by the mobile component.

- **Modifications to application source code:** The developer should define ways of partitioning the applications. This leaves Spectra with the possibility of modifying a limited amount of the code and thereby enables it to perform a lot better than what it would without the modification.

- **Granularity of remote execution:** There is a tradeoff between fine-grained and coarse-grained remote execution. The first kind will increase the possibility
of locating functionality on one or more remote servers. Coarse-grained remote execution can on the other hand provide better performance due to less overhead. Spectra uses the second alternative.

- **Correct results:** Executions performed either on the remote server or the client has to end up with the same results.

These requirements are important for location-aware applications if one would like to divide the execution between the client and a server to improve the performance. A framework could provide this kind of feature or it can enable the creation of it.

### 8.2 Location-aware Prefetching

Performance for wireless networks will always be lower than for wired networks. The major problems, as addressed by Kirchner et al. [25], are very limited bandwidth, high delays, occasional poor or totally absent coverage and frequent disconnections. The way Kirchner et al. overcome these problems is by using prefetching, which is done by transferring data the user might need in the near future to the user’s device before he or she needs it. By using prefetching the user can access data without any delay since it is already cached in the users device. There are two major advantages by applying prefetching. The first is as mentioned less delay when trying to access data since it is already in the device’s cache. The other is less data bursts on the network since prefetching is performed when there is available bandwidth instead of on demand.

Kirchner et al. [25] also identifies two costs associated with prefetching:

- CPU power is used to calculate what data to prefetch and when this should be done. The amount of time the prefetching takes is divided into gathering data for making the decision of prefetching and the actual cost of prefetching.

- The waste of bandwidth and server capacity as a result of prefetching data that is never used.

There is a lot of work related to prefetching in the areas of operating systems, processors and file systems.

As identified by Kirchner et al. [25], there are three filtering parameters that have to be addressed by the prefetching mechanism. The parameters are a user’s interests through user profiling, her priority of services defined by the user or the application provider, and finally a user’s movement pattern (with respect to locations, speed, direction, and itineraries).

For users of a location-aware applications prefetching can be important for the perception of performance and the usability. An application framework should enable the use of prefetching or at least the support for creating such a service. The next section describes a scheme that emphasis the use of location for deciding what data to prefetch. This could be use to be used as a reference point for comparing with a prefetching schema that a framework might provide.
8.3 Predictive Prefetching

In [8], Cho proposes a predictive prefetching scheme that exploits knowledge about the user’s movement to limit the prefetching to most likely future contexts.

The time it takes for a user to get location specific information is the sum of delay for a move to be detected and the information acquisition delay. For reducing the first factor, the time interval between each location check can be reduced. Prefetching can be used to reduce the second factor. This should however be minimized as much as possible due to communication and storage limitations. The prefetching scheme proposed by Cho [8] takes these limitations into account.

In his article [8], Cho proposes a schema where he uses a rectangle where the user is likely to move and prefetches all possibly needed information within it. The rectangle is built up of small square possible zones of movement and information retrievable. The rectangle is determined by using a distance or depth (d) of the rectangle of possible zones calculated by taking the square root of the sum of squares of two speed components of the users speed vector (in 2D). If one of the speed components is zero, then the other non-zero component is used twice in the computation. The width of the rectangle of possible zones is calculated as the upper bound integer of the mean value of the sum of the two speed components. This rectangle of possible zones is calculated when the user is about to leave his or hers previous rectangle of zone. Examples of this schemes use can be seen in Figure 8.1.

This mechanism for prefetching has been tested with good results and outperforms
circle based prefetching, which is a technique where all information around the user is prefetched in a radius equals to his or her speed when leaving the previous prefetched area.

A location-aware guidance application should use a schema that is at least as good as the one described in this section to minimize prefetching.

8.4 Adaptive Resource Management

According to Petterson et al. [40], any usable approach to mobile computation must be somewhere between interdependence and autonomy. Exactly where this point of balance is has to be regulated dynamically and adaptively.

Cyber foraging and infostations are two ways proposed by Petterson et al. [40], that can improve the performance of location-aware applications. This means that they are surrogates for performance. Cyber foraging is a guide to areas with better bandwidth. This lets the user extend the available resources. Infostations are areas where high bandwidth connections are available for mobile devices. The challenge is to make these two approaches work invisibly and seamlessly.

There are however some issues that need to be addressed. First is the level of trust a user can achieve by these surrogates. Shared use of these surrogates is another issue since it leads to the question of load balancing and scalability. User speed is also important because a user session might have to span across multiple surrogates.

Patterson et al. believe that it is important to develop cost effective techniques for discovering resources as they come in and out of service when the user moves or there are other elements of influence. Another technique that needs to be established is monitoring of the mobiles resource so the device’s location and orientation sensing techniques can change according to its battery state. The final techniques are staging data, and partitioning and off-loading computation.

These issues can be important for the application’s overall performance. As an example it might be an idea to have infostations where the is a other interesting objects as well. This might affect the requirements for an application framework and especially the monitoring of the device’s battery level with respect to quality of service.

8.5 Summary

There are several different ways of improving the performance of location-aware services. Some of these are general and could be implemented as part of the framework. Others are application specific, meaning that it is a concern for a location-aware application rather than the application framework.
Chapter 9

Privacy

"Journalists covering Location-Based Services (LBS) frequently search for reasons to explain why LBS revenue expectations have not met early predictions. [...] Privacy, as well as the issues surrounding it, is notoriously on the receiving end of the blame, regularly identified by under-educated industry press as one of the main reasons LBS is still slow to grow into its own.”

- Jonathan Spinney, Industry Manager, Location-Based Services ESRI

Privacy as SearchSecurity.com defines it has to do with three topics:

- **Personal Information Privacy**: Personal information users share will not be shared with anyone else without their permission.

- **Message Privacy**: In an open network messages should only be readable for the invited parties.

- **Anonymity**: There are occasions when a user may want to stay unknown.

There are several issues concerning privacy that is important to address. Different researchers have looked at different aspects of privacy and as a result offer different solutions to these problems. This chapter will start with a section on user concerns arising with respect to privacy issues. It is an important section as it justifies the need for the other sections in this chapter. Section 9.2 discusses different frameworks for arranging the aspects of privacy, before Section 9.3 looks at privacy and tracking, which many feels like is the most intrusive aspect of location-aware systems.

9.1 User’s privacy concerns

In [5], Barkhuus et al. have studied peoples’ concerns for the use of location-aware services. They have concentrated their research around location-tracking services, which are based on other parties tracking the user’s location and position-aware services where only the device uses the knowledge of its own location.

They describe four services:
• **Ringing profiles in private settings:** The mobile phone knows if the user is in a private context and changes the phone’s ringing profile accordingly.

• **Ringing profiles in public settings:** As the prior services, the phone’s settings change according to its context but the context is within the public sphere.

• **Lunch service:** Lunch suggestions are sent to the user’s phone when close to restaurants or similar locations.

• **Localization of predefined friends:** The mobile phone alerts the user when some of the user’s predefined friends are nearby.

The users thought that the first and the last service were the most useful ones. The lunch service was viewed as the least useful and also the most intrusive service. On the other hand, the private ringing profiles were the least intrusive. The localization of friends was looked upon as intrusive by the same users that found it useful. As a conclusion Barkuus et al. state that most people are not very concerned about their privacy with respect to location-aware services. The participants averaged 2.75 for all services on a scale from 1 to 5, where 5 is ‘highly concerned’ opposed to 1 which is ‘not concerned’. Location-tracing services are considered more intrusive than services that only are position-aware. A final conclusion is that people are more concerned about others being able to track their location than their own mobile phone reacting to its location.

However, this survey indicates that as people start to use location-aware applications their concerns for privacy will increase. Privacy should be a part of the application framework as it is important to all applications in the portfolio of applications running using the same platform.

### 9.2 Different aspects of privacy

There are different aspects of privacy addressed by different researchers. As a result there are several different frameworks for viewing privacy. This section will address a few of these frameworks starting with the privacy matrix presented by Gunter et al. in [7]. All the different aspects should be addressed in a framework addressing privacy.

#### 9.2.1 The Privacy Matrix

In [7], Gunter et al. presents a matrix for describing the privacy issues associated with locations-based services. There are three primary axes of interest as shown in Figure 9.1. These are the collection of information, access to the information, and the use of that information. Privacy issues in a particular context will be a point in this three-dimensional space. These authors believe that putting privacy into this privacy matrix will yield a number of important practical and conceptual insights, which is important to establish as the technical development puts pressure on the established norms of location privacy.
9.2.2 Privacy Design Issues

Three key design ideas regarding privacy are the focus points of Terveen et al. in [26].

These design ideas are:

- *Personalized disclosure*: Different level of location detail revealed to different users.
- *Transparency*: The users should be to foresee what the effects of the privacy policies will have on their privacy.
- *Ambiguity*: There should always be some doubt whether a user was at a particular location or not.

The main focus of Terveen et al. [26] is on creating location-aware applications that strengthen existing social ties instead of putting the emphasis on trying to create new ones. It is important to have this in mind when considering the adoption of these design ideas.

There are three different classes of applications that contribute to this focus. It is important to be aware of which applications the authors of [26] had to better understand the privacy design ideas. These applications can be divided into three categories:

- *GeoTemporal Matching*: Applications that find common behavior in users’ geotemporal routines, which can be the basis for strengthen personal connections.
- *GeoTemporal Messaging*: Creating new interaction opportunities by creating applications that enables people to leave messages in space and time.
- *GeoAwareness*: Applications that enables new ways of interacting with friends, family, and colleagues.

It is important that the users are given control to specify whether and how much of their location information is made available to other specified users. This brings us
back to personalized disclosure, transparency and ambiguity. To accomplish these
goals different different "zones" need to be used for different user's personalized
disclosure, and only reveal a certain area in which the user is to support ambiguity.

9.2.3 Collection, Retention, Use and Disclosure of Location Information

The same way as the location-aware information is processed in practice, Minch [33] has created a framework for organizing the activities for a better understanding of privacy concerns. These activities, which are the basis for the framework are:

- **Collection:** Location-related information can be collected either by the mobile device itself or externally by the devices it communicates with. The location information collection can occur automatically or on request. Others technical issues are whether collection is continuous or discrete, and further issues related to accuracy and reliability.

- **Retention:** There are two major issues addressed here with respect to retention. First is where the information is stored. It can be stored on the mobile device or externally by others. The second issue is concerned with how much and for how long the information is stored.

- **Use:** The use of location information in particular applications is only limited by the processing ability and ingenuity of the users or system designers.

- **Disclosure:** There are numerous technical and non-technical issues concerning disclosure of location-related information.

Minch uses this framework to look at privacy issues:

- **Collection:** The primary issue concerning privacy and collection is who decides whether the location-awareness is enabled or not. By using defined zones or regions the location is not determined exactly. Minch points out that the privacy issues raised in location information collection are relatively minor, since there is little potential for abuse until the information reaches later stages in this framework.

- **Retention:** The issues concerning retention and location information is what, where, how long and how securely information is stored. As with collection, the first importance issues is who decides what data to store, where to store it, and indeed whether anything is stored at all. These issues are important because it affect potential future uses (and abuses) of the information and it helps dictate who controls the information and how it later can be used or disclosed. The importance of how long the information is stored has to do with the potential for long term tracking and the pattern recognition.

- **Usage:** The processing and communications power of today’s computers and networks combined with the use of location information opens up an almost unbounded number of privacy issues. The most detrimental use of this information is to associate the information to the users of the location-aware
devices. It is also here important to look at to which extent users should be able to decide to what degree one should be identifiable or remain anonymous.

• Disclosure: Minch points out that there are "endless" possibilities of privacy violations concerning disclosure of the location information to a third party.

There are some areas of regulation of privacy: Governmental regulations; standard-based regulations - voluntary standards proposed by non-governmental organizations; industry/trade group regulations; advocacy/public interest group regulations; and marketplace regulations.

As a conclusion Minch points out in his article [33] that no single control is likely to assure privacy. It is not possible to predict all uses of location information, and it is not possible to prevent all abuse.

This means that privacy has to be addressed in the application framework as well as the application itself.

9.3 Privacy and Tracking

By being able to track users over some time, a user can reveal the user’s identity. As a result, the ability to restrict the possibilities the location-aware service providers has for long time tracking of users is crucial to accomplish privacy. In this section will present two ways to protect against location tacking.

9.3.1 Protecting Path Privacy

In [29], Gruteser et al. discuss different degrees of anonymity in path tracking location-aware applications.

The weak kind of anonymity is obtained by the service providers letting the users use pseudonyms that can be changed periodically. This might not provide much privacy if the user never changes his pseudonym when communicating with a given service provider.

There has to be a larger group of potential service users that travel along the same path at the same time to provide strong anonymity. An adversary could try to combine other available information with an anonymous path to identify the user. If there are many users traveling the same path at the same time, it gets increasingly difficult to figure out the users’ identification.

However, it is not likely that many users will travel the same path at the same time. Gruteser et al. offers in their article [29] two forms of weaker anonymity protection:

• Path segmentation: Privacy can be provided by segmenting the users path into many smaller segments where the service provider cannot determine, which two segments are from the same user. With this protection it might be possible for an adversary to identify one user in one segment but not in another. In theory it might be possible to link two segments together by prediction if there is
only one user, but it will be difficult with many users. Gunteser et al. describe a model that gives the range of acceptable intervals applications can safely publish data and thereby providing privacy.

- **Minutiae Suppression:** One can try to hide the most distinctive characteristics of a path to minimize the possibility of a user being identified.

### 9.3.2 Mix Zones

The mix zones model proposed by Beresford et al. in [2] protect user identities by restricting the positions where users can be located. The model provides location information to a location service provider by using a trusted middleware system, which is positioned between the underlying location system(s) and the untrusted third-party applications. These applications register in the middleware interest in a geographic space. This space is called an applications zone. An important aspect of this model is that each user needs to have one or more unregistered geographical regions where they cannot be traced by any applications. These areas are called mix zones since within these zones; the user’s identity is mixed with all the other identities. The applications do not receive a traceable user identity associated with a location of the user. Instead, it receive a pseudonym, which allows communication between user and application as seen in Figure 9.2. As a result of this model applications should be able to provide short-term location-aware applications without the ability to track long-term user movements.

### 9.4 Summary

The concerns for a location-aware framework and privacy are mostly towards the different aspects of privacy in Section 9.2. However the different ways to restrict against tracking can be useful for the application framework as a way to provide privacy among the different applications. The tracking protections schemas will be used as reference implementations for privacy and tracking requirements in Chapter 14.
Figure 9.2: Mixed Zones by Beresford et al. An example movement of three people through a simple mix zone. Who went where? Source: [2]

(a) plan view of the mix zone.

(b) Timeline of movements.
Chapter 10

Business Possibilities

"The global location-based services (LBS) market continues to grow rapidly. Worldwide more than 77 million mobile customers currently use LBS, and that number is expected to grow to 400 million by 2005, according to industry research. A similar trend in LBS revenue, which could reach more than US $ 19 billion by 2006, is also expected. The stimulus for such rapid growth can be attributed to two primary forces: consumer safety regulations and the potential for revenue-generating, consumer-oriented services."

- Hewlett-Packard [20]

This chapter will evaluate different aspects around location-aware application and services. The first part of this chapter looks at different aspect for m-business in general. These aspects will be used further in this chapter as well as in Part III the Contribution. The second section addresses the adoption of mobile technology. It will be used to identify future requirements for the system. Further, value propositions for the stakeholders are taken into account. The distribution of money is important for how the stakeholders will use the application framework. Further this might have severe implications for the system requirements. In Section [10.4] the main focus is on selecting a set of location-aware applications, which can work together and form a portfolio. The focus on application portfolios is important for the location-aware application framework, and the process of choosing these applications might be crucial. In the next section, a set of important location-aware system issues will be addressed. These will be an important part of the business requirements in Chapter [14] as they are a result of first hand experience in the business field. The final section handles business models that might be important for an application framework.

10.1 Analyzing the m-Business Landscape

This part of the chapter looks at different aspects of m-business. It is an important part as it sets the focus for the location-aware application business aspects addressed
10.1.1 Application Framework

The basis for mobile business is the user needs as argued by Camponovo et al. [18] (as seen in Figure 10.1). There are three different supporting blocks that together fulfill the user needs. These blocks are service content, network and device delivered by different actors as addressed in the next section. In addition to these blocks there is a regulation context. The figure also describes some key points for each block. These points do not address all possible aspect of m-commerce, but they are supposed to improve the description of each block.
10.1.2 Actors

Componovo et al. [18] has with respect to the application framework in Section 10.1.1 also presented an example of key players in Figure 10.2. These players are representatives for the different blocks addressed in the previous section. Government is the key player when getting to the regulation context and is in charge of most legal regulations. There are other context players like standardization groups and customer unions. The different parts of Figure 10.2 are addressed in the next paragraphs.

The network operator can be several kind of players. Internet Service Provider (ISP), virtual operator meaning operators who provide communications through other players, and venues as hotels, museums and others who provide WLAN are examples of such players. Mobile network operators are another important group of players in this block.

There are two kinds of service content providers; the payment agent and content provider. A payment agent can be an important issue for the framework as it has to fit in. Content provider is of course important since without content there is nothing of interest for the user. The focus for location-aware guidance application will be addressed further in Part III - Contribution.

Device makers are different players that provide different kinds of devices as seen in the figure. A further evaluation of the different device manufacturers are specific to this report done in Chapter 6 - Location, Chapter 7 - Devices, and Part III - Contribution.

The central part of the figure is however the user needs. In this example the users are different corporate players. The concept of user need will be part of an actor analysis later in this report.

A value proposition for the different stakeholders is done in the Section 10.3.

10.1.3 m-Business Model Framework

For general m-business Camponovo et al. [18] has proposed a framework founded on four main pillars. They use these pillars for identifying the relevant indicators of a Balanced Scorecard. The Balanced Scorecard can among other things be used to evaluate different aspects of an application as well as an application framework. Camponovo et al. use this for evaluating a m-business idea. It can also be used for evaluating the location-aware guidance application’s business possibilities; this is however outside the scope of this project. The pillars as shown in Figure 10.3 are:

- **Product innovation**: This is the way the company differentiates itself from its competitors. This is focused on the value propositions, which are the benefits and offerings the firm proposes to its customers.

- **Customer relationship**: This is a description of the market and the firm’s relationship to its customers. This is a combination of the target customers,
Figure 10.2: Examples of key players. Source: Componovo et al. [18]
customer relationships with respect to maintaining and acquiring new customers and the distribution channel.

- **Infrastructure management**: Is the basis for delivering the businesses offerings and customer relationships. This point is a combination of activity configuration, the company’s capabilities and resources, and its partner network. This can be seen in combination with Section 10.1.4.

- **Financial aspect**: Creating value is the reason for this model. It is composed by a revenue model and cost structure, which ends up in profit or loss for company.

## 10.1.4 Value Network

Camponovo et al. [18] argue that Stabell and Fjeldstad’s Value Network model [43] is the most appropriate to use for most businesses and especially for mobile network activities. These activities are network promotion, contract management, services provisioning and infrastructure operation in addition to the secondary activities, which are administration, human resource management, technical invention and procurement. This model stresses that an actor has to have a network of other actors to be able to provide value for its customers. Amberg et al. in [3] prefer to use Porter’s Value Chain model, which is a different model covering many of the same aspects.
10.1.5 Scenario Planning

For being able to predict the uncertain future of m-business, Camponovo et al. [18] believes in using scenario analysis. Scenarios take into account all the weak forces in the environment to describe possible and probable futures. There are a number of different ways to design scenarios. However this can be used together with Section 10.2 which describes how technology is adapted.

To create a scenario is an important part of this thesis. A scenario will be used as a basis for the application requirements in Part III - Contribution.

10.1.6 Mobile Market Scorecard

All the other subsections in this Section (10.1) builds up to the Mobile Market Scorecard, which Camponovo et al. [18] have made a model for, see Figure 10.4. This model is adopted from the model in Figure 10.3 which is presented in Section 10.1.3. It is addressed again to describe how to use the different parts of this Section is put together. There are four perspective to this framework:

- **Market**: This perspective looks at the demand for wireless applications. Market surveys and adoption studies are used to analyze this perspective.

- **Industry**: Actors with their relationships and structure in the wireless industry is the issue in this perspective, and is investigated by using industry analysis methods and looking at the actors’ business models addressed in Sections 10.1.2, 10.1.3 and 10.1.4.

- **Innovation**: The technology side of the wireless industry is the focus in this perspective. It is important to address issues inside the contexts of technology, business, society and regulations and investigate them using scenario planning as addressed in Section 10.1.5.

- **Financial**: The focus of this perspective is investigated by doing different financial analysis on technical solutions, services and actors’ business models.

This framework identifies the different aspects that have to be addressed by the key application stakeholders. The framework is used to choose a strategy for location-aware services. This is addressed in Section 10.4.

10.2 Mobile Technology Adaption

The adaption of mobile technology goes according to Yuan [49] through five stages:

- **Visionary**: New technology with few people that can see its business value.

- **Missionary**: A few companies or employees see the value of the technology and starts to use and profit from it.
• **Ordinary:** The technology has been well accepted by the mainstream business executives who have made plans on how to implement solutions based on this technology.

• **Commodity:** Implementations have been standardized, which means that the market barriers are low and that the technology is widely adopted across wide area of industries making profit of it.

• **Maturity:** A few dominant players supply most of the commodity technology. These stages are shown in Figure 10.3.

These steps are important as they set the focus on the need for scalability and to see that one will have to have a framework that can handle the different kinds of new standards that arrives without too much hazard.

### 10.3 Value Propositions for the Stakeholders

Nokia [35] argue that the new market for open location-aware applications market offers new benefits and business opportunities for everyone in the value chain:

• **Consumer:** Can enjoy new and innovative location-aware applications that can ease their lives.

• **Electronic market/physical retail stores:** The retail applications business can grow due to increased physical retail and electronic delivery.
Figure 10.5: Technology adoption curve
• **Mobile phone manufacturer**: These producers can potentially gain economic advantages due to differentiation of devices, which runs on open software platforms and highly penetrated positioning systems.

• **GPS technology manufacturer**: There will be a greater demand for GPS technology so that more accurate positioning can be delivered.

• **Network positioning technology vendor**: Can deliver positioning where GPS are out of range or on devices without GPS possibilities.

• **Corporate**: Have potential for achieving better brand visibility.

• **Service provider**: Can deliver a package of location-aware applications that are tailored to the customers needs. Can also use these applications for marketing purposes if the customers agree upon receiving such information.

• **Developer**: Can deliver a new range of software specially tailored to the location-aware business domain.

• **Network operator**: There will be growing bit-volumes and thereby increased revenues caused by a growing number of location-aware client-server consumer applications. There is also potential for additional revenues by incorporating mobile billing.

For the location-aware application framework this is important as it has to support different ways of creating revenue and keeping track of these to be able to divide the revenue among the actors.

### 10.4 A Framework for Selecting a Location-Aware Services Strategy and Service Portfolio

Tilson et al. have in [12] proposed a framework for selecting a location-aware services strategy and service portfolio. They use a model (see Figure 10.6) for aiding the designers to choose among different location-aware service strategies and portfolios. They suggest using the model proposed by Camponovo et al. [18] (see Section 10.1.6) for developing location-aware service concepts, which is the first step in the model in Figure 10.6. The scorecard address the location-aware application marketplace, the service, the organizational capabilities and the technical capabilities.

These dimensions are not independent from each other or their context. In addition there are a wide range of uncertainties concerning all these dimensions and their context. These uncertainties will not be addressed here but they should be kept in mind.

A set of different concepts for use remains after performing the first step in Figure 10.6. These concepts should be filtered by size of opportunity, which is the second step in the model. In the third step of model the concepts that remains have shown the highest revenue potential. This step is a filter according to the ease of implementation. Implementation concerns both organizational and technical implementation.
Figure 10.6: Location-aware service strategy framework. Source: [12]
CHAPTER 10. BUSINESS POSSIBILITIES

The fourth step has to do with portfolio and strategy selection. It has as indicated in Figure 10.6 three steps: Generate candidate portfolios; perform scenario analysis; and select service portfolio. The types of services included in the portfolio have to mirror the uncertainties that are present. Other issues that should to be addressed are existing resources, type of organization, and type of mobility in the organization, in addition to where and how much value is added by the portfolio. These issues depend on the proposed application types. The result of these steps is a portfolio of location-aware service offerings with a good strategic understanding. The final step is the implementation of this portfolio.

Providing support for different portfolios of location-aware applications is a key feature for the application framework.

10.5 Important Factors when Deploying Commercial Location-Aware Systems

In [18], Camponovo et al. explore the challenges and major issues of m-commerce by using the model that can be seen in Figure 10.7. The first issue is the user needs that would benefit form a killer application. Service content means integration of standards to get easier application development, and billing and pricing. Devices should be generalized, but it is a question of Phone vs. PDA vs. laptop, dedicated vs. generic device, and multi-modality. For the network provider centralization can be a way to go, but issues like UMTS vs. WLAN vs. ad-hoc, network interoperability, and infrastructure are interesting in this context. This will be important as these issues affect general requirements for a mobile application framework.

There are other specific issues that are more important for the location-aware framework. Ubisense has extensive experience with location-aware services. Ubisense [6] believes that the most important factors to consider when deploying location-aware for commercial use systems are:

- **Value**: If a technology is going to be commercially successful, it must address a real need for the users. This may be the most important single factor.

- **Robustness**: In addition to solve a problem for the customer it will have to be so reliable that it can solve problems in all kinds of environments at all times.

- **The role of infrastructure**: The cost of installing the infrastructure will substantial. It can however be reduced quite a bit by appropriate design and quantified before the system is installed. There will be minimal maintenance requirements if the infrastructure is properly designed.

- **Technology for scalable business**: Building ad-hoc solutions for each and every application will not be a good idea. It is a fare better idea to reuse certain components.

- **Standardization**: The market should be the root for location-aware technology standardization and one should be careful not to adopt standards, which can be detrimental to the market adoption.
10.6 Business Models

"...a business model provides a description of the roles and relationships of a company, its customers, partners and suppliers, as well as the flows of goods, information and money between these parties and the main benefits for those involved, in particular, but not exclusively the customer."

- Harry Bouwman [19]

This is one of many definitions of a business model. It is out of the scope of this project to address this topic thoroughly. However, business models are important for the success of location-aware services. Nokia [35] states that one will need simple and effective business models for location-aware applications to be successful. A framework for location-aware services should enable different kinds of business models. This can also have important implications on different user scenarios.

An important part of all business models is the ability to charge customers, and preferably in different ways. A framework for location-aware applications should at least support the ability to charge customers.
10.7 Summary

This chapter has evaluated different aspects around location-aware application and services. Starting generally with a section on different aspects of general m-business, the chapter continues with a section on how mobile technology is adopted. This is important for the application framework as it has to respond to future requirements as well as present. Further, the stakeholder’s value propositions were taken into account. The framework has to support the different stakeholders with respect to the business models as outlined in the final section. For satisfying different customers as well as the different stakeholder’s current as well as future requirements, different application portfolios has to be supported. The next chapter will identify different categories of applications and some of the requirements these will have on the application framework. Other requirements are those of Section 10.5, which were a set of important location-aware system issues. These are an important part of the business requirements as they are a result of first hand experience in the business field.
Chapter 11

Future Location-aware Applications

This chapter looks at a variety of different applications, scenarios and services that are location-aware. These will not be evaluated thoroughly as these are snap shot ideas proposed by different people or organizations. Nokia [35] has proposes a categorization of location application/service categories as seen in Table 11.1. These categories will be addressed further in following sections.

<table>
<thead>
<tr>
<th>Category</th>
<th>Application/services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navigation and route finding</td>
<td>Interactive navigation</td>
</tr>
<tr>
<td></td>
<td>Routes</td>
</tr>
<tr>
<td>Community</td>
<td>Friend finder</td>
</tr>
<tr>
<td></td>
<td>Location-aware imaging</td>
</tr>
<tr>
<td></td>
<td>Location sharing</td>
</tr>
<tr>
<td>Location-aware entertainment</td>
<td>Entertainment and fun</td>
</tr>
<tr>
<td></td>
<td>Location-aware gaming</td>
</tr>
<tr>
<td>Location-aware information</td>
<td>Finding places of interest</td>
</tr>
<tr>
<td></td>
<td>Information services</td>
</tr>
<tr>
<td>Safety</td>
<td>Emergency Dispatch (E911/E112)</td>
</tr>
<tr>
<td></td>
<td>Child/family tracking</td>
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<tr>
<td></td>
<td>Auto theft tracking</td>
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<tr>
<td></td>
<td>Roadside assistance</td>
</tr>
<tr>
<td>Tracking</td>
<td>Fleet management</td>
</tr>
<tr>
<td></td>
<td>Vehicle dispatch</td>
</tr>
<tr>
<td></td>
<td>Rental car tracking</td>
</tr>
<tr>
<td></td>
<td>Remote workforce management</td>
</tr>
</tbody>
</table>

Table 11.1: Location application/service categories. Source: [35]

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11.1 Navigation and Route Finding

Interactive navigation and routes are the different examples of navigation and route finding defined by Nokia [35]. There are several implementations of this kind of applications. These are sometimes bundled with location-aware information, which is addressed in Section 11.4. An example of this kind of application is:

**Driving directions and information** - A location-aware service providing step-by-step driving directions that adapt to the user’s location. There are different systems like this already implemented. One example is Volvo’s Road and Traffic Information (RTI) system [48]. Important aspects of this kind of applications can be information about parking lots, hotels, gas stations, constructions work etc.

11.2 Community

The subcategories of community location-aware applications are friend finder, location-aware imaging, location sharing. Friend finder is finding out where your friends are. It is nearly the same as location sharing, which is sending information about where you are. It does not allow tracing as the friend finder does. Location-aware imaging means that a picture is tagged with a location, which can be sent to others. This can be used to e.g. invite people to a party by sending a picture with the people at a party and location to others. Location-aware imaging can also be used to organize photo albums. Other location-aware community applications examples are:

**GeoTemporal Matching** - As described in Section 9.2.2, GeoTemporal Matching by Terveen et al. [26] is an application that finds common behavior in users’ geotemporal routines, which can be the basis for strengthening personal connections.

**GeoTemporal Messaging** - This is as the GeoTemporal Matching application described in Section 9.2.2 and proposed by Terveen et al. in [26]. GeoTemporal Messaging lets the user creating new interaction opportunities by enabling people to leave messages in space and time.

11.3 Location-aware Entertainment

For some, entertainment and fun are important aspects of a mobile world. There are numerous possibilities. One is the Location-aware Guidance application that is important for this thesis. This application can also be categorized within location-aware information, defined in Section 11.4. Another example introduced by Nokia [35] is location-aware games addressed shortly. However, other entertainment applications are:
CHAPTER 11. FUTURE LOCATION-AWARE APPLICATIONS

Location-aware adult entertainment - A lot of technologies like the Internet and VHS grew in their early days as a result of the users being able to enjoy in adult entertainment. A good location-aware adult entertainment application can potentially push the adoption of the location-aware services in general.

Location-aware games - There might be great potential in location-aware games. For example "BotFighters" from It’s Alice [47] has proven to be a good investment for its owner. The game peaked at 1 million SMS per week after 3 months in Russia [37]. After 3 years it averages 1 million SMS per month. There is great marked potential in new and better devices combined with UMTS.

11.4 Location-aware Information

Finding places of interest and information services are well known aspects of location-aware applications. Some examples are:

Location-aware Yellow Pages - The user can search for businesses and business types with respect to ones location. This service is not far from the Finding people and services application, but the focus is a close link to the ordinary Yellow Pages.

Location-aware promotion - Location-aware promotion could have been a potential killer application for firms that work with advertisement, had it not been for legal issues, e.g. in Norway the Markedsforingsloven §2b [44] prohibits promotion with electronic equipment without permission granted by the user prior to the promotion.

Location-weather forecast - Nokia [35] proposes a weather forecast that is specific to the users location.

Location-aware guidance - Guidance with respect to ones location is not a new business possibility. There are several aspects to this application and the main focus for this thesis. It will be further addressed in Chapter [13].

Selecting bus routes - Matthew Kam [30] has proposed a service where the user can look for the closes bus stop. The user can also check where or how far away the bus for getting to a given location is and where the bus stop for that bus is. As an added feature an alarm can be set off on the location device when the bus i.e.g. 2 minutes away.
11.5 Safety

The different subcategories or examples of safety applications described by Nokia [35] are emergency dispatch (E911/E112), child/family tracking, auto theft tracking and roadside assistance. Some of these areas are similar to other services in other categories, and could probably be replaced by those. However the context of these applications makes them critical. Other applications that more or less fit into this category are:

**Fire fighter training** - Location information can enhance and adapt the fire fighter training to get better and more realistic training e.g. by being able to use fixed gas jets more safely in scenarios. This idea proposed by Ubisense [6] can also be adopted in other setting like military exercises.

**Visitor management in security-conscious sites** - Certain companies like e.g. pharmaceutical and defense industries, often require that visitors are escorted by a member of staff at all times. This for making sure that safety and protection of confidential or classified information is enforced. The visitor management system can by tracking visitors and their hosts and thereby alerts these when security regulations (either accidentally or deliberately) are being breached. It is also possible for the company to record a security audit for future analysis.

11.6 Tracking

Fleet management, vehicle dispatch, rental car tracking and remote workforce management are the subcategories that Nokia identifies in this section. These are mostly business applications been used to optimize efficiency in certain kinds of businesses. The two examples in Section 11.5 could also be in this category. Another example is:

**Maximizing productivity of a hospital environment** - Ubisense [6] believes that efficient workflow planning requires up-to-date information about the state of the real world. This includes location of staff, patients and equipment to be able to optimize the usage of the hospitals resources.

11.7 Outside the Categories

There are certain applications that are difficult to put in any of the categories listed above. Examples of these are:
CHAPTER 11. FUTURE LOCATION-AWARE APPLICATIONS

Activation of non location application - Another application proposed by Nokia [35] is for a certain application to automatically launch when arriving at a predefined location e.g. the latest news when arriving at work.

Ringing profiles in private settings or public setting - Barkhuus et al. [5] has as discussed in Section 9.1 described an applications where the ringing profile changes with respect to where the device is located.

11.8 Summary

There are a lot of different aspects to consider when implementing these kinds of applications. These categories have different characteristics and therefore requirements towards a location-aware application framework. This issues will be a further addressed in Chapter [14] - Requirements.
Chapter 12

Oracle Application Server

Oracle Application Server 10g (OracleAS) is a full scale Java 2 Enterprise Edition (J2EE) application server, implementing the J2EE 1.3 specification. It has been chosen to be the centerpiece of Telenor\'s Common Service Framework (CSF). In this chapter, we will describe some key features of OracleAS in general, before we focus more narrowly on wireless and location-aware services.

12.1 General overview of OracleAS

An overview of OracleAS is shown in Figure 12.1. As is shown in the figure, OracleAS is a highly integrated application server, incorporating many features. The product is centered around a module called J2EE & Internet Applications. On top of this, a Portal module is defined. The Wireless module is a module allowing wireless devices such as mobile phones to communicate with the application server. In order to achieve better performance, a Caching module is added. Business Intelligence collect statistics for future use, while E-Business Integration makes integration of existing services and users with the new business possibilities. And of course, an interface for Management and Security exists. These modules will be further described in the following subsections.

A more technical view of OracleAS is shown in Figure 12.2. Here, the different parts are divided into collections of Services. The modules and sub modules from Figure 12.1 will also be related to the different services.

12.1.1 J2EE & Internet Applications

This is the major component of the Oracle Application Server. It is the foundation for all the other modules, and provides a platform for deploying Internet-based applications, web sites and web services.

For deploying web sites, OracleAS include the Oracle HTTP Server. This is based on the industry-leader Apache HTTP Server [14], but with additional and modified modules. This server will handle all normal HTTP requests, and is capable of
CHAPTER 12. ORACLE APPLICATION SERVER

Figure 12.1: Overview of OracleAS. Source [11]

Figure 12.2: Technical overview of OracleAS. Source [11]
delivering content using a wide array of programming languages including regular HTML\(^1\), PHP\(^2\) and Perl\(^3\). Using CGI\(^4\), any executable program can be used to produce content for the web-site. The HTTP Server is a part of the collection of Communication Services.

For applications developed using J2EE technology, OracleAS has implemented the full J2EE 1.3 specification. This includes support for Servlets, JSP pages and EJB\(^5\). The HTTP Server can act as a mediator, receiving HTTP requests and forwarding them to the correct J2EE container. When using EJB, OracleAS has full support for both Entity-, Session- and Message-Driven Beans. The handling of EJB, Servlets and JSPs is a component in the collection of Application Services.

Web Services is one of the new promising technologies. Web Services is a way for applications to exchange information through a standard interface, using XML. The use of XML makes it easy for applications developed using different programming languages to work together. OracleAS provides a handler for requests to Web Service enabled applications. In the Connectivity Services category, adapters for enabling applications developed using different programming languages and technologies with Web Service access are found. By using one of these adapters, just about any application can be accessed through the standard Web Service interface.

The other components of Connectivity Services are different types of connectors and mediators. These connectors allow applications deployed on OracleAS to connect to resources such as databases, input and output streams and message queues.

Several different methods of communication with OracleAS are possible. All these methods have been collected as Communication Services. Already, HTTP has been mentioned, other possibilities include Java RMI\(^6\) and IIOP\(^7\) for remote access to EJB and SOAP\(^8\) for a lightweight XML-based messaging protocol. The two last services in this section, Wireless and Web Cache, will be presented in Sections 12.1.3 and 12.1.4.

In the collection of System Services, services spanning multiple technologies are placed. This includes both local and distributed transaction handling, messaging services such as the JMS\(^9\), scheduling of requests and resources, pooling of shared resources and capabilities for clustering of several servers and other resources to enhance performance and reliability.

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\(^1\)HyperText Markup Language
\(^2\)http://www.php.net
\(^3\)http://www.perl.com
\(^4\)Common Gateway Interface
\(^5\)Enterprise Java Beans
\(^6\)Remote Method Invocation
\(^7\)Internet Inter-Orb Protocol
\(^8\)Simple Object Access Protocol
\(^9\)Java Messaging Service
12.1.2 Portal

The next module in Figure 12.1 is Portals. This module makes it easier for an enterprise to create portals with information. A portal is a collection of information from different sources. These sources can be clipped versions of normal web-pages or specifically designed portlets. The module is composed of the Integration and Commerce Services from Figure 12.2.

OracleAS includes many pre-defined portlets providing for example login/logout with single-site sign on, user management, search and user personalization. It is possible to deploy any portlet developed according to the specification given in [24].

12.1.3 Wireless

Wireless services in OracleAS enable the use of mobile devices such as phones and PDAs. It provides much functionality for enabling mobile applications, including location-aware mobile applications. This functionality includes adaption of content to fit different devices, different communication protocols, location and positioning.

The wireless module of OracleAS will be described in detail in Section 12.2.

12.1.4 Caching

The Caching module is introduced to improve the performance of OracleAS with regards to delivery of web pages. It acts as a front-end, receiving HTTP requests and treating them according to specified rules. If the caching module has a valid copy of the requested web page, it will return this page. If the copy in the cache is invalid, the module will forward the request to the HTTP Server(s), and store the returned page. The result is faster delivery, load balancing and failover.

The module can also perform caching of partial pages and assembly of these parts with parts requested from the HTTP module. This is useful for example in a portal page with a great deal of the page being identical for all users. The cache will assemble these parts with parts unique for each user.

12.1.5 Business Intelligence

The Business Intelligence module of OracleAS is provided for improving the quality of decisions made by employees by giving them better access to information needed. Each user can define queries to just about any data-source in an ad-hoc manner. Complex calculations can be performed easily on the results of these queries, enabling more informed actions and decisions for the user.

This module also lets developers create high-quality reports in a variety of formats. These reports are generated from queries as mentioned, and can be converted into for example HTML-pages, XML documents and PDF documents. By using the XML

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10Down-scaled, showing only selected bits of the information on the original resource
documents, the result can be converted to new formats using standard converters, such as XML-to-excel.

12.1.6 E-Business Integration

Today, it is more and more common to integrate several different applications in order to improve the total portfolio of a company. This is mostly done by either joining to the same data source, or by some sort of messaging. OracleAS includes connectors and adaptors for connecting to most data sources, as well as services for messaging and easy, standards-based communication.

This functionality enables a company connect their applications internally (A2A\footnote{Application-to-Application}) as well as connecting to other companies (B2B\footnote{Business-to-Business}).

12.1.7 Management and Security

A complete application server has a need for easy management of applications, users and security. This is provided by the Management and Security module. This module provides a web-based interface enabling administrators to deploy, undeploy and manage all applications as well as the application server itself.

OracleAS use a single sign-on policy, allowing a user to log in once and have access to all applications. User management such as adding new users, placing users in correct groups, adding or removing privileges and password management is provided. The users are kept in OracleAS integrated LDAP\footnote{Lightweight Directory Access Protocol} environment.

12.2 Wireless applications with OracleAS

The wireless module of Oracle Application Server is provided to make development of wireless applications specific for mobile devices such as mobile phones and PDAs easier. The goal is to make better use of the new possibilities related to mobile computing and technologies. An overview of the module is shown in Figure 12.3. As shown in the figure, the wireless module is composed of several submodules, Mobile Portal, Mobile Applications, Multi-Channel Server, Foundation Services and Development Tools. Most of the other submodules use services from the set of Foundation Services. The different submodules will be described in the following subsections.

12.2.1 Mobile Portal

The Mobile Portal submodule will make any portal deployed on OracleAS available for a mobile device. It integrates tightly with the Multi-Channel Server to be able to...
deliver content normally meant for a normal desktop computer to a mobile device. The Mobile Portal is the front-end mobile devices will use. This front-end enables users to communicate using a wireless browser, voice or messaging. It will route each request to the proper underlying application.

### 12.2.2 Mobile Applications

A suite of applications ready for deployment is provided as part of the Wireless module. These applications are provided so that a company quickly can deploy the most common mobile applications. These applications include Mobile Office support such as e-mail, directories and calendars, Mobile Messaging such as SMS, MMS and wireless extensions to Instant Messaging systems such as MSN, Jabber and ICQ.

Also, some location-aware applications are shipped with the wireless server. These applications include maps, driving directions and business directory (location-aware yellow pages). These applications rely on information from a third-party regarding content, as well as the user has to provide his location manually in some form. They are of little use outside of the United States, as few content-providers are available elsewhere.

### 12.2.3 Multi-Channel Server

Possibly the most central part of OracleAS Wireless is the Multi-Channel Server (MCS). This component is responsible for making content available for a wide array of devices using different delivery technologies. It will intercept a response from an underlying application, and adjust this to the needs of the device it is meant for.

In effect, the MCS adds an abstraction layer between the application and the device enabling a developer to develop the application without any concern regarding devices and communication technology. The same application can be accessed using a
browser on a mobile phone using WAP, a PDA using WLAN, using a SMS or MMS scheme on another mobile phone or voice based communication.

The MCS will transform valid XHTML into a valid format for the device. For example VoiceXML for a voice based interaction and WML for WAP. Also, images, video and audio-streams will be adapted to suit the device of the user.

12.2.4 Foundation Services

The Foundation Services are provided to make the life of a developer easier. These services are pluggable, and can be used from any application deployed on OracleAS Wireless. They provide basic functionality for performing a wide array of tasks needed in many applications.

Some of these services are provided as either a Java API\textsuperscript{14} or as Web Services, while others are an integral part of OracleAS, giving access through a web interface. Most of the integral parts are also available as APIs, making updates from a normal application possible. The different services will now be described.

**Messaging** provides an API for sending messages to different devices. The message is automatically adapted to the capabilities of the device. The service is based on drivers for different protocols, and comes with ready-to-use drivers for the most common solutions such as SMS, MMS, fax, voice and IM. Messaging can be either one-way or two-way. One-way messaging means that there will be no response from the client (mobile device) to the server sending the message. Two-way messaging enables this option, allowing for a greater degree of interaction with the user.

**Location-aware Services** adds location-awareness to the application. The use of and possibilities with location-aware applications will be described in detail in Section\textsuperscript{12.3}

**Personalization** is a web-based utility for users to manage their preferences and profiles. This allows a user to manage the way he wants to receive content, what applications he wants to use with mobile service and to customize portals. Location marks for use in location-aware services and personal contacts are created, modified and managed here. Finally, security and privacy issues are handled from this module.

**Analytics** provides a way to monitor usage patterns and create reports of this. In this way, providers can see what is the most used services and develop these further, as well as see what services are less used and will not require their attention that much.

\textsuperscript{14}Application Programming Interface
Content Syndication contains the ability to transform content from any web application for use on mobile devices. This transformation will reorder content and adjust images and video to fit the device. The transformations are done either automatically or by empowering pre-defined rules, and can transform any content, ranging from regular HTML- to complex XML-documents as well as multimedia streams.

Billing provides an API for billing when using a service. This API is just provided for use, and the actual implementation of the API must be done specifically to integrate with a company’s own billing system. It can then be used from any application, enabling the developer to charge for use of certain services in the application. The API will then handle the billing transactions, save them, perform the actual billing and log everything for future reference.

Commerce is a service for providing a mobile wallet. Payment of services can be done using this API. As for the billing API, this API has to be implemented specifically to function.

12.2.5 Development Tools

The set of Development Tools provided with OracleAS Wireless lets developers work with wireless applications more easily. The Wireless Development Toolkit (WDK) is a simulation environment providing all functionality from the full server used for testing of applications. It allows for testing on a personal computer, and can simulate the server, devices and the interaction between them. The interaction can be performed in the form of voice, messaging, and mobile browser or by using J2ME. All these types of applications are supported by the WDK. The JDeveloper Wireless Extension is a version of the WDK meant for use with the Oracle JDeveloper IDE also providing code templates, development wizards and automated deployment.

12.2.6 Example of use

Figure 12.4 shows an example of use with a mobile phone accessing the wireless server by using WAP. The mobile phone sends its request, routed through the normal WAP gateway to an instance of OracleAS Wireless (top of figure). This instance will then pass this request through to the end application. The response from the application will pass through an adaptor, making it fit most appropriately to the device in question. Then the response will follow the normal flow through the WAP network back to the mobile phone.

Figure 12.4: Example using WAP and OracleAS Wireless. Source [11]
12.3 Location-aware applications with OracleAS

When developing a location-aware application, a developer needs services for adding location-awareness to his application. This support is provided by OracleAS through the Location Foundation Service. This foundation service contains APIs for different aspects of the concept location-awareness. Oracle has identified some critical aspects included in OracleAS Wireless:

Mobile positioning is the process of associating a location with a device or user. This subject will be described further in Section [12.3.1]

Geocoding address the need to create a mapping between physical locations and coordinates with a concept of an address, place, region or the like. Regions can be defined in a hierarchic manner.

Mapping is created to be able to provide a geographical map of an area to a user. This map will be based on a point or set of points, and will show a certain segment of the world around the base point. The size of this segment is of course configurable.

Routing provides driving directions from a location point A to a location point B. The support for this in OracleAS is given by providing an API for performing routing. The actual routing must be done by some external provider linked into the system. Using routing services is often combined with mapping to provide a graphical view of the suggested route.

Traffic information can be used in many situations, for example when a user want to avoid getting stuck trying to get from location A to location B. Traffic information is often used together with Routing services.

Business directories or Yellow Pages can be made location-aware. This means that when a user requests information, the information is based on his location, listing only hits that are relevant inside a given geographical range.

Most of these aspects have to be provided by an external provider. OracleAS only provides an interface to an application being be developed, the actual content delivery for each aspect is done by using a driver connecting to the external provider. This use of a driver enables different providers to develop their part of the system independently. For example, a provider for positioning can use GPS or he can use WLAN to locate a device. The application using this content will function independently of the underlying technologies.
12.3.1 Mobile positioning

As stated, mobile positioning is the process of associating a location with a user or a device. In most cases, a normal assumption will be that the user and device are co-located at the same location. The actual positioning of a user can be done either manually or automatically in OracleAS Wireless.

**Manual** positioning requires the user to define his location, by selecting a pre-defined *Location Mark*. A location mark is a handle in OracleAS, defined as a user preference, linking a named location or place with physical coordinates. When a user selects a location mark, OracleAS will regard this to be his current location. Examples of location marks are a user’s office or home. Rules related to the location marks can specify that a user is at a certain mark at a certain time, such as a user being at his office on normal days from 8AM to 4PM.

**Automatic** positioning occurs when the system automatically calculates the location of a user. The acquisition of a user’s location is done through a layered framework provided by OracleAS called the *Mobile Positioning Framework*. This framework allows developers to access a public API to determine a user’s current location. The framework will handle caching of location, act as an abstraction to the underlying positioning technologies and handle privacy issues. The framework also lets a developer define quality of service (QoS) expressed as a maximum age in the cache.

12.3.2 Location events

The *Location Event Server* is a component of the location service for enabling event-based applications. It generates an event notification when a specific condition is true. This condition can be as simple as a user reaching a certain location, or a complex collection of criteria such as all members of a group of users are at the same location.

The event server use information provided from the positioning system, and evaluates the conditions based on this information. As soon as a condition evaluates to true, an event notification is generated. A *Location event agent* is responsible for creating the condition and handling the notifications as they are created. The agent notifies any client subscribing to the event, forwarding the event. The application can then handle the event appropriately.
Part III

Contribution
The contribution focuses on the user scenarios and requirements for a location-aware guidance application. The final chapter, the Oracle 10g Wireless Application Server is evaluated as a location-aware application framework.
Chapter 13

Scenario - Tourist Guide

There are several different possible scenarios for location-aware applications as seen in Chapter 11. In this chapter there will be a further exploration of a location-aware tourist guide.

The basic idea behind a location-aware tourist guide for mobile devices is to provide tourist information to the user. This information is selected automatically with respect to the user’s location, and can be composed of both text and multimedia such as images, sound and video.

There are different stakeholders that have different opinions for such a service. An overview of these stakeholders is given in Figure 13.1 which is outlined according to the model in Section 10.1.2. The following sections address these actors and their view in detail.

13.1 The User Perspective

John is 45 years old and a tourist visiting Norway with his wife Monica. He has registered his mobile phone to use a location-aware tourist guide during his stay in the country. As he arrives in Trondheim he receives an overview of different interesting places to visit in the city. Some of these locations are listed as location-aware, some are not. John can select the different places and get a short description of them.

He decides to go to Nidarosdomen, the cathedral in Trondheim. When arriving, he can see the sign confirming this place has a location-aware guidance system. He immediately knows that this is the same system that he has registered his phone with, and that he can use his phone to receive information inside the cathedral. When he enters, he gets a message asking him to confirm that he wants to receive information when inside. He confirms, knowing that a small amount of money will be charged at his next phone-bill.

After confirming, John can see an overview of the entire area and several pre-defined routes around the cathedral. He selects one, and starts his tour. As he moves around
Figure 13.1: Actors overview
to the marked points-of-interest, he gets notifications that he is at a point with a multimedia presentation. He selects to view the presentation. His wife does not think the presentation is as interesting, and decides to walk ahead. When they registered to use the system, John added her as a friend to be able to find her if they got apart. After she confirmed the request, John could find her from his mobile phone, and she could find him.

As he moves into the cathedral, he notices the very beautiful mosaic window at the inner wall. To his left there is a picture of the same window, and a mark showing him a hot-spot. As he moves his phone close to this hot-spot, a presentation of the window, how it is composed and its history starts to play on his phone.

John starts to move before the presentation of the window is done playing, to move closer. As he walks, he passes a new point-of-interest. His phone notifies that this point is nearby, but John wants to see the rest of the presentation, and ignores this notification. If he wanted, he could have switched instantly to the new presentation.

When John is finished with his tour, he can not see his wife nearby. He decides to find her by looking her up in the guide system. She has moved on to Bispegården, another location-aware attraction situated next-doors from the cathedral. He sends her a message, asking her to meet him at the entrance so they can view Bispegården together.

13.2 Network Provider

The network provider is responsible for providing the necessary infrastructure for the location-aware framework. This infrastructure consists of communication channels and the positioning system.

In many cases, there will be a combination of several different actors cooperating to provide the total infrastructure needed. An example from Norway related to the user perspective in the previous section will include a telephone company for providing course-grained location information (the area or town a user is located) and communication channels. The different sights (like Nidarosdomen or Bispegården) have a need for finer-grained location information, and will likely provide their own location infrastructure, for example using WLAN and RFID.

Billing the users for their use of the system will also be the responsibility of the network providers. Again, they may need to cooperate in some way to collect payment and distribute to the different actors.

For all of these actors, it is important to be aware of privacy issues. It is especially important to ensure that a user does not feel like he is being traced without his consent and can control to whom his location is revealed.
CHAPTER 13. SCENARIO - TOURIST GUIDE

13.3 Developer and Content Provider

There are three kinds of actors in this category: application developer, content owner and content enabler. Both the content owner and the content enabler are content providers. The relationship between these can be seen in Figure 13.1

13.3.1 Application Developer

The application developer would like to have a common framework for developing location-aware applications. In this framework, there would be an API specially fitted for this purpose in a widely known programming language. This will enable most developers to work on the applications without much time spent on learning the framework and programming language.

Different mobile devices should be supported so one does not need to develop different versions of the application for different devices.

In addition different systems for location positioning should be abstracted away to make it fit into a common API. When there is low bandwidth or many users prefetching should be used to ensure a constant quality of service to the users. On the other hand, modularity is also a key issue since it is important that the system should be modifiable. This will enable the developer to easily adopt the application to the changes in the underlying technologies like communication or location, or perhaps have several different technologies. It should also enable the developer to fit the application into a application portfolio.

13.3.2 Content Owner

The content owner in this scenario is Nidaros bispedømme. They administer the cathedral, Nidarosdomen, identify the important information and enables the location and communication providers to install the needed infrastructure. They also provide the information for the system to the content enabler, which is addressed in the next section. By opening up their location, they can get payed without having to employ people to charge for entrance. Instead they receive payment for the information provided through the system. They also have to inform visitors about the service and how to use it. The system should provide the what, who, how and when about the location-aware tourist information retrieval. This will enable the cathedral to improve its information and its presentation.

To enable all users to enjoy the location-aware guidance application, the cathedral will have some PDAs that they can be rented out to the visitors at given hours. This will provide a certain amount of usage, which can be important for the overall system success.
13.3.3 Content Enabler

A content enabler like Klipp og Lim Media should work with the content owner and the application developer to create the application content. The creation of multimedia presentations that is associated with a given location is done in cooperation with the people working for the cathedral. The presentations should have a set of different languages enabling different nationalities to use the system. In addition, it should have a standard file format that is supported by the system and the devices. Uploading presentations should be done through an easy to use interface, which enables the content enabler to set the area for where the location information should be provided.

13.4 Device provider

Device providers must provide the end user with devices with the characteristics needed in location-aware applications. These characteristics include the ability to handle multimedia content as well as communication and positioning. The devices should have enough memory to enable some sort of buffering or prefetching of multimedia and other content.

Developing applications for the devices should be done using a standard set of programming languages and communication protocols. The manufacturers must provide this standard set in their devices. An example is the use of J2ME as a programming language and HTTP as a communication transfer protocol.

13.5 Regulator

A regulator sets the premises for what the other actors are allowed to do. A typical regulator is the government and law-enforcement units. Some of the premises set include privacy regulations and communication technologies are allowed to be used. All applications must conform to the premises set by the regulators.

Even though the regulators rarely are directly involved in development of applications, they may provide funding for this development. Also, many issues are not revealed and regulated until the applications are in actual use. Therefore, cooperation between the regulator and the other actors is needed.
Chapter 14

Requirements

This chapter is divided into two different sections. The first section is general requirements that are closely linked to issues described in the prestudy. The second section is deals with the requirements that are withdrawn from the tourist guide scenario in Chapter 13.

14.1 General Requirements

There are several general requirements for location-aware applications and the systems they are running. By applying the different areas addressed in the prestudy, we can see the important aspects of requirements, which are important for a location-aware application framework. The following sections will look at these general issues.

14.1.1 Positioning

Several requirements related to the use of different positioning techniques, how to provide location information to a user or application, mapping and notifications related to location are listed in Table 14.1

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTR1</td>
<td>Enable the use of different positioning technologies, depending on the device in use and the infrastructure available.</td>
</tr>
<tr>
<td>PTR2</td>
<td>Provide the most accurate available location information, up to the accuracy needed for the application and context at hand.</td>
</tr>
<tr>
<td>PTR3</td>
<td>Enable an easy mapping between physical coordinates and the concept of a place or area.</td>
</tr>
<tr>
<td>PTR4</td>
<td>Support notifications when location-aware events occur, such as a user arriving at a specific location.</td>
</tr>
</tbody>
</table>

Table 14.1: Requirements concerning positioning techniques
CHAPTER 14. REQUIREMENTS

14.1.2 Devices

The requirements related to devices in location-aware applications are about how a framework should be able to handle different devices, making applications independent of the devices they are used with. The requirements are shown in Table 14.2.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR1</td>
<td>Adapt content to the different capabilities of different devices transparently.</td>
</tr>
<tr>
<td>DR2</td>
<td>Adapt delivery of content using different communication technologies transparently.</td>
</tr>
</tbody>
</table>

Table 14.2: Requirements concerning devices

14.1.3 Performance

There are several issues in Chapter 8 concerning performance for location-aware applications. Some of these issues can be applied to a location-aware framework and are listed in Table 14.3 as requirements concerning performance. The requirements are a little vague since they only indicate possible ways of increasing performance, and there is a wide variety of actual implementations. PeRX means Performance Requirements and X is its numbering.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PeR1</td>
<td>Balance processes between the client and the server to improve performance of applications. Resource monitors, self-tuning operation, modifications to application source code, granularity of remote execution and correct results as identified in Section 8.1 are requirements for being able to achieve this balancing.</td>
</tr>
<tr>
<td>PeR2</td>
<td>Easily enable the implementation of prefetching by providing user profiling, priority of services defined by the user or the application provider and finally a user’s movement pattern (with respect to locations, speed, direction, and itineraries). These are important aspects for enable prefetching as described in Section 8.2</td>
</tr>
<tr>
<td>PeR3</td>
<td>Adaptive resource management by keeping record of each devices state, like battery level and location.</td>
</tr>
</tbody>
</table>

Table 14.3: Requirements concerning performance

14.1.4 Privacy

A lot of privacy issues are addressed in Chapter 9. Some of these issues should be stated as requirements for an application framework. These requirements are described in Table 14.4
CHAPTER 14. REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PrR1</td>
<td>Provide <em>personalized disclosure</em> which means that different users should see different location granularity for other users.</td>
</tr>
<tr>
<td>PrR2</td>
<td>Provide <em>transparency</em> which means that the a user should be able to foresee what information is revealed and what other users possibly know about them.</td>
</tr>
<tr>
<td>PrR3</td>
<td>Provide some <em>ambiguity</em> whether a user is at a given location or not by not revealing the user’s exact location but rather the area where the user is.</td>
</tr>
<tr>
<td>PrR4</td>
<td>Provide the ability for a <em>user to decide</em> upon what kind of collection of location information that can be used.</td>
</tr>
<tr>
<td>PrR5</td>
<td>Provide <em>limitations concerning storage</em> of location information.</td>
</tr>
<tr>
<td>PrR6</td>
<td>There are methods for protecting against <em>long term tracking of users</em>. Different applications should have different areas of where the users can be traced or there should be other limitations to the traceability of users.</td>
</tr>
</tbody>
</table>

Table 14.4: Requirements concerning privacy

14.1.5 Application Support

The application framework should support applications in the categories as indicated in Chapter 11. Table 14.5 presents a set of requirements being a result of this categorization. ASRX is an acronym for Application Supported Requirement number X.

14.1.6 Business Possibilities

The business requirements described in Table 14.6 are general and have to do with the ability to make money of applications running inside the framework. BR stands for Business Requirement.

14.2 Location-aware Guidance Requirements

This section will address the different users and try to identify requirements for the different actors identified in Chapter 13.

14.2.1 User Requirements

A general outline of user requirements for the client part of the system is given in the use case diagram, which can be seen in Figure 14.1. The user use cases have certain implications for the requirements of a location-aware application framework. The user requirements are listed in Table 14.7. The numbering is URX where UR stands for user requirement and X is it number.
### Requirement Description

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASR1</td>
<td>Support navigation and route finding applications. This means providing support for Geographical Information System (GIS) services like routing and maps.</td>
</tr>
<tr>
<td>ASR2</td>
<td>Support community applications. These kinds of applications are concerned with being able to match the different users’ locations to be able to see which users are close to each other. The need for privacy has to be addressed to support these kinds of applications.</td>
</tr>
<tr>
<td>ASR3</td>
<td>Support location-aware entertainment applications. These kinds of applications are very different so the only specific requirement will be to be able to pay for the services in addition to the basic need to position the user.</td>
</tr>
<tr>
<td>ASR4</td>
<td>Support location-aware information applications. For enabling these kinds of services one has to be able to relate information to a location or an area. It also has to provide different levels of information for different users.</td>
</tr>
<tr>
<td>ASR5</td>
<td>Support safety applications. Privacy is important for this category. The information provided when using this information can be very sensitive. Authentication and authorization will be a part of proving only certain people with the information provided.</td>
</tr>
<tr>
<td>ASR6</td>
<td>Support tracking applications. Since people are being tracked in these applications the hot issue is again privacy and many of the issues of Chapter 9 will be important. To provide the possibility to continuously track users is of course an important feature.</td>
</tr>
</tbody>
</table>

Table 14.5: Requirements concerning possible location-aware applications

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR1</td>
<td>Billing support which means that the user can be charged through his or hers phone bill, or that there should be other kinds of payment support.</td>
</tr>
<tr>
<td>BR2</td>
<td>Support a portfolio of applications, which means that it should be possible to have a set of different applications running in the application framework at the same time.</td>
</tr>
<tr>
<td>BR3</td>
<td>Robustness, meaning that it will have to be reliably available to its users at all time. This will build user trust and comfort.</td>
</tr>
<tr>
<td>BR4</td>
<td>Scalable, meaning that it will support a growing business with an expanding application portfolio and an increasing number of users.</td>
</tr>
<tr>
<td>BR5</td>
<td>Support standards, including both standards for communication to and from devices, and standards for developing and deploying applications. This will be crucial for the ability to use an application on more than one device and for letting developers use familiar development techniques and tools.</td>
</tr>
</tbody>
</table>

Table 14.6: Requirements concerning business possibilities
Figure 14.1: User Use Cases
### Chapter 14. Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UR1</td>
<td>Register to get location-aware guidance information. This may be done using a mobile phone or on the Internet.</td>
</tr>
<tr>
<td>UR2</td>
<td>Receive information about guidance-enabled sites when getting close to their locations.</td>
</tr>
<tr>
<td>UR3</td>
<td>Be able to pay for usage by using their mobile phone.</td>
</tr>
<tr>
<td>UR4</td>
<td>Provide multimedia adapted to the users device.</td>
</tr>
<tr>
<td>UR5</td>
<td>Provide a map or an overview of the whole area. This overview should contain information specialized for each user, including points of interest.</td>
</tr>
<tr>
<td>UR6</td>
<td>The user should be able to see his location in the overview.</td>
</tr>
<tr>
<td>UR7</td>
<td>The user should be able to see possible routes to follow in the overview.</td>
</tr>
<tr>
<td>UR8</td>
<td>The user should be able to see where he has been in the overview.</td>
</tr>
<tr>
<td>UR9</td>
<td>The user should be able to see the location of other users in the overview.</td>
</tr>
<tr>
<td>UR10</td>
<td>In case of emergency the user should be able to contact assistance from site’s employees.</td>
</tr>
<tr>
<td>UR11</td>
<td>Add other users to a group of users of interest. The other users will have to agree on this information. This is a two-way grouping where the users are placed in each others groups.</td>
</tr>
<tr>
<td>UR12</td>
<td>Send messages to a single user or all the users in the user’s group.</td>
</tr>
<tr>
<td>UR13</td>
<td>Should be able to activate items by positioning the device close to a certain spot, which the system will react to.</td>
</tr>
<tr>
<td>UR14</td>
<td>The user has to be able to stop the tracking of where he is.</td>
</tr>
</tbody>
</table>

Table 14.7: User requirements
14.2.2 Network Provider Requirements

The network providers being the communications provider or the location provider should have an interface that enables the to provide a set of services. These services can be seen in Figure 14.2, which is an overview of the network provider’s use cases.

These use cases are the basis for a set of requirements for the system, which are addressed further in Table 14.8. The numbering of these requirements is NRX where NR is for Network provider Requirements and X is for the actual numbering.

14.2.3 Application Provider Requirements

The application provider requirements can be divided according to the actors of Figure 14.3, which is a part of all the actors seen in Figure 13.1.

Application Developer

The requirements important for the application developer are listed in Table 14.9. ADRX is used for numbering where ADR stands for Applications Developer Re-
CHAPTER 14. REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR1</td>
<td>The communication provider should be able to provide an interface that should enable the system to bill users. The system should be able to adjust to different types of payment procedures.</td>
</tr>
<tr>
<td>NR2</td>
<td>The communication provider should be able to deliver different kinds of communications which the system should easily adapt to.</td>
</tr>
<tr>
<td>NR3</td>
<td>The network providers must enforce privacy; no unauthorized party must be able to get sensitive information about the users.</td>
</tr>
<tr>
<td>NR4</td>
<td>The location provider should be able to provide different kinds of location granularity through different sets location system of which the system should be able to adapt to.</td>
</tr>
<tr>
<td>NR5</td>
<td>The location provider should be able to provide different sets of GIS systems which the system should be able to use and adapt to, to provide mapping and routing.</td>
</tr>
</tbody>
</table>

Table 14.8: Network provider requirements

![Diagram](image.png)

Figure 14.3: Application provider applications
CHAPTER 14. REQUIREMENTS

Figure 14.4: Content enabler use cases

requirement and X is the number.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADR1</td>
<td>A specially fitted API for a well known programming language, which will make the development of location-aware applications easier and quicker. This API must be available for use in many location-aware applications, and provide all functionality needed.</td>
</tr>
<tr>
<td>ADR2</td>
<td>Automatic adaption of an application to different devices without having to write different versions of the application for each type device.</td>
</tr>
<tr>
<td>ADR3</td>
<td>Different positioning systems can be used without having to adapt the application to it.</td>
</tr>
<tr>
<td>ADR4</td>
<td>Use of prefetching techniques to enhance performance.</td>
</tr>
<tr>
<td>ADR5</td>
<td>Supports a portfolio of applications which can interact or work on their own.</td>
</tr>
</tbody>
</table>

Table 14.9: Application Developer requirements

Content Owner

The content owner has no specific requirements with regards to the framework.

Content Enabler

The content enabler is a direct user of the framework and works on one its interfaces and more so than other application providers. As a result the content enabler has a few use cases (as seen in Figure 14.4) for it. This provides different kinds of requirements listed in Table 14.10. The number is an abbreviation of Content Enabler Requirements with an incremented number appended to it.
CHAPTER 14. REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CER1</td>
<td>Be able to add <em>multimedia presentations</em>.</td>
</tr>
<tr>
<td>CER2</td>
<td>Be able to add <em>multiple languages</em> for a given presentation.</td>
</tr>
<tr>
<td>CER3</td>
<td>Set location area or point for where a given presentation should be viewable (<em>hot-spot</em>).</td>
</tr>
</tbody>
</table>

Table 14.10: Content enabler requirements

14.2.4 Regulator Requirements

There is one requirement that the government is particularly concerned about when it comes to location-aware applications. As indicated in Table 14.11, the requirement is for the user to easily be able to stop the tracking of devices. RRX means Regulator Requirement plus a number.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR1</td>
<td>The user should be able to <em>stop all tracking</em> easily.</td>
</tr>
</tbody>
</table>

Table 14.11: Device developer requirements
Chapter 15

Evaluation of Oracle Application Server

This chapter will evaluate Oracle Application Server Wireless with regards to the requirements identified in Chapter 14.

15.1 Evaluation of General Requirements

A set of general requirements for all location-aware applications were identified in Section 14.1. These requirements are evaluated in the following subsections.

15.1.1 Positioning Techniques

The different requirements identified related to the use of different positioning techniques in Section 14.1.1 are evaluated here.

PTR1 - Different positioning technologies The use of different positioning techniques and technologies is supported by OracleAS. OracleAS provides a neutral API for an application to get the location of a user or device. This API is independent of the underlying technology and uses a custom driver for connecting to a positioning system such as a server collecting location using WLAN or GPS. This driver must be implemented for each technology or collection of technologies.

PTR2 - Most accurate available location OracleAS will use a driver to connect to a positioning system if the location currently in the cache is outdated. Then it will be up to this driver to provide the most accurate location information about the user.

PTR3 - Mapping The geocoding module of OracleAS Wireless addresses the need to perform the mapping between coordinates and place or address.
CHAPTER 15. EVALUATION OF ORACLE APPLICATION SERVER

PTR4 - Notifications  OracleAS has a module for giving notifications to applications registered to listen to these events. These notifications can be based on conditions related to location.

15.1.2 Device Support

Section 14.1.2 identifies two requirements for the framework and handling of different mobile devices. These requirements are evaluated here.

DR1 - Adapt content  OracleAS automatically detects the type of device a user is using. It then will adapt the content to suit the device in question. Images and video will be transformed to fit the display, and text markup will be changed accordingly. With proper markup in the text, it can also be adjusted to work in voice-based applications.

DR2 - Adapt delivery  OracleAS use a set of standard-based communication technologies. The use of standards allows for transformations between the different standards. OracleAS will do this transformation automatically to fit the capabilities of the user’s device and network available.

15.1.3 Performance

Requirements related to the performance of location-aware mobile applications are given in Section 14.1.3. How OracleAS will be able to address these requirements is evaluated here.

PeR1 - Balance processes  OracleAS has no means to dynamically handle balancing between the server and the mobile device. It will on the other hand take care of much of the heavy computing, for example related to the adaption of content to fit the device.

PeR2 - Prefetching  OracleAS does not provide any form of prefetching. This has to be taken care of in another manner. A framework built on top of OracleAS could include such functionality, but it is difficult to provide it in a generic fashion usable for all applications. The other alternative is to make the application at hand responsible for performing the prefetching itself.

PeR3 - Adaptive resource management  No support for adaptive resource management is provided by OracleAS.
15.1.4 Privacy

OracleAS Wireless handles security and privacy management from the personalization foundation service. The requirements from Section 14.1.4 concerns privacy, and the handling from OracleAS is evaluated here.

**PrR1 - Personalized disclosure**  A user can specify who will be able to access the information about him from OracleAS. Thus he can decide to not allow an application or other user to access the information.

**PrR2 - Transparency**  From the personalization module of OracleAS a user can see all information available about himself. He can check what other users are able to see.

**PrR3 - Ambiguity**  A user can define that his exact location should not be revealed. Using the geocoding interface an area is defined. The location of a user can then be known to be within a given area, but the exact physical coordinates may be kept secret.

**PrR4 - User decisions**  When a user has accepted that an application will be able to access information about his location, OracleAS will provide the application with this information. It will not be able to differentiate between different positioning techniques.

**PrR5 - Limitations to storage**  OracleAS does not on its own hand store the location information. A cache is used to increase performance, but long-time storage of location and time is not available. An application using OracleAS could of course perform this form of storage by itself.

**PrR6 - Long term tracking**  A user can specify that an application will only be able to access information about his location within certain time and location frames. He may say that application A will only be able to see information when he is in Trondheim, Monday to Friday between 8AM and 4PM.

15.1.5 Application Support

The ability to handle many kinds of applications is crucial for the success of a framework. A classification of applications and their requirements are given in Section 14.1.5. OracleASs ability with regards to these requirements as follows.
ASR1 - Navigation and route finding  OracleAS Wireless is delivered with pre-built systems for such applications. One can make use of the existing solutions completely, or decide to develop an application using the available APIs, depending on the specific use cases at hand.

ASR2 - Community applications  An application can request to get the information about a user’s location. If this user has allowed the application and user using the application to access this information, he will be able to figure out if they are close by.

ASR3 - Entertainment applications  The billing API in OracleAS provides a general form for applications to handle billing of customers.

ASR4 - Information applications  Applications will be able to get access to information about the location of users (provided the have access). Handling of different levels of information to different users must be done in the application itself.

ASR5 - Safety applications  These applications have many of the same needs other applications have. They need access to location information, but for some of the critical safety applications a user should not be able to stop tracking. As it is today, a user may deny any application access to his location in OracleAS.

ASR6 - Tracking applications  An application can poll OracleAS at intervals needed for the application. It can then track the user. This is of course only possible if the user has agreed and given permission to the application.

15.1.6 Business Possibilities

In Section [14.1.6] requirements from a business perspective were gathered.

BR1 - Billing support  OracleAS includes an API for billing. This will integrate with existing billing solutions, and the customers will be billed in their normal ways.

BR2 - Portfolio of applications  Many applications can be deployed simultaneously on OracleAS. All of these can use the wireless and location-aware APIs offered by the server. Hence, a portfolio of applications can be developed and deployed. A user can then decide to use and give different applications access to information it might need about him.
BR3 - **Robustness**  Clustering and failover is supported by OracleAS. This means that in event of a server crash, another server will handle the load until the crashed server is back online. This failover is automatically handled by modules in OracleAS.

BR4 - **Scalability**  The clustering available with OracleAS makes it possible to divide the load between several physical servers. Thus new hardware can be added as needed when more users need more resources.

BR5 - **Support standards**  OracleAS is based on standards. Both the internal handling of J2EE applications and the communication protocols supported are standard-based. The use of standards will let more developers be familiar with how to develop and deploy their applications, as well as support more devices.

### 15.2 Evaluation of Guidance Requirements

The requirements for a location-aware guidance presented in Section 14.2 are requirements for a specific location-aware application. Some of these requirements are outside the scope of a general framework, while others are related to the requirements of the previous section.

#### 15.2.1 User Requirements

The requirements of a user for a location-aware guide are defined in Section 14.2.1. Most of them can be dealt with in the same manner as the general requirements evaluated earlier, while others require more specific care.

**UR1 - Register**  A user can register from his phone using two-way messaging or on the Internet. OracleAS can be reached using any of these front ends. The APIs available for handling permissions of a user’s location can be used from both a mobile phone and a web-based system.

**UR2 - Receive information**  When the user has allowed the guidance application to access his location, the application will be able to sense when he is close to a guidance-enabled site. Then the user can be sent information from the application. By using the mapping functionality of OracleAS graphical views of large areas can be sent to the user.

**UR3 - Payment**  The application will use the billing-API to bill the user, and then the payment will come on the normal bill the user receives from his telecom operator.
UR4 - Adapted multimedia OracleAS will automatically adapt the multimedia content to fit the user’s device.

UR5 - Map overview The mapping and routing functionality in OracleAS can be used to provide maps. These maps can include information about areas of interest. By allowing the user to set his preferences in the application, the areas shown to the user may vary from user to user, depending on the settings. This is an application-specific filtering, so the application must select which points to show to each user.

UR6 - See own location The location of the user is known to the application. Then it can include this information with the map, and plot the user into the map.

UR7 - See possible routes A combination of using mapping and routing functionality from OracleAS can provide a set of possible routes to follow from a destination to another. These routes can then be displayed to the user, who then will select which route to follow.

UR8 - See where he has been If an application logs the location of the user continuously it can display this information to the user afterwards.

UR9 - See location of other users Provided that the user has access to the information about other user’s location, it can plotted into the overview, just as his own location.

UR10 - Contact assistance By providing a help-function in the application, a user can make contact with employees. The employees may then find the location of the user, and find and help him very quickly.

UR11 - Add users When a user wants to add another user to his group of friends, they must allow him to know their location. If they confirm and give access, the application can monitor their position and show, either continuously or on demand.

UR12 - Send messages The messaging API of OracleAS allows for sending of both text and multimedia messages between users.

UR13 - Activate items By providing a form of sensor and tag such as the RFID system, there could be generated a location-aware event when a user holds his device close. The guiding application can listen for such events, and act upon them.

UR14 - Stop tracking A user can at any time decide to deny an application or user access to information about his location. In this way he can stop tracking. Another way to stop tracking will be to turn his device off.
15.2.2 Network Provider Requirements

The requirements identified for the network provider in Section 14.2.2 deals with both how the provider must act in order for location-aware applications to be successful, but also what a framework must provide for the provider in terms of functionality and APIs.

NR1 - Billing  By implementing a driver for the billing API of OracleAS, a communication provider will enable the billing of users. This driver must connect to the existing billing systems of the provider.

NR2 - Communication  OracleAS is based on standards, and will adapt delivery of content to appropriate communication channels. These channels must be provided by the provider.

NR3 - Enforce privacy  The security mechanisms included in OracleAS provide a great deal of privacy. The network provider needs to make sure no information about the user is released through any other interface.

NR4 - Location granularity  The provider must implement a driver for retrieving the location information. This driver can use different technologies, providing different granularities. As the driver is accessed through a generic API from OracleAS, the applications using the information will not be able to know which technology is used.

NR5 - Different GIS systems  The APIs provided by OracleAS requires a driver for retrieving information. The choice of how to implement these drivers is up to the providers. They can use a variety of GIS systems to provide mapping and routing.

15.2.3 Application Provider Requirements

In Section 14.2.3 requirements to the roles Application Developer and Content Enabler were identified. Most of these requirements are already addressed, but they will be listed here anyway.

Application Developer

ADR1 - Fitted API  The generic API offered by OracleAS for getting positioning information, maps, routing etc. should be one possible API. This API can be used by all location-aware applications.

ADR2 - Automatic adaption  OracleAS will automatically adapt the content to fit the user’s device.
**ADR3 - Different positioning systems** Any positioning scheme can be used, as long as a driver is available. There can be many such drivers working at the same time.

**ADR4 - Prefetching techniques** The issue of prefetching is, as previously stated, not an issue for OracleAS but must be considered for each application. OracleAS can provide the means to actually send information to the user, but deciding when and what to send to the user is the choice of the application.

**ADR5 - Portfolio of applications** OracleAS can have many applications running simultaneously, allowing for a growing portfolio of applications.

**Content Enabler**

**CER1 - Multimedia presentations** Multimedia presentations can be uploaded to OracleAS. When such a presentation is ready, OracleAS will adapt content to the devices in use.

**CER2 - Multiple languages** The issue of multiple languages can be solved by providing several presentations that are only different by the language. When a user requires a presentation, the application must choose the correct one, depending on the language the user has specified.

**CER3 - Enable hot-spots and areas** The mapping function in OracleAS combined with geocoding can be used to define areas and specific hot-spots. Then event notifications can be generated based on these definitions.

**15.2.4 Regulator Requirements**

The one requirement set by the regulators in Section 14.2.4 relates to the users ability to stop all tracking.

**RR1 - Stop all tracking** OracleAS gives a user the option to deny everyone from knowing his location.

**15.3 Summary**

As we have shown in this chapter, Oracle Application Server support most of the requirements identified for a framework for location-aware mobile applications. Its strengths include the ability to handle many different devices with a variety of physical capabilities and different communication technologies.
Chapter 15. Evaluation of Oracle Application Server

However, there are a few shortcomings and challenges. One of these challenges is the fact that OracleAS only provides a set of APIs for an application to use. The actual work of providing results from calls one of these APIs must be implemented by an external provider. This can be a major effort, but many of the APIs are already implemented by some providers, and these implementations can be used as guides for new ones.

Among the shortcomings of OracleAS we find the issues of performance. Neither adaptive or configurable balancing of processes nor prefetching is supported. These issues are important for the quality of a user experience, and must be supported in some way. This support can be provided in one of two ways: By implementing some sort of extension to the APIs provided by OracleAS or, by making such decisions the responsibility of each application.

Other shortcomings are related to users’ privacy. OracleAS fails to let a user decide what positioning technology to use. This decision is made by the driver available. A possible solution could be to implement a different driver for each technology, and let a user select what drivers should be allowed to use. This could be done as an extension to the APIs provided by OracleAS. Another solution would of course be if the user could turn off transmission of signals needed for a particular technology. OracleAS also fails to prevent storage of location information, due to the fact that an application can store the location of a user as it sees fit. A technical solution to this problem seems difficult, but by using strict rules for application developers and possibly some kind of sanctions to those who break the rules, it can probably be avoided.
Part IV

Discussion, Conclusion and Future Work
This part sums up the project. It contains a discussion, a conclusion and a suggestion for future work.
Chapter 16

Discussion

This chapter presents discussion about the most important aspects of this report and the project. First, the process and results from the prestudy are presented in Section 16.1 and then there is an evaluation of the scenario before the requirements are discussed. Section 16.4 discusses the evaluation of the Oracle Application Server before the final section addresses personal experiences.

16.1 Evaluation of the Prestudy

Location-aware applications need to consider a wide range of different issues from technical to legal via privacy just to mention a few.

The prestudy tries to consider a lot of these concerns. To cover all possible aspects of every issue that location-aware applications come in contact with is practically impossible. An evaluation of a location-aware application framework also has to take into account possible stakeholders. Different stakeholders have different impact on the evaluation. They have also different concerns with different levels of importance.

This project has tried to evaluate some of these concerns. The choice has been to emphasis on positioning techniques, devices, performance, privacy, business possibilities and future location-aware applications. These issues have been important in evaluating the Oracle AS. Each issue could have been further evaluated but after picking the most relevant work in each field some less interesting aspects had to be somewhat left out. The final evaluation has not been much affected by this.

Chapter 16 business possibilities, is emphasized somewhat stronger than we would have done in the first place. The importance of business aspects was stressed by both Telenor R&D and Klipp og Lim Media. As a result, the chapter addresses some issues that are not key issues for the evaluation of OracleAS as a framework for location-aware applications even though they are an important foundation for the requirements.
CHAPTER 16. DISCUSSION

16.2 Evaluation of the Scenario

The scenarios take into account different aspects for the most important actors. It also explores what is possible with present technology and possibly much better than using a customer driven design, which tends to focus on commonly known technology. This means that it takes a lot of different perspectives and maybe provides new kind of requirements since the scenario addresses the different actors.

16.3 The Requirements

The requirements identified address issues related to location-aware mobile applications in general and a location-aware guidance application is particular. The set of requirements do not focus on only the functional requirements of a single application, but also takes other aspects into account. This has been necessary in order to be able to evaluate a framework for all location-aware applications.

We feel the requirements cover all the needs of the important stakeholders for a framework for location-aware mobile applications. We also feel they are a good basis for a thorough evaluation of this framework.

16.4 Discussing the Evaluation

The evaluation addresses all the requirements of Chapter 14. The Oracle Application Server Wireless fulfills most of these requirements, and the exceptions are summarized in Section 15.3. The strengths of the evaluation is that it is based upon such a wide range of different requirements. On the other hand it does not take into account other frameworks. This in addition to actually test the framework in action is the weaknesses of the project. The project had too short a lifetime to be able to do this, as Oracle Application Server is a very large system with many attributes. The documentation of the Oracle Application Server is extensive, all functionality is described in detail. As a result, the evaluation is thorough and accurate.

16.5 Personal Experiences

There are a few key factors for this project that we would like to address in this section.

First of all, we have learned very much about the domain of location-aware applications. That means the challenges as well as the possibilities and benefits of such applications, and different aspects of the OracleAS.

Oracle Application Server is large and it is not easy to understand all of it right away. That said, it provides a lot of functionality and is an impressive system. It can solve some of the problems that location-aware systems face today and we look forward to get to know it even better.
It is challenging to work with three different actors that have different perspectives, interests and goals. We have learned that one need to be able to deal with the politics of such collaborations. It has been a few negotiations to get to where we are now. The positive side is that the requirements have different perspectives that are valuable for evaluating an application framework.
Chapter 17

Conclusion

Today, many researchers have addressed the need for location-awareness in many applications. Many projects have developed location-aware applications, but no general framework for developing and deploying such applications exist.

This project aimed to evaluate Oracle Application Server Wireless as such a framework for developing and deploying location-aware applications. Many different aspects influence such applications, and a set of requirements for a framework had to be identified. This was done by investigating the most important aspects and examples of applications.

The functionality of the Oracle Application Server was then compared to the set of requirements. This showed that many of the requirements were covered but some will not be directly supported. These unsupported requirements can be dealt with by developing another layer on top of Oracle Application Server.

Throughout the project, the need for a general framework has been clear. Both development cost and complexity of location-aware applications is high. By using a good framework, both the cost and the time needed for development can be reduced much.
Chapter 18

Future Work

This project resulted in an evaluation of Oracle Application Server Wireless as framework for location-aware applications. This chapter indicates different possibilities for future work on this framework.

The ultimate test for the Oracle Application Server would be to use it in a full scale implementation and testing of a location-aware application for guiding. This implementation would have to address the different levels of location-awareness (Micro-Macro-Touch) to see how well the OracleAS performs in an actual real-life test. To be able to do this we would have to find solutions to fulfill the OracleAS’ shortcomings with regards to the requirements proposed for a complete framework.

A driver for a location server must be created. A location server is a component integrating several of the different positioning techniques from Chapter 6. There should be a seamless transaction between the different positioning technologies.

A large-scale user test using the location-aware guidance scenario will also enable user comments, and can better enlighten the users’ needs. How do users feel such an application should behave? Where is the limit as to how intrusive the application can be?

Controlling performance by using prefetching is another important feature not supported by OracleAS. A further investigation of how prefetching can be generalized could be an option for further work. This investigation can lead to an architecture for how to implement different prefetching schemes, and a test-implementation of this. The result can be especially valuable if such a test is done in parallel with large-scale user testing. The use of prefetching can improve the overall usability and user satisfaction of an application.

Another direction of further work is to implement and run a portfolio of location-aware applications to test the scalability of the application framework. This can again be used in a full scale, real life study on location-aware application usage. When looking at a portfolio of applications, the question of common content will arise. How can different, but in some way similar, applications share content? Content can be information for the user and location information such as areas and hot-spots, and a mapping between the two. Is it possible (or even desirable) to have
CHAPTER 18. FUTURE WORK

a “Create Once – Publish Everywhere (COPE)” functionality?

Another aspect of a portfolio of applications is the potential problem when two different applications want to deliver content to the user at the same time. How can this be solved?

Many content providers will want to do the same things when thinking about location-aware applications. Things like defining areas and hot-spots is a tedious and in many ways difficult process. The same goes for associating content with the defined locations. An easy-to-use front-end system for designing information-intensive applications will help many providers in developing and deploying new location-aware applications.

These topics are interesting for NTNU, Telenor R&D and Klipp og Lim Media, and will be evaluated for future work between these parties.
Bibliography


