

# Privacy vs Location Awareness

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## Abstract

The usage of location information to adapt the applications to the current location and provide the user information that is relevant to the current situation is a fascinating concept. It is based on the fact that the relevance of the information is closely related to the location. Privacy of the location information is a very important question in combination with the location awareness. Failure to protect the privacy of the location information of the users can have enormous consequences, and even lead to an Orwellian society.

## 1 Introduction

There are millions of handheld devices like mobile phones and PDAs in use today. Because of the mobile nature of these devices there are many occasions where it would be nice to know the current location of the device. This location information can be used to provide all kind of value-added services that we could not have dreamed about before. These include new kind of advertising, navigation and information services. By using the location information the applications can better adapt themselves to the environment and provide the user useful information that is relevant to the current situation of the user. Such applications that use the location information are called *location aware* and the whole concept is called *location awareness*.

Techniques for providing location information have been around for quite a long time, but they haven't been used much until now. The success of the wireless devices has been the main driver for the rise of the location awareness. Next couple of years are expected to be the breakthrough of the location awareness. Location awareness is a topic of much interest at the moment.

This paper gives an introduction to location awareness and the privacy issues that are related to location information. Section 2 describes the concept of location awareness and also gives an overview of the current technologies for providing the location information. Current location aware applications and future possibilities for location awareness are presented in Section 3. Section 4 is devoted to privacy issues. It takes a look at the privacy issues of the location information in the point of the view of the located object and also to privacy of the located objects nearby. Section 5 presents what legislation says about location information and its usage in location aware applications. Finally, Section 6 gives a brief summary of the issues presented in this paper.

## 2 Location awareness

Location awareness is based on the fact that only some information in the world is relevant for you at the moment [3]. For example if you are hungry and you are in Helsinki, you probably want to have information about restaurants nearby instead of having the information about some restaurants in Paris. *Location awareness* means that the application is somehow aware of the current location and can use this information to present, retrieve or filter the information appropriate to this position [5]. For example the restaurants that are within 400 metres could be shown and once the user has selected one of those the device can guide him there.

Location awareness is only a small part of the so-called *context awareness*. Context awareness means the usage of context information in applications. Context information can include things like identity, spatial, temporal, environmental, social, resource and physiological information. All of these can be used to adapt the application to current environment of the application, for example location, time, light level and people that are near by.

Location awareness is based on the usage of *location information*. Location information can be gathered in a number of ways. The most important techniques are presented in the rest of this Section. The precision of location information is crucial for many applications. It is constrained by the facts like power consumption and the size of the device. Location information is always attached to some entity that is being track. These entities are called *located objects*. Located objects can be persons, animals, valuable items like cars, deliveries or anything that we want to track.

*Proximity awareness* means that the PDAs or other handheld devices are aware of the devices that are near by. For example in the meeting the PDAs of the people attending the meeting, could automatically change important information or when printing something the printout would be sent automatically to the nearest printer. Proximity information can be calculated from the location information.

Location awareness can be either relative or absolute. Absolute location awareness means that the actual location is known, for example coordinates of the location or in what place (room, building, city) [3]. There are several technologies like GPS that provide the absolute location awareness. Relative location awareness knows what located objects are nearby. This kind of location awareness enables the objects to move around and have the information of the other located objects updated automatically. Relative location awareness can be simulated by using an absolute location aware system, if the device can send its location information to the network and receive information about other located objects from the network.

### 2.1 Techniques for providing the location information

There are several different kinds of techniques to get the location information. These techniques include GPS, infrared sensors, mobile phones, badges, electronic keys and even more exotic ones like footstep force profiles. Two approaches to location awareness can be identified. The traditional one is based on tracking the device with the help of GPS, radio bearing, ultrasound, magnetic or infrared tracking. The other approach is to attach

passive markers like barcodes or active markers like infrared transmitters to the environment. These markers enable the mobile device to read its location information [5]. The main difference between these approaches is where the intelligence is placed, i.e. is the device smart or is it a simpler one and all the intelligence is put into network.

Because of the varying techniques that are used to provide the location information and lack of standards, the applications are normally quite closely tied to the particular location technique used. In order to be able to use a wide range of techniques easily for creating location aware applications a general location system would be needed. One such model is present in [14]. This kind of global system would be helpful for the application providers, since they could easily provide applications, which are not tied to a particular technique like today.

The technical information presented in the following sections is derived from [12].

## **2.2 Satellite approaches**

### **GPS**

*GPS (Global Positioning System)* has been around for over twenty years now. It has been thought to make a breakthrough for years, but until now it has not made it. GPS has its roots in the military world and this has strongly affected its usage. GPS is owned and operated by the US DoD (Department of Defence). GPS used to have decreased precision in the civil usage, so called SA (selective availability), but the DoD stopped the interference of the signal on 1st of May 2000 [12]. The military background of the GPS system has hindered the usage of it, since many countries do not want to be too much dependent on the US. Also the fact that DoD can anytime stop the GPS service because of political reasons, for example because of some international crises, has been a negative factor. That is one of the reasons why EU is preparing a European satellite system called Galileo [8]. Galileo should be in use around year 2008.

GPS usage is free and it provides global coverage. GPS is based on 24 satellites that orbit the earth and send signals. GPS receiver receives the signal from three or four satellites and calculates the position on the basis of the distance from the satellites by taking advantage of the satellite orbit information. The whole system is based on having very exact clocks in the satellites and measuring the time differences. The precision of the location information is ten meters at the moment. Manufacturers are all the time working on providing smaller and low power consumption receivers. They have already succeeded to put the GPS receiver to a swatch [12]. GPS has problems in the indoor usage and in big cities, because it needs to have a visual contact to the satellites [2]. The precision of the location information can also vary depending on the circumstances where it is used.

## Differential GPS

The precision of GPS can be enhanced by using correction information from fixed land stations. These land stations follow the position of the satellites all the time and calculate temporary local correction information. This method is called *differential GPS*. The correction information can be sent over air by using RF-transmitters, satellites or mobile network. By using differential GPS the precision of location information is a couple of metres. The usage of differential GPS requires that the device used for positioning has capability to receive the correction information. This is easy in the case of the mobile phone. The provision of correction information is usually a commercial service. In Finland such a service is provided by Digita [12].

## AGPS

*Assisted GPS* means the methods that are used to assist the GPS location device to get the location information in the environments where the GPS is not working as expected. Because the signal from satellites is weak, the GPS receiver requires a visual contact to the satellite. This is a problem in cities, indoor usage and also in the forests where vegetation is dense. In these situations the GPS can be assisted with network positioning or censoring methods. One approach is to try to filter out the signal from the coherence by applying specific methods. This requires, however, quite a lot of calculation capacity so it is not reasonable to do it in the handset.

## 2.3 Mobile phone positioning

*Mobile network based positioning* is a new emerging service. It is supposed to be an integral part of the future mobile networks. Because of the large success of the mobile phones this will make the location services available to many users. Therefore there are quite good chances that location awareness will make a breakthrough. The only possible problem might be the precision of the location information.

### Cell of Origin

Mobile phone systems know the position of the phone at the cell level, i.e. on which cell it is. This method is called *Cell of Origin (COO)*. Cells vary in size from a couple of hundreds of meters in cities to tens of kilometres in countryside. Therefore this position information is not very precise. The problem with this method is that it provides the location of the base station that the phone is currently using. However, it might be the case that this base station is not the closest one.

### Signal strength

Measuring *signal strength* is one way to get the location information. It is based on the assumption that the signal strength is inversionally proportional to the distance. This method requires the signal from three base stations to be received. In reality the changes in the environment including the user affect the signal level, so that the method is not very exact. In cities this method can provide a little bit more precise location information than COO method, but in countryside the precision is much better.

### **Direction of arrival**

Direction of arrival methods *AOA* (*Angle of Arrival*) or *DOA* (*Direction of Arrival*) are based on determining the direction of mobile phone in relation to the base station. In this approach the base station determines the direction of the incoming signal by using a group of directional antennas. This method requires the signal to come directly from the handset to the base station, which is quite rare at least in city environment. Typically there are multiple reflected signals, because of buildings and other obstacles.

### **Time of arrival**

*TOA* (*Time of arrival*) and *TDOA* (*Time Difference of Arrival*) techniques are based on estimating the distance from the base station by measuring the time it takes for the signal to travel from handset to the base station. Method requires that at least three base stations can receive the signal. Time synchronisation of the base stations can enhance the precision of this method.

Time difference of signals coming from different base stations can be detected also in the mobile phone. This information is then sent to the mobile location server in the network. Method is called *Observed Time Difference (OTD)* or *Enhanced Observed Time Difference (E-OTD)*. This method would require updates to the mobile phones. Field trials of E-OTD report a precision of 50 metres or less [12].

### **Hybrid methods**

There are also mobile phones that use GPS for getting the location data. By combining different kind of location techniques, for example GSM network positioning and GPS positioning the availability and precision of the location information can be improved.

In the mobile phone based positioning services a special network component called *MLC* (*Mobile Location Center*) is used by many of the operators that provide location services [16]. This component can hide the actual technology that is used to provide the location information. This way operators can start to offer new services with the current methods and as new more accurate methods become available they can take them into use.

### **Standardisation**

In September this year big manufacturers Nokia, Ericsson and Motorola founded a new organization to develop the interoperability of different locating approaches in mobile phone systems. This organization is called *Location Interoperability Forum (LIF)* [15] and its purpose is to develop further the location-based services. The foundation of such an organization is a good thing, since there are so many approaches to providing the location information.

The standardisation of the network locating technologies has also started. In Europe ETSI has included the GPS, TOA and E-OTD methods in the GSM standards [12].

## 2.4 Indoor techniques

### Ultrasound

*Ultrasound* method requires that ultrasound transmitters are installed for example, to the ceiling. The positioning device has a microphone, which receives the ultrasound information and calculates the position of the device on the basis of the measured travelling time. The precision of ultrasound method is approximately 5 centimetres up to the distance of 20 metres from ultrasound transmitter. There have to be a visual contact between the transmitter and the microphone.

### RF and WLAN

*RF (Radio Frequency)* technique can be used for locating an object in short ranges. The method is based on observing a reflector or transmitter in the observation field. Usually the located object also sends some identification information.

*WLAN (Wireless LAN)* and *Bluetooth* techniques can also be used for providing location information. WLAN can provide the location information on the precision of the base station. This can mean a precision from a couple of metres to tens of meters. Bluetooth has a range of ten meters. The reflections of signals in indoor usage make the locating based on measuring the signal travelling times quite difficult.

### Infrared

*Infrared* locating resembles the RF technique. It requires a visual contact between the transmitter and receiver. The system may include also sensors and other devices that are devoted to collecting and transmitting the information. Infrared-based tracking systems have been manufactured for shopping and hospital usage. Usually the implementations combine RF and infrared technologies.

### Others

*Pseudolithes* are devices that are used to simulate the satellites on the ground. They are used in places where satellites are not available, for example in buildings and tunnels.

Traditional way of locating is to update the previous position on the basis of travelled distance and direction. This approach requires some sensors for measuring the distance and direction. The problem of sensors is that the position is not very exact after a series of updates.

Location information is also gathered in some places as a side product. For example when using magnetic keys for opening the doors of a building the information is stored somewhere. More exotic possibilities include the usage of special purpose tiles that identify the footstep force profiles of the person who enters the room. This identification is done by adding special tiles to entrance points [19].

### 3 Location aware applications

Location aware applications are just in the beginning of their lifecycle. They have enormous market potential and interest is high among the service providers. Service providers and operators are all the time searching for new value-added services so that they could differentiate themselves in the competition. Location aware applications are estimated to make a real break through next year. Some visionaries believe that the worldwide markets for location-aware applications will be worth 20 billions in 2005 [16].

Two types of location aware applications can be identified. They are pull and push applications. Pull application provides the information on the request of the user, for example the user can ask where the nearest flower shop is. Push applications will provide the information to the user from the initiative of the network. This mode is called push, because information is pushed to devices in a certain area.

#### 3.1 Application areas

Location aware applications can be provided in multiple areas. The only limiting factor is the creativity of service providers. Below is a collection of the services that are suggested in the literature and articles. This gives some kind of picture of the possibilities of location awareness. However, forecasting the future is not an easy task. There will certainly be services that we can not think about yet.

##### **Billing**

Location based billing provides the possibility for operators to bill different rates based on the location. This could mean that you get cheaper calls at predefined areas, for example at home and at office. You could also change your predefined areas by sending a message to the operator [4]. Other examples of billing could be automatic billing at theatres, cinemas, trains and busses. These services would be based on proximity awareness.

##### **Safety**

Safety area includes many possible applications. The most attention has been given to the emergency call locating. FCC has ordered that every mobile 911 emergency call in the United States has to be located within 125m on the 1st of October 2001 [16]. This has created a need for the wireless operators to develop and take into use the location tracking services. However, since the schedule is tight there is the risk that operators are too busy with the emergency calls and ignore the other services. This is not a wise thing to do since, the actual benefits are coming from other location aware services that they can implement. Also different kind of push services that provide information or warnings can be implemented. This could mean, for example, that if there has been a toxic waste accident all the people in the area could be advised to stay inside.

##### **Information**

Information providing has endless possibilities in location aware applications. Location information can be used to help in navigation while travelling or provide information about where is the nearest restaurant or flower shop. Tourist guides that use location information

can show background information about the place the tourist currently is. Other information services could include things like traffic warnings or advertisements pushed to the handset.

### **Tracking**

Tracking objects like pets, children or valuable items or deliveries is nowadays quite common. This way they can be found easily when needed. There have been experiments in the office environments of tracking people. One such experiment was the Active Badge, which is presented in next section. Generally the tracking of employees tries to enhance the productivity. GPS positioning has been used for tracking trucks and route optimisation for a long time. It has also been used as a navigation tool in outdoor activities like hiking and sailing.

### **Proximity awareness**

Automatic sensing of the devices or persons that are nearby is one application area. This could mean that incoming calls are directed to the phone closest to you or that printouts from PDA are automatically delivered to the printer closest to you. Proximity awareness could also include things like PDAs changing information automatically in meetings or finding out if your friend is nearby.

## **3.2 Examples of implemented applications**

**Lancaster Guide** University of Lancaster has developed a tourist guide *GUIDE* [6] for tourists visiting the Lancaster. The system was based on the usage of portable PC as terminal and WLAN as data delivery method. It had two kinds of communication modes. First each cell transmitted relevant information to this particular area. Secondly the user could request for a specific information. Location of the user was on the cell level or the user could provide the exact location.

**Active Badges** *Active Badge* [1] system at the Olivetti Research Lab was one of the first context-aware applications. The system was able to locate persons in the office and forward calls to the closest phone. Each person wore a badge that sent IR-signals to the environment. These signals were received and stored by the sensors in the environment. A central location server collected this information from the sensors for processing. The system was able to locate persons, tell who were in the proximity, which persons were in the proximity of a specified location and tell where the user had been during the last hour.

**Smart floor** *Smart floor* [17] is a system for identifying the people based on their footstep force profiles. The system uses special kind of floor tiles with force measuring sensors to collect the data as users walk over them. The system relies on the uniqueness of footstep profiles within a small group of people (up to about 15). By carefully positioning the tiles to the entrance points of the rooms, users can be tracked in a convenient way. The footwear of the person does not affect much the accuracy of the system. The system has achieved a user identification accuracy of 93 percent.

**Friends Finder** NTT DoCoMo has a *Friends Finder* service [4] in Japan. It is a service that provides the location of the user to his friends. The user has defined the persons who are allowed to see his location beforehand. The service is based on pushing the location

information when a friend is, for example within half a kilometre range.

## 4 Privacy issues

Location awareness is a concept that manufacturers and governments are pushing ahead at full speed. Almost all the discussion has been concerned with the question what can be done and what kind of applications can take advantage of the location awareness. The privacy issues that come along with the location tracking have not been thought very much. If the privacy issues are overlooked by the governments and manufacturers, this can lead to the kind of the society that has been described by Orwell [18]. There the government knows always where the individuals are and who are they with.

There are two issues that come along with the location awareness. One is the actual location of the located object. The other is the proximity awareness information. Proximity awareness means the information of which located object are near to each other's. Proximity awareness information is usually directly derivable from location information of various located objects.

### 4.1 Location information

Important issues arise when we think about the privacy aspects of location information. One of the issues is to whom we are providing that information and for what purposes. There is clearly a need to restrict the access to location information so that it will not be available to all who will request it. In some cases it would be desirable that the information could be anonymous, so that it could not be attached to any person.

Location tracking technologies are already used to track valuable items, pets and even children. This is not very far from the situation where everyone is monitored by someone. This is quite alarming, since there is a tendency that when new technologies come available those are taken into use without considering too much the consequences [7]. This is why the privacy issues should be part of the design work all the time. Privacy of the individuals is so important a thing that it should not be sacrificed for the sake of the technology.

Collection of location information should be apparent to all the users. There are already nowadays systems that provide the information as a side product and that way all the users do not realise that their location is known. This is the case for the magnetic keys for example. Magnetic keys have, however, one problem. The usual case in the offices is that only one person uses the key and at the same time several persons enter the building. So the information provided by magnetic keys is not very reliable. Another more usual case of location information is the usage of credit cards. Every time you buy something with your credit card, location information is produced as a side effect.

The lack of privacy with GPS location tracking systems in trucks has led to strikes at UPS (United Parcel Service) in the US [19]. The effect of the tracking is that control over the days work is taken away from the driver and more tight working days result as some of the natural breaks are taken away. The location tracking can be used to monitor and evaluate individual worker achievements, which can lead to increased stress and even in decreased

work efficiency. The problem is caused by the fact that no human being is able to work always effectively without breaks. The same problem applies to all tracking systems that are used by the employers. If the tracking systems are used wrongly the human beings can start to feel like robots that are supposed to do 100 percent work all the time. The effect of tracking is more a psychological one, because the working hours and breaks are defined in legislation. At least in Finland the legislation on the drivers' breaks is quite tight.

One particular problem for the privacy is the push service. Push service can be used to send information to user without the user requesting it. This service could be advertisements or informational messages. Pushing advertisements has the same problem that every Internet email user has encountered. A lot of meaningless spam messages filling up your inbox. If the same would happen also to mobile phones it would have very undesired consequences. This is a big problem that the operators have to solve.

In the information pushing case there has to be a way for the user to say that he does not want to receive advertisements. The reason for receiving the advertisements could be, for example that by receiving 10 advertisements per day you would get calls free of charge.

Protection of location information could be done so that the actual user information is not transmitted to the service provider. For example in the case of the mobile phone, the service provider could only know that someone is asking the location of the nearest restaurant in this particular location. The actual user information would be in the possession of the operator and billing would be done through the operator only. This has the disadvantage that all the billing has to go through the operator. The service providers would rather like to see a system where they can get the money directly.

Banks, operators and service providers are competing hard for the customers and try to expand to the areas of each others. They all would like to do the charging of the customer by themselves and also store the customer data in their own registers. This will most certainly affect the possibilities that we have for protecting the privacy of the users, since the commercial benefits can beat the individual's privacy requirements.

## 4.2 Proximity awareness

Also proximity awareness brings up challenges. It might be the case that PDAs or some other appliances that are carried by individuals could change information automatically when near to each other's. This raises the issue that how to limit this kind of automatic behaviour. We should be able to define under what conditions we are allowing the exchange of the data and on what conditions. This kind of dynamically changing network of some devices is called *ad hoc network*. Ad hoc networks are an active area of research and discussing the privacy issues of these are outside the scope of this paper.

The information about the people you meet and you are currently with is clearly sensitive. There are many situations where this information would be harmful to the persons. For example your wife could see that you are in the local pub instead of the office. If this kind of information would be available it could be used to identify organisational structures or political minorities. This could be hazardous for minorities in some countries.

## 5 Legislation

This chapter is based on the legislation of Finland. The main question is what legislation says about privacy of location information. Another question is if personal registers are created in the situation of PDAs sharing visit cards in the meetings.

### 5.1 Location information

Legislation defines under what conditions the usage of location information is possible. There are laws concerning home privacy, secret watching and others that could affect the location tracking and location based information services. *Navi-program*[11] discusses the legislation related to the location information in its paper about personal location information [12].

The current situation looks like that the location information can be used for location aware services, if the user gives a permission for the usage. In the case of mobile network based positioning it is not so clear, however, whether the laws forbidding the usage identification information are mandatory.

Location information is usually personal information and it has to be treated accordingly. This means that the Personal Information Law has to be followed including the sections concerning the purpose of the usage and need for that information. It would seem to be the case that the current legislation does not allow the provision of unsubscribed services.

There are two laws that can be applied to location information. These are *Personal Information Law* [10] and *Law about Privacy and Security of Telecommunications* [13]. The Personal Information Law is supposed to protect the personal information. The Security Law of Telecommunications tries to protect the security of telecommunications and privacy of the user information. There are no laws in Finland that actually concern location information.

#### Identification information

*Identification information* means according to [13]: "*The phone number of the subscriber or other identification information that is produced during the call*". Location information can be classified as identification information, when it is produced during receiving or transmitting message between base station and mobile station. For example cell information is identification information.

According to law network operators are not allowed to tell others anything about telecommunications identification information. The identification information can be used for marketing telecommunication services with the permission of the subscriber. Whether the location information can be used for other purposes is somewhat unclear, but the current opinion is that if the subscriber allows it, the information can be used. The legislation is controversial and it may need refining in the future. There is also one problem since the user and the subscriber might be different persons. The law concerning identification information says that the permission from the subscriber is needed for the usage of the information, but nothing is said about the actual user.

One potential problem in the legislation is that no law forces the mobile network operator to give away location information to third party service providers even if the subscriber has given the permission. This can make the competition difficult in the location aware services, since the operators can have a monopoly on the location aware service markets.

### **Personal information**

Finnish Personal Information Law [10] defines the *personal information* in a following way: "*Personal information means such description of the person, personal characteristics or living environment that can be identified to concern a certain natural private person, his family or the people living with him in the same household.*"

The location information can be considered to be personal information. However, the Personal Information Law is a general law, so the Law about Security and Privacy in Telecommunications takes precedence over that one in the case of identification information.

There are several points in the Person Register Law [9] that affect the usage of the location information. The collection of information must be planned and they must be handled carefully.

Chapter 4 Section 16 of Person Register Law : "*Personal information can be used only for the purposes that were defined before the collection of information.*"

According to Person Register Law Chapter 2 Section 5 "*companies can collect personal information about customers and employees*". The same section says also that "*only personal information that is necessary for the usage of the personal register can be collected*". Usually this does not give permission to the operators to use the location information unless some location aware services have been subscribed. It is clear that the customer relationship alone does not give a permission for the usage of location information.

Chapter 4 Section 18 of Person Register Law: "*Personal information must not be given away from the personal register without the permission of the individual, his order, because of some other law or in such circumstances that it can be thought to be part of the normal operation of the register holder to give away that information*". This section allows the usage of the location information if person permits it.

One thing worth noticing is that the Person Register Law only covers identifiable person. So for example anonymous person information is not protected by the Person Register Law. So if there is a way to collect location information anonymously, that can be done without the restriction of Personal Information Law.

The delivery of information from a person register for advertising, selling over phone or other direct marketing and address service purposes, is allowed if the registered person has not forbidden the usage and it is evident that the registered person knows of the delivery of personal information.

### **Push services**

All the location aware services can be divided to two types of services. Either the user has subscribed the service or it is provided to him without subscription. Especially different kind of pushed marketing services could be examples of the latter. Unsubscribed location aware services have one problem, they do not have the permission for location

information usage from the user. This is a problem, since the Security Law of Telecommunications forbids the usage of location information without permission. So the provision of unsubscribed services is illegal.

When the Person Information Law applies the situation is more complicated. Theoretically, it could be possible to use the location information without the users permission, on the basis of customer or service relationship. In reality, however, this is very unlikely because of restrictions on the purpose of the usage and necessity of the usage.

The Security Law of Telecommunications disallows the usage of telecommunications automatically for direct marketing purposes without the permission of the user. So the delivery of unsubscribed marketing messages is illegal even if the location information would be legally available.

### **Tracking**

Location information enables the tracking of, for example employees, children and old people. According to personal law there has to be good reason for such tracking. If the location information is identification information, permission from the subscriber is required. The tracking of employees is legal, if there are good reasons for doing so. So it is possible to track employees even without their permission in the many cases. In the future the legislation will be changed in the direction that the employer would have to ask permission from the employee or at least tell the employee that he is being tracked.

## **5.2 Proximity awareness**

In proximity awareness the personal devices exchange electronical visit cards or other personal information with each other. These actions can create a person register. These registers can be private or the register may be maintained by an operator. Legislatively these are separate cases.

Person Register Law Chapter 1 Section 1 says the following: *" This law does not concern the collection, recording or usage of personal information for personal or other purposes that are comparable to normal private usage."*

Clearly in the normal case, when the device can be thought to belong to an individual person the Person Register Law is not applicable, because of the above statement. However, what about the case when the PDA belongs to a company. In the normal case it can still be seen as personal but if the same PDA is shared by more than one people then the situation might be that Person Register Law applies. Also in the extreme case that PDAs are sharing person address books or other person registers the usage would not be private anymore.

The operator will also keep different kinds of registers, for example of the mobile phone users visiting the operator network. These registers are subject to Security and Privacy Law of Telecommunications.

## 6 Summary

Location awareness is a very interesting concept. It has enormous market potential with many applications beyond the current understanding. As we are on our way to a wireless information society, there is a need for location aware services. Location awareness can help us to deal with the ever increasing amount of data.

The techniques for providing the location information are available but there is still work to be done in the standardisation area. The lack of standards may slow down the location awareness, since many competing technologies may be deployed. The locating techniques also need to be improved to guarantee the precision and availability needed. At the moment the techniques used in the actual services are not precise enough. The introduction of mobile network based positioning services will be the main driver in the field of location aware computing, since the number of mobile subscribers is huge.

Solutions to the privacy issues of the location awareness are still unclear and affected by the legislation. Also the type of the service affects the privacy requirements, for example push and pull services have different kind of characteristics. The competition between the operators, service providers and other parties affects also the privacy issues. All of them want to be able to charge the customer by themselves.

Legislation has some problems in the case of the location information. It is not so clear which laws apply in every particular situation. The future will show how the laws will be applied and what new laws are required. Generally permission from the user is required for using the location information. There are also some things that might make the provision of location aware applications hard for service providers, like the thing that operators do not have to give location information to third party service providers. So clearly there are needs for some changes to be made to the legislation.

Location awareness and context awareness in general are areas which will affect the usability of the services and make them easier to use. They will change a lot the way we use the devices around us. When they will be available in large scale remains still as an open question.

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