2013

Multi-Dimensional-Personalization in mobile contexts

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http://hdl.handle.net/10026.1/1576

http://dx.doi.org/10.24382/3471
University of Plymouth

Multi-Dimensional-Personalization

in mobile contexts

by

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A thesis submitted to the Plymouth University

in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Computing and Mathematics

Faculty of Science and Technology

May 2012

II

Abstract

During the dot com era the word "personalisation” was a hot buzzword. With the fall of the dot com companies the topic has lost momentum. As the killer application for UMTS or the mobile internet has yet to be identified, the concept of Multi-Dimensional-Personalisation (MDP) could be a candidate.

Using this approach, a recommendation of mobile advertisement or marketing (i.e., recommendations or notifications), online content, as well as offline events, can be offered to the user based on their known interests and current location. Instead of having to request or pull this information, the new service concept would proactively provide the information and services – with the consequence that the right information or service could therefore be offered at the right place, at the right time.

The growing availability of "Location-based Services“ for mobile phones is a new target for the use of personalisation. "Location-based Services“ are information, for example, about restaurants, hotels or shopping malls with offers which are in close range / short distance to the user. The lack of acceptance for such services in the past is based on the fact that early implementations required the user to pull the information from the service provider. A more promising approach is to actively push information to the user. This information must be from interest to the user and has to reach the user at the right time and at the right place.

This raises new requirements on personalisation which will go far beyond present requirements. It will reach out from personalisation based only on the interest of the user. Besides the interest, the enhanced personalisation has to cover the location and movement patterns, the usage and the past, present and future schedule of the user. This new personalisation paradigm has to protect the user’s privacy so that an approach supporting anonymous recommendations through an extended "Chinese Wall“ will be described.

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Acknowledgements

Hereby I would like to thank my supervisor team:

- Prof. Dr. Steven M. Furnell (Director of Studies) for his patience, support in dealing with the administrative stuff, being a great discussion partner, constant support especially during the hard times I had and towards the end of the thesis write up.
- Prof. Dr. Udo Bleiman for getting me into this program and establishing the connection to Plymouth University, his support, setting my head straight when necessary, support during the difficult period of the program and his patience.
- Dr. A. Phippen for his support.

In addition I would like to thank the very supportive members of the Centre for Security, Communications and Network Research (CSCAN) and the administrative staff of the Plymouth University: Ms. Carole Watson and Lucy Cheetham.

I would also like to thank my fellow students from the Hochschule Darmstadt (Germany) like Dr. Ingo Stengel, Tillman Swinke, Dr. R. Löw and the other students of the PhD seminar in Germany.

Also I would like to thank my wife Hisano Matsumoto-Schilke, daughter Marina and my parents Helmut und Gerlinde Schilke for their patience and support.

Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

Relevant scientific seminars and conferences were regularly attended at which work was often presented and several papers prepared for publication.

Publications: are listed in the appendix “A.4 Conferences attended and Publications”: Relevant conferences and PhD supervision meetings, Trainings and PhD seminars have been regularly attended (at which work was frequently presented). The list of the conferences can be found in the appendix “A.4.1 Conferences attended”.

Word count of main body of thesis: approx. 67.054 (incl. all tables, figures and captions)

Signed

Date ……………1.5.2012……..……………..

Glossary of Abbreviations

A-GPS/AGPS	Assisted GPS
CF	Collaborative Filtering
CRUD	Create Read Update Delete
DB	Database
D-GPS/DGPS	Differential Global Positioning System
DMOZ	Directory MOZilla
DNC	Do Not Call (List)
ELBS/E911/E112	enhanced (emergency) LBS
FTC	Federal Trade Commission
Galileo	satellite based navigation system – a project from the European Union (EU) and European Space Agency (ESA)
GIS	Geographic (or Geographical) Information Science or System
GPS	Global Positioning System
GSM	Global System for Mobile Communications, originally Groupe Spécial Mobile
HEW	Department of Health, Education, and Welfare today called: United States Department of Health and Human Services (HHS)

HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IMAP	Internet message access protocol
IMEI	International Mobile Equipment Identity
IP	Internet Protocol
ISP	Internet Service Provider
JSON	JavaScript Object Notation
KML	Keyhole Markup Language
LBA	Location-Based-Advertisement
LBS	Location-Based Service
LBM	Location-Based-Marketing
MDP	Multi-Dimensional-Filtering
NGN	Next Generation Networking
OAuth	Open standard for Authorization
ODP	Open Directory Project
OECD	Organisation for Economic Co-operation and Development
POP3	Post Office Protocol version 3
RCR	ReCord Reason
REST	Representational state transfer
SIP	Session Initiation Protocol

SMTP	Simple Mail Transfer Protocol
SOAP	Simple Object Access Protocol
SPAM	unsolicited electronic messages
SPIM	instant messaging spam
SPOT	Single Point Of Trust
SSL	Secure Socket Layer
SQL	Structured Query Language
TCP	Transmission Control Protocol
UMTS	Universal Mobile Telecommunications System
VoIP	Voice over IP
WADL	Web Application Description Language
WLAN/WIFI	Wireless Local Area Network
WSDL	Web Services Description Language
XML	Extensible Markup Language

1 Introduction

This work introduces a next generation personalisation and recommendation approach which extends the approaches of most previous personalisation projects. Besides the personalisation efforts, the location of the user and a temporal component will be taken into account. These can be considered to be the main dimensions used or applied for this new personalisation approach – hence the name "Multi-Dimensional-Personalisation" (MDP) concept.

"Personalisation" was a hot term during the dot com era. In 1999, at a Gartner Group symposium, it was predicted that "… by 2003, nearly 85 per cent of global 1,000 Web sites will use some form of personalization (0.7% probability)" (Abrams et al. 1999). It seems that this prediction did not become fully true. Through the meltdown of the dot com companies, a lot of the hype faded. Nowadays personalisation is seen in a broader context known as an "Adaptive Interface". The first two levels of the adaptive interface (i.e., conceptual and semantic level) represent the personalisation (the other two levels are called syntactical and lexical – adapted from Foley et al. 1990). Another form of personalisation is defined as recommender or recommendation systems. These systems can be based on collaborative filtering (Goldberg et al., 1992; Resnick et al., 1994), Content-Based Filtering (Pazzani and Daniel Billsus, 1997; Balabanovic and Shoham, 1997) or a hybrid approach (combination of Content and Collaboration based Filtering, Balabanovic and Shoham, 1997; Claypool et al., 1999; Cotter and Smyth, 2000; Melville et al., 2002).

This introduction initially shows how the terms have been defined and used by other researchers. The relationship of the terms and samples of the application of these approaches are presented. It then presents how the new approach will be extended to allow the combination of dimensions, for example, of user interest, the location and the time (or time brackets) for recommending and presenting the right information or service proactively. The approach allows the offering of personalised views on information and services in the online world (e.g., web pages etc.) as well as the offline world, that is, the real world. Additionally, it allows a user to have specific sites by the service personalised and extends this approach to all participants (online offerings as well as offline, real world offerings). One of the key issues is to organise information in a way that a system can use to support the user and pass a selection / recommendation to the user, depending on the active user model / personality.

Personalisation supports users by giving them access to information which matches their (actual) interest. It filters large amounts of information and returns a view on the information which matches the user's preferences. This thesis introduces a next generation personalisation approach which goes beyond the approaches of earlier personalisation projects. Besides the personalisation efforts (usually only based on the users interest), the location of the user and a temporal component will be taken into account. The approach shall enable the user and the application to span a bridge between the online and the offline world. The MDP concept can be applied in various approaches from a location based personalized recommendation engine based on search results to a mobile marketing system where the recommendations or notifications are delivered by information providers or advertisers. For this work the latter approach was chosen.

Abowd and Mynatt (2000) wrote that "Most context-aware systems still do not incorporate knowledge about time, history (recent or long past), other people than the user, as well as many other pieces of information often available in our environment“ (sic). By adding knowledge of the future plans of the user, for example, by using information from the users schedule the Multi-Dimensional-Personalisation (MDP) approach will be able to provide even more than this. In order to provide the user with recommendations which match his interests coupled with his location and the right timing, a new scheme has to be established. As there are a lot of privacy and security or trust issues involved, the user as well as the provider of the recommendation have to be provided with a solution for this problem. This is supported by Askwith who wrote that "… users are concerned about the commercial misuse of their personal data for marketing (and possibly other) means. In many situations, therefore, the entire behaviour of a user may be considered private. For mobile environments we can identify four types of sensitive user information: message content, identity, location and actions (e.g. connection to services)” (Askwith et al, 2000). These four types of user information are sensitive because they would allow a third party to take advantage of the user, for example, by knowing the location and the identity so that the user could be tracked down. Another example is that, based on the message content or the actions of the user such a service could be misused for unwanted targeted advertisement.

1.1. Objectives and aims of the Research

In 2002 and 2003 the idea came up to enhance the, at that time available, Location Based Services (LBS) which have been still in its infancy in Germany (and have been ever since that time). Instead of having to ask (or pull) information from a service provider (at that time always the mobile phone service provider) and additionally also provide the question what the user was looking for (e.g., a Cab or Pizza) the idea was to provide the user proactively with the information when and where he would want (or needs) it. In the keynote speeches by Bill Gates called ”Information at Your Fingertips” (at COMDEX 1990) and ”Information at Your Fingertips - 2005” (at COMDEX 1994) where he said "that all the data typically needed in business, school or any endeavour should be instantly accessible from a desktop personal computer” (1990) or "any piece of information you want should be available to you” the research idea extends this idea from the online world or desktop to the real world, .which means, that any piece of information you want (or need at that moment in time) should be available to you where and when you want it.

When smart phones have been introduced into the market the capabilities of these mobile devices extended from "just phones” to portable computers with many features like mobile internet connection, for example, via UMTS (Universal Mobile Telecommunications System) and the possibility to retrieve a location via GPS (Global

Positioning System). These devices could be extended by programming applications for them which extended the functionalities. As the devices had a rather small CPU and memory not all processing for such advanced LBS services could be performed on the mobile device so the research idea focused on using the mobile device as client and a server system to process the data collected by the device and entered by the user and return proactively personalised information at time and place when the user would need it. In order to do so a concept was proposed which should provide all the necessary building blocks to provide such advanced proactive services. After some initial discussions a concept was developed, published and presented (Schilke SW, 2003; Schilke et al., 2004). The concept defined the different building blocks necessary to describe or implement such a system. Besides the idea of using multiple dimensions for this type of personalisation a structure for system which preserves the privacy of the users but is able to deliver recommendations to them when and where needed. The idea was during the research phase extended to a scenario for mobile marketing / mobile advertisement. By doing so, the concept needs to take into account that information providers or advertisers need the possibility to select a potential target audience without exposing the user's data to them. On the contrary the user needs full control over the data collected and information provided to them. This includes a way of giving feedback or reporting spam. To summarise the research objectives:

1. Describe a concept which allows the personalised interest and location based proactive delivery of information (at the right place and time).

2. Depict a system architecture which takes security and privacy requirements into account for the communication between the involved parties user, mobile client device, server system and information provider / advertiser.

3. Evaluate the concept and its components by using mock ups / sample application and experiments to be able to collect the necessary data and

experience to form an opinion of the system could be used in a real world implementation.

4. To define a model for MDP which shall provide data protection / security and privacy by design to win the trust of the users.

5. To evaluate the MDP concept with end users and experts to get feedback about the proposed solution.

The aim of the research is to describe a concept, architectural proposal and service design for a new and unique location based personalisation system which takes various dimensions like time, location interest etc. into account to provide a good user experience and gives the user the possibility to control his data which is guarded and protected data protection wise by the system. These dimensions allow such a system to provide personalized (interest) location based recommendations and notifications to a user just at the right time. Depending on the application other dimensions could be added. For example in an e-learning scenario the chosen degree program, progress of studies or language preferences could be taken as dimensions.

1.2. Thesis Structure

The thesis is structured as follows:

- Chapter 2: Presents a review of the related literature and research works – divided into subsections covering the different topics. Based on this review the next chapters will take a deeper look into the different topics related to this work.
- Chapter 3: Provides a description of the movement patterns, GPS trajectories recordings and discussion of the findings. The information will be used to

describe the basic idea of the concept and leads to the questions which will be used in an end user survey.

- Chapter 4: Describes the end user survey which was conducted and the results of the survey are discussed. These results are used as the groundwork which will help to define the concept in next chapter.
- Chapter 5: Presents the MDP (Multi-Dimensional-Personalisation) concept and discusses the concept. The concept will then be extended to an architectural proposal (i.e., service design).
- Chapter 6: Defines the architectural proposal, that are the requirements for an implementation of the concept is outlined in the form of a service design. As the requirements build on the initial idea and as the end users survey results are used in the concept a validation based on the opinion of experts will be used.
- Chapter 7: In order to validate the MDP concept, its acceptance and its feasibility an expert questionnaire was developed and distributed. The results are presented and discussed. This chapter will be used as to prove that the concept and architectural proposal respectively the service design of MDP is vaild and could be used in a real world scenario. The results will be presented in the next chapter.
- Chapter 8: A summary of the work with the conclusions, the achievements, the limitations of the research and identified areas for further research.
- Chapter 9: References
- Chapter A: Appendices

2 Contemporary technologies for LBS personalisation

The idea for Multi-Dimensional-Personalisation (MDP) was presented to the University of Plymouth with the strong feeling that this concept could be not only a unique and new application for smartphones but also it would be a contribution to the knowledge in this specific area of science. Especially as it is a work spans several areas of the sciences and it is not only limited to computer science. The unique combination of different dimensions extends the existing approaches while preserving the privacy of user. In addition the user deals only with one system which acts as the middleman and protects the user from exposing his data to multiple parties.

The thesis covers a new and unique concept for Location Based Personalised Services and builds up on various concepts and technologies from different domains in science. The field covered by the MDP literature and related works research covers, for example, city planning, geographical information sciences, mobile commerce and mobile marketing or advertisement, location based services, personalisation, security, trust, privacy, user acceptance, marketing.

One factor is touched but not fully covered which is to build a valid business model for such a service as it has not been seen as a topic for this type of research work. In addition there is no blueprint defined for a real world implementation. This work defines the concept, its functionalities and requirements which have to be taken into account for implementing MDP in the real world.

The following sections will cover the different aspects by referring to the literature and related research projects.

2.1 User location and recommendation services

This section covers issues like Location Based Services (LBS), location- /context-aware systems, GPS, Mobile systems, Mobile Marketing or advertisement, and ubiquitous computing.

As a basis for all the proposed MDP services the location of the user (or its mobile device) has to be acquired. Available technologies for acquiring a location are, for example, Cell-ID, Round Trip Time, Observed Time Difference, and Satellite (GPS). In the Europe Community there are plans to establish another satellite based location / positioning system by a European project call Galileo but at the time of writing this work nothing was implemented yet.

Mountain and Raper, 2000 define that smartphones or "Mobile devices are generally owned by a single individual allowing personalisation of the information sent to mobile users”. Smutkupt et al. (2010) writes that "Due to the fact that the mobile phone is portable and is switched on most of the time, mobile advertising is likely to reach the target audience almost all the time, without restrictions pertaining to time and place. This feature seems to be most beneficial to time- or location-sensitive information such as news alerts, promotional coupon updates, and traffic reports“. The work of Okazaki and Taylor (2008) supports the claim made by Smutkupt et al. (2010).

Unni and Harmon (2007) define mobile location-based advertising (LBA) as a new form of marketing communication that uses location-tracking technology in mobile networks to target consumers with location-specific advertising on their cell phones. Their definition of LBA is that it is a combination of location-based marketing (LBM). Their idea is that LBM activities include all aspects of the marketing mix of the mobile location approach. In their paper LBA is described as a concept mainly focusing on the more advertising related strategy and communications (Unni and Harmon (2007)).

Even if GPS has some shortcomings (like reception loss or problems in buildings or underground) this can be compensated by the MDP system. Hightower and Borriello (2001) stated in their survey of location systems that GPS (Global Positioning System) is the most widely known location system in use. In their survey they describe GPS as an excellent lateration framework to determine the geographic location of an object. As mentioned above they identify that one drawback is the problems to receive a signal from the GPS satellites indoors. About the quality of the location or position acquired from the GPS they describe that GPS receivers can determine a location of an object with 95 per cent in a 10 meters range and by using a differential GPS receiver the precision could increase to a 1-3 meter rage for 99 per cent of all location information acquired (Hightower and Borriello, 2001b). Brimicombe and Li (2006) describe another shortcoming that not only indoors but also in other areas where the direct sight to satellites is blocked (like (underground) car parks, tunnels, between Skyscrapers …) the reception quality degrades and delivers poor or no results at all.

Bajaj et al. (2002) wrote that the satellite-based Global Positioning System (GPS, initiated in 1978 by the US Department of Defence) has become like the standard for locating a position. In their paper they describe that using GPS trilateration the GPS device evaluates the signal from three satellites to get a precise position. This can be supported by using advanced methods like DGPS (Differential GPS) or for, for example, indoors with AGPS (Assisted GPS) by supporting acquiring a position by using an infrastructure like cellular, Bluetooth based, or wireless local-area network in order to get a "known“ position information to support the calculation of the actual position of the mobile device.

By using a GPS receiver which receives data from the GPS satellites such as date, time, latitude and longitude the application on the smartphone can use this information. Additionally the GPS receiver can provide information like altitude, heading, No. of Satellites, Status of the received data which can help to determine, for example, the route the user is following. Especially the heading or direction could support the MDP systems prediction of the route the user might use. Dibdin's (2001) definition for the absolute location is that it presents a unique reference on a grid which is described by the latitude, the longitude, and the altitude of the location. In addition, If you consider moving objects, the direction complements the absolute location.

2.1.1 Location Based Services, Marketing and Advertisement

Paavilainen (2002) described that there are two main mechanisms for LBA as well as LBS which are pull and push. The pull modus is requiring an interaction from the (mobile) user to request certain information for a certain location (e.g., his actual position acquired by a GPS module from the mobile phone). The push modus is a more proactive way where a system delivers information for the actual location or a location which is ahead on the trip of the user which should match the preferences set by the user. There is a perceived danger of "too may“ or "Not wanted“ push messages. Therefore it has to be possible to tailor the user setting preferences and use a feedback loop to optimise the push style delivery.

Based on the know location of a mobile user, for example a user of a smartphone equipped with GPS capabilities, such a system could provide services at or around this location. There are several definitions what Location Based Services (LBS) are:

- Services are accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the terminals (i.e., mobile device). A major part of the future Mobile Internet services is expected to be LBSs (Virrantaus et al., 2001)
- A wireless-IP service that uses geographic information to serve a mobile user. Any application service that exploits the position of a mobile terminal.
- geographically-oriented data and information services to users across mobile telecommunication networks (Shiode et al., 2004)
- any services or applications that extend spatial information processing, or GIS capabilities, to end users via the Internet and/or wireless network” (Koeppel, 2000)
- services that integrate a mobile device’s position with other information so as to provide added value to a user (Schiller and Voisard, 2004)
- the delivery of data and information services where the content of those services are tailored to the current or some projected location (and context) of the user (Brimicombe and Li, 2006 & 2009)

For Brimicombe and Li (2006) the key issue is that not only the current or predicted position of the mobile user using a LBS service is known but also the location is needed for the customised delivery of the services expected by the user.

Hendrey (2001) describes three Generations of LBS:

- First generation: The user has to enter a location he wants information (pull)
- Second Generation: The user still has to request or pull information but the mobile device provides some sort of location information
- Third generation: This approach has more precise location information and can react on triggers to automatically provide information or proactively initiate services around the location of the user

The study results of Paavilainen (2002) favour a pull approach over the push approach. In their opinion a push approach supports more the type of users which actively choose to be informed by such a service and have provided information about their interests. Another result of their study is that the LBA service was portrayed as being offered by the cell phone operator. The trust (relationship) in the operator had a positive effect on perceived benefits of LBA. This suggests that claims about LBA benefits are likely to be credible from trusted service providers (and marketers).

Wehmeyer (2003) wrote that their assumptions that time, location, and task involvement are relevant for the effectiveness of (mobile) advertisement have been supported from the literature they reviewed. But that a user is less likely to feel disturbed by (mobile) advertisement in case he is less active instead of during times with higher activities.

For his claim Wehmeyer also refers to Barnes and Scornavacca (2004); Drossos and Giaglis (2004) and Li et al. (2002) which are supporting these results.

2.1.2 Context- and Location-aware

For Day (2001) the term context is characterised by the information's which describe the situation of an object or person with its surroundings and the interaction between them. This includes also the mobile phone and the application used at this point in time.

Context-aware systems are similar to Location Based Services some definitions are:

- Schilit and Theimer (1994) defined that context aware software is adapting to the surroundings of its use and nearby objects and the changes in the surroundings over time.
- Marmasse (1999) describes their understanding of a context-aware system that based on longitude and latitude coordinates the system learns and analyses data based on the behaviour of the user to identify frequent locations (frequent and longer stays) such as "work" or "home". By doing so there is no interaction with the user necessary besides that their system comMotion is requesting the user to name such spots identified.
- Harter et al. (1999) definition is that a context-aware system needs to know about the (mobile) device of the user and its capabilities (e.g., network infrastructure) besides the location in order to adapt to the changing environment the user is moving around.
- Abowd et al (1999) defines context it as information which can characterise the situation a user is interacting with its surroundings and the mobile device, respectively the application running on it. The situation can be described by parameters like location, identity, time, and activity. By using this information a context-aware system is able to provide relevant services and information to the user which matches the actual context.
- Abowd and Mynatt (2000) extend this definition to Ubicomp (ubiquitous computing) for applications which are not only context-aware but include information from the physical and computational environment of the user. Additionally they suggest that

such a system should extend the use of such data to time, history (short and longer past of the user) and other information relevant to the user and its environment. As a minimal set of variables for the context they define five W's: Who, What, Where, When, Why.

- A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task (Day, 2001). It has to be mentioned that this definition could be extend from user's tasks to user's interests as well.
- Pirttikangas et al. (2004) defines a routine as a temporal sequence in context which occurs frequently. Such a routine can consist of similar actions. In order to identify or learn such routines it is important to observe the historical context of the routines. Staying in place frequently for a longer period of time allows identifying it as an important place. These places can then be requested to be named by the users (similar approach as Marmasse (1999)).
- Riekki, J. et al. (2005) defines context aware system as systems or architecture that supports building context-aware applications for mobile users. In order to achieve this, the system has to learn locations based on phone profiles based on the context of calendar events and location.
- Lee et al. (2011) describe an ideal context-aware system as pro-active. The user would not have to request information or services as the system would provide the user with appropriate context matching services or information.

All these descriptions and definitions describe context-aware systems as systems taking the environment of the (mobile) user into account. Such systems take into account frequently visited places, the interaction of the user, the situation of the user and its device to allow a system to deliver context relevant services and information. This lower level context can be extended by incorporating other identifiers related to the user. Such another context for a user can be the higher level activities a user is engaged in. Farrahi and Gatica-Perez (2008) analysed real-life data from the "Reality

Mining” dataset with a probabilistic topic model and they could identify location-driven and proximity-driven routines in an unsupervised manner. The topics they could identify "topics meaningfully characterize some of "... the underlying co-occurrence structure of the activities in the dataset, including "going to work early/late”, "being home all day”, "working constantly”, "working sporadically” and "meeting at lunch time”.

An interesting fact was discovered by (Levinson and Kumar, 1995): chaining trips became more common during the study period, as individuals tried to accomplish more activities in less time and avoid adding trips. The peak also spread; with rising mobility, non-work trips are undertaken earlier in the day, often on the journey to or from work.

Their algorithm BeaconPrint (Hightower et al. (2005)) evaluates trace logs recorded by users (e.g., 24/7 GPS traces, 802.11 connections logs and GSM radio response-rate fingerprints). By using these log information the algorithm is capable to learn and recognise frequently visited places a user has been during the time the logs have been recorded. The result is 90% accuracy in recognising these recurring places. .

But also the other algorithms they compare their algorithm to (Ashbrook and Starner’s (2003) GPS Dropout plus Hierarchical Clustering Algorithm (A&S), Marmasse and Schmandt's (2000) comMotion Recurring GPS Dropout Algorithm and, Kang et al.’s (2004) Sensor-Agnostic Temporal Point Clustering Algorithm (KSAC)) are delivering results (depending on the trace logs) which are above 65%. It is notable that the A&S algorithm performed on one trace log dataset rather poor (25+ %). One of the dependencies for the algorithm to provide good results was the staying time at this place.

Location awareness, as defined by Schmidt et al. (1999) is a special type of context-awareness. The term "context” is used to encompass the entire characteristics of an individual’s physical condition, social environment, information about the user, the user's tasks, location and physical environment. Location awareness concerns the use of information about an individual's current location to provide more relevant information and services to that individual (Worboys and Duckham, 2004).

In a survey by Kaasinen (2003) the research is based on a pull location aware scenario or an existing pull based LBS services but raises the question about push services as well. One example for a push LBS service is about location-aware spam. Some interesting results of this study are:

- Users are open to get information pushed to them as long as they get something valuable for them in their situation or context.
- Yunger users have a positive attitude to receive location- / context-aware advertisement as long as they can select what, from whom and when they receive it.
- Even if a user is positive towards such services this can change quickly if they feel they receive too much and not wanted information.
- An important issue is that the location alone does not provide benefit for push delivery of information. The user needs or better wants a personalised and not excessive delivery of interesting, useful and timely information or services.
- Another point made clear that the information has to be delivered ahead of time so that the can actually use the information when the user is at the location.
- The trust and faith of the user into such a system should not be recklessly sacrificed. It should be transparent to the user which data is collected and what happens with it. Once the user is lost because of his trust in the system and that his data is protected was shattered it is hard to regain his trust.

2.1.3 Location, Places, Routes, Control and Prediction

Systems move from GPS coordinates, which means, a location, to places with a meaning (regardless if the meaning is only for one user "home“ or many users like "Shopping Centre“) or context. Kang et al. (2004) provides a number of statements which describe this area quite well:

- A place can be defined as a location to the user which has a level of importance and meaning to him. Examples are ”my place of work”, "the place we live”, or "my favourite lunch spot".
- Coordinates acquired can be mapped to places by association coordinates with a meaning. The company building, which is the work place for a user can be defined by square described by coordinates. If the user location is within this square he can be considered to be at work.
- Frequently visited locations translate to significant places. They appear as clusters of coordinates in location trajectories.

Kang et al. (2004) describes an algorithm which is using clusters of frequently visited location coordinates to identify places which have significance to the user (because of the frequent visits or long stays there).

The results delivered show a high precision in detecting such places when compared to the logs taken by the user. The algorithm uses location coordinates and the time they have been acquired to build clusters and ignores distortion coordinates (e.g., go outside the building for a smoke) to be able to build the clusters around a certain defined close area with some meaning for the user (ibid.).

The results of their experiments shows that it is not only possible for their algorithm to extract frequently visited places with a significances for the user but also deliver a good performance to recall these places on returning visits with few false recognitions. Another result of their studies is that they think they can improve the performance of the algorithm by using better GPS devices and might add additional contextual data from the device used (ibid.)

Liao et al. (2005) used Relational Markov Networks (RMM), machine learning and labelled place data to automatically determine which of the recorded places the home of the participants of the experiment is. Their system delivered very good classification accuracy (Error rate 7%) in finding the home and work locations of their subjects. They also tested a HMM (Hidden Markov Model) with their data which was out-performed by the RMM.

In Kand et al. (2004) work the direction for future work in this field is identified that the destination of the user shall be determined by using not only the current location of the user but also the history of the movements of the user. By using not only the coordinates but also the time (bracket) and day or days of the visit to a place the destination of the user can be more precisely predicted and the user can be proactively provided with assistance.

In an assessment Wiehe et al. (2008) used GPS equipped mobile phones to track travel patterns and the daily schedule of adult users and found it very feasible not only to track very precise the user's locations but also to extract information from the recorded schedules. The participants stated that the recordings did not influence their normal behaviour. As a result they concluded that mobile phones with GPS offer not only a feasible but also ideal method to track travel patterns and locations of user's..

An algorithm developed in the research project of Liao et al. (2007) was able learn daily transportation routes by a user based on GPS track recordings, predict these routes and could discover places of importance to the user (e.g., frequency of visit).

Patterson et al. (2003) is adding meaning to GPS tracks by using real-world knowledge like bus schedules and stop locations, together with acceleration and speed to deduce "mobile places“ (which are e.g., bus, car), as well as parking lot locations and bus stops where users change mode of transportation.

Similar to Liao (2004) Montoliu and Gatica-Perez (2010) use user location points which are clustered using a time-based clustering technique which discovers stay points while dealing with missing location data. As second step they perform clustering on the discovered stay points to obtain stay regions.

The algorithm used by Montoliu and Gatica-Perez (2010) could provide location data for approximately 63 per cent of a day (of a real life user). These results are very promising to support the proposed concept by providing the necessary data about significant places of the users.

Mountain (2005) writes in his PhD thesis that automated techniques which help to identify the area where a mobile user is at the moment or will be at a given time without the needs of a user to interact with their device while on the move is important. This geographic context can be filtered depending on the situation in different ways for example depending on the distance from the actual location (spatial proximity), depending on the time needed to travel to that region (temporal proximity), the prediction of the location the user is heading to or other means.

In their study (Do et al., 2011) they used multiple sensors from the phones (i.e., GPS, GSM, Wi-Fi, Bluetooth, and accelerometer) to identify semantic places and physical proximity of the user and his phone.

They also found that phone usage depends on the "where“ a person is and on the social context of the person.

From the recorded GPS data they extracted stay points which are time stamped, small circular regions in which user stays for at least 10 minutes. The stay points have been clustered into meaningful places (of a maximum size of 250m) by using an algorithm (grid clustering) proposed in Montoliu and Gatica-Perez (2010).

Their results showed that a typical mobile user is visiting the most frequently five of the eight places / locations across the entire experiment period. Frequently visited places like the user’s home and office typically ended up on the top five list. The presented the places discovered to the users and asked them to label them. One of the results has been that people stay at home twice the time they stay at their workplace (without counting the time from 0:00-6:00 am at night). Another result of this experiment was that at the places Home, Work, Friend-Home, Other 96.7% of all location-detected phone usage have happened. They conclude that "the fact that contextual factors were indeed found to affect the use of the phone is a relevant finding“ and they state that there is "... the regularity of daily life“.

Hoh et al.(2006) used a database of week-long GPS traces from 239 drivers in the Detroit, MI, US area. Examining a subset of 65 drivers, their home-finding algorithm was able to find plausible home locations of about 85% of these drivers, although the authors did not know the actual locations of the drivers’ homes.

Choujaa and Dulay (2010) stated that the mobile phone is a unique way to allow the automated prediction of a mobile user's behaviour to offer ubiquitous services. Their approach used an information theoretic approach to quantify if it is difficult to predict the activities of a mobile user when his activities at selected points in time are known.

In their research they (Choujaa and Dulay, 2010) used these categories: at home, at work, at some other location or receiving no signal. By applying Shannon’s conditional entropy they tried to determine the points in time which could be used to predict the user's activities at other points in time. This was also evaluated by checking which points in time from the users activities history can be used for a precise prediction of the user's future activities. They could show that by reducing the uncertainty by using historic points in time of the user's activities it was possible to predict the future activities of the user up to three weeks in the future successfully. A dependency of the user's activity from another user's activity could also be inferred from their experiments.

Location prediction has already been researched and used in the area of wireless cellular networks, some examples are:

Location Prediction used for	Researched by
performance enhancements and mobility management	Liu and Maguire Jr., 1996
improved assignment of cells to location areas	Das and Sen, 1999
more efficient paging	Bhattacharya and Das, 2002
call admission control	Yu and Leung, 2002
802.11-based indoor localization	Park et al., 2010
real time location system for low-rate wireless personal area networks	Son et al., 2010
location tracking system(LTS) for low-rate wireless personal area networks	Cho et al., 2008
sub-cell movement detection method for mobile networks	Heszberger at al., 2011

Table 1 Applications use of location prediction

Location prediction was researched for other means already (Table 1 Applications use of location prediction). The research was extended towards the prediction of the movement of mobile user’s. Choi and Hebert (2006) used an approach to predict the future movement's based on the past movement history. Their approach is capable of learning movement patterns in an open environment, which was one of the limitations in some prior works. Their approach uses the similarities of short-term movement behaviour's by modelling a trajectory as chain of these short segments. They assume that these short segments are noisy realizations of latent segments and that the transitions between these latent segments follow a Markov model.

Choi and Hebert (2006) could forecast a bus movement by using a second-order Markov model and make a prediction with an error less than 4.5 meters in 90% of times by doing a three-second look-ahead.

In an experiment by Bao and Intille (2004) the participants wore five small biaxial accelerometers. Their results showed that everyday activities could be recognised with an overall accuracy rate of 84% (using Decision tree classifiers). By using the sensors available to modern mobile / smart phones It should be possible to achieve similar results. Their experiments showed that it is possible to classify user action's like walking, running, climbing stairs, standing still, sitting, lying down, working on a computer, bicycling, and vacuuming with accuracy rates of between 80% to 95%.

In the work of Sohn et al. (2006) they found that GSM data from unmodified GSM mobile phones can be used to recognize high-level properties of a user's mobility mode. They could recognize mobility modes among, for example, walking, driving, stationary, and where yielding an overall average accuracy of 85%. Their approach is using a given "... series of GSM observations with a stable set of towers and signal strengths, we conclude that the phone is not moving. Similarly, we interpret changes in the set of nearby towers and signal strengths as indicative of motion“ (ibid.).

Liao et al. (2007) are using a hierarchical Markov model which can learn and extrapolate the daily movements of a user. By using multiple abstraction levels they are able to enrich pure GPS coordinates with higher level information like the user’s destination and mode of transportation. Their system is using unsupervised learning from raw GPS data to create a probabilistic model of a user’s daily movement patterns by using a Rao–Blackwellized particle filters at multiple levels of their model hierarchy. They were able to detect new behaviour of the user or errors a user made, for example by taking the wrong bus by modelling the user's activities in a context with historic (recurring, regular) behaviour data. The transportation mode (in their model: bus, foot, car, and Building), location, and velocity is identified in their system from the GPS sensor measurements. The movement of a user between a start location and the end location is expressed by trip with a certain route and the transportation mode used. The route is expressed in their model as transition probabilities which allow them to predict the person's choice of route when reacing an intersection. Their model also allows detecting "wrong“ or novel behaviour of the user. After 25% of the trip of the user the system could determine the goal with 75% accuracy. This went up to 82% when half of the trip was over reaching 98% accuracy after 75% of the trip was over.

Zheng et al. (2008) found that it is possible to extract usable information from raw GPS data collected from a user and use this contextual data for mobile and geo-oriented applications. The raw GPS data can be used to extract information about the user like it's transportation mode (e.g., walking, driving) and helps to understand the context a user is at a given point in time. They base their approach on supervised learning to extrapolate the transportation mode of the user from the collected raw GPS data. Their approach consists of three parts:

1. a change point-based segmentation method
2. an inference model
3. a post-processing algorithm based on conditional probability.

In their study they evaluated these algorithms:

- Decision Tree
- Bayesian Net
- Support Vector Machine (SVM)
- Conditional Random Field (CRF)

They started with four classes (called Bike, Bus, Car and Walk) and later reduced it to only two classes "Walk Segments” and "non-Walk Segments”. If the Decision Tree algorithm is used in their approach almost 90 per cent of the actual change points (e.g., from Walk to Bus) can be identified from corresponding GPS data. Some other experiments showed that detecting if the user of a mobile device is sitting or walking was proven possible (Mäntyjärvi et al., 2001).

Reddy et al. (2010) focused on the transportation mode context of a mobile user when moving in the real world. With their transportation mode classification system they differentiated between stationary, walking, running, biking, or in motorized transport based on GPS data and acceleration data collected from the user's mobile phones. They use a classification system build upon chain of a decision tree followed by a first-order discrete Hidden Markov Model. The classification system is 93.6% accurate in the identification of the transportation mode.

Espinoza et al., (2001) describe a LBS system called GeoNotes – it allows to put virtual annotations at real world places via their system. Their theory about the usage of mobile systems can be described as follows:

A mobile user can be expected to be more leisure oriented. Depending on their location there are less issues a user has to devoted their attention too and there might be less no no needs to adhere to deadlines. Been outside a mobile user might be interested in the social geographical surroundings he is in and might be curios to explore new and interesting things for his entertainment. In their opinion a push based information / notification systems seems to be more suited for leisure time. This mobile scenario opens a new world for information technology usage while on the road or outside which is different from traditional desk bound computers and the way they are used.

They raise several questions and describe different problems about these scenarios, for example how such a system can support a user when there are 5.000 (mobile) annotations at place to find out (filter) which ones are important for the user. An important issue for them is the question to find a balance between pushing data / information about the user's surroundings to the user's mobile device and how the can avoid that the user is or feels disturbed. There is a trade-off between being overwhelmed and just the right amount and right information.

The result of their research Espinoza et al., (2001) concludes that one important success factor for a mobile information system is the capability to allow filtering information which is unimportant to the user. In addition their findings are that a user must be able to flag notes or even senders so that this information will be no longer be pushed to them.

The experimental results from Gidofalvi et al. (2007) show that on the one side there is a large mobile marketing potential (LBA) but in their opinion there is a danger to deluge a mobile user with too much information. Their recommendation is to allow users to control which information (or ads) are delivered to them when and to limit the number of information provided.

2.1.4 LBS SPAM

Fuller (2005) defines spam as "… what the consumer perceives as an unwanted or unsolicited marketing". In his definition marketing material can relatively easy become SPAM as soon as the consumer sees it as unwanted. His key factors that contribute to marketing becoming unwanted are:

- Frequency: When a customer opts-in to receive information, it is not carte blanche to hit them up for anything at any time—regardless of what the attorney down the hall wrote in the legal fine print. It's also necessary to consider how the message will be considered in light of all the other messaged a consumer receives daily. Less is more; just because you can market to them, doesn't mean you should.
- Relevance: A Cross-promotional programs can be acceptable as long as the promoted goods or services are relevant to the user and its context.
- Control: If the Consumers no longer have control over, for example, their e-mail. If hundreds of marketers target a user how can it be expected that the consumers a willing to opt-out to every site they visited? And would that work if they could opt-out for every site? The answer to both questions is no regarding to Fuller (2005).
- Confidentiality: the information of a user which opt's-in should not be shared to partners.
- Unsolicited: A Consumer may perceive messages or sources of messages they did not directly opt-in (like "partner" marketing) as unsolicited.

In his work Fuller (2005) is defining a Code of Conduct in privacy is broken into these Six C's:

- Choice: mobile marketing is acceptable only to consumers that opt-in to receive it.
- Control: consumers who opt-in must have any easy way to opt-out of all mobile marketing.
- Constraint: consumers should be able to set limitations on messages received.
- Customization: analytical segmentation tools will help advertisers optimize message volume, ROI and relevancy to the consumer.
- Consideration: consumers must perceive value in any mobile marketing campaign.
- Confidentiality: Privacy policies must be aligned between the carrier and the brand.

Another interesting fact presented by Fuller (2005) in this is that 65 per cent of US consumers were willing to give personally identifiable information in exchange for relevant mobile marketing. This is supporting the fact that mobile users, if treated right, are willing to use personalised mobile marketing, advertisement or recommendations if they are treated right and have a benefit from it.

As it is similar to spam another interesting fact is that in the USA 58 Million phone numbers in 2004 and 209 million in 2011 have been registered in a Do Not Call (DNC) registry / database which is used to allow telemarketers to clean up their call lists every 31 days. (FTC, 2004 & 2011) This shows that people do not want unwanted advertisement calls on their telephones.

These results and definitions from the literature and research works mentioned give a valuable input for the MDP concept. The filter is applied on the MDP server side based on the interest and location of the user and on the client side by giving feedback on the received recommendations to the system and blocking unwanted recommendations or notifications (or their sources) and marking them as spam if necessary.

2.1.5 Daily routine and movement of users

Based on the location or position of the mobile user, the MDP server can collect this information in order to allow the prediction of frequently visited locations and paths or routes taken between these locations.

Marmasse & Schmandt (2001) described that users living there daily routines a system could learn their travel patterns and frequent visited locations by using the GPS trajectories of this user. If a user is visiting a location frequently this location must have a special role in his life. In the same paper they refer to their own earlier works which supports the claim that for the MDP system a loss of the GPS signal could be used to identify buildings a user is staying. They conclude that if GPS tracks end (i.e. the signal is lost) and begin again in a certain area and the users "stays" within that area for a certain time that this area could be seen as a building in which the user has no reception of the GPS signal and therefore cannot update his position. The goal of their research was to predict where the user is heading and estimate the arrival time to the destination by evaluating different algorithms for pattern recognition and analysis of the collected data. By classifying the data they predicted on which (regular) route the user was. In their experiments they used and evaluated three different techniques (Bayes Classifier, Histogram Modelling and Hidden Markov Model). In the case of their research the histogram modelling has delivered the best results for the detection which route was used and to predict the arrival time quite good. Hoh et al. (2006) was using a k-means clustering algorithm on the data collected in their experiment their home identification algorithm could correctly identify approximately 85 per cent of the homes of the participants in the experiment. It has to be mentioned that their algorithm returned a large number of false positives. Bhattacharya and Das (2002) explain in their paper that:

> "The movement history of a user is deterministic, but a matter of the past. The mobility model, on the other hand, is probabilistic and extends to the future. The tacit assumption is that a user's movement is merely a reflection of the patterns of his/her life, and those can be learned over time in either off-line or online mode. Specifically, the patterns in the movement history correspond to the user's favourite routes and habitual duration of stay. The essence of learning lies in extracting those patterns from history and storing them in the form of knowledge. Learning aids in decision making when reappearance of those patterns are detected. In other words, learning works because "history repeats itself". Characterization of mobility model as a probabilistic sequence suggests that it can be defined as a stochastic process, while the repetitive nature of identifiable patterns adds stationary as an essential property."

This statement is a key point of the basis for the MDP concept. If all users would just be roaming around randomly a personalised location based recommendation service matching the context and interests of the user would not be possible. A similar statement supporting this is that "the past is the key to understanding the future" (Longley et al., 2005) for such services.

In their research Song et al. (2004) used an Order-2 Markov predictor with fall back for location prediction functionality. They concluded that this implementation delivered the best results with a median accuracy of about 72% for mobile user's by using long trace lengths. Another result of their research was that these systems need a certain amount of historic trace data in order to be able to initialize the probability tables of the algorithm to provide good results. In the case of new traces (e.g., a traffic diversion), which have not been recorded in the past historic traces, the probability of the results drop. Their algorithm used a fall back strategy to shorten the used traces / context for the prediction to be able make valid prediction with a better accuracy. f

Another research project by Sohn et al. (2006) showed that it is also possible to determine the transportation mode by using GSM phones and their traces. Sohn et al.

(2006) could distinguish the transportation mode (walking, driving, or stationary) of a person with an 85% accuracy. The overall accuracy was 85% whereas the experiments delivered for precision values between 70.2% and 95.4% for an outcome with the right prediction. Among the three mobility modes stationary, walking, or driving the walking mode delivered the most false positives (precision 70.2%). This seems to have based on the difficulty to distinguish between slow driving and walking. For the MDP concept this will allow to determine, for example, if the notification or recommendation has to be send ahead of time and location because the user is driving in a car. A similar result is presented by Krumm and Horvitz (2006). Their "Predestination" approach is predicting a driver's destination as he is progressing on the trip. In their opinion predestination can be used to deliver proactively information on the route ahead of the driver like points of interest and traffic problems. This allows to reduce the amount of information the driver will be presented with as it is possible to filter information the driver would not need to see as he would not be in a geographical reach where these messages would be important. The Predestination algorithm delivers results with a median error of two kilometres respectively three kilometres at the halfway point of a trip / route. These results support the claim that a system using historic movement patterns and the actual location and movement (i.e., speed, direction / heading) is capable to identify not only the most likely route but also the destination. By doing so the uncertainty of different start times of a trip (e.g., a time bracket for leaving to / from work) can be lowered by identifying the goal of the trip by taking the taken route into account.

The storage of such movement pattern, that are, the GPS trajectories of the users requires a scalable architecture which can handle the storage and querying of such data. A Geographic information system database or a moving objects database as described by Wolfson et al. (1998). A special consideration has to be that the MDP Intermediate and the MDP AD Server will need usable but anonymised data to protect the privacy of the user. In addition the querying functionality of the MDP Ad Server hast to be especially tailored to reveal only results which can be seen as anonymous snapshots in time (rather a quantity of user the single users in a defined area matching the location and selected time bracket). In addition the prediction functionality needs to be able to have access to the necessary data to estimate which users are at a certain time (bracket) are in a certain area (Wolfson et al., 1999). The regular movement pattern of the everyday life and locations frequently visited of a person can be used to gain information about the everyday life of persons and at what times they are at particular places (Hanson & Hanson, 1993).

The literature and research projects show that there is a potential for location based advertisement and marketing or providing recommendations / notifications to a mobile user as long as some rules are preserved. The main issue is not to SPAM the user and allow him to control what and how he reserves the information. It is possible to provide a mobile user with relevant information based on their position as long as such a services as access to that information and can use it for the good of the user. Misuse of such information will cause a loss of trust and therefore harm the acceptance of the users towards such a service.

2.2 Personalisation, recommendation and context awareness

Personalisation can be defined as:

- Personalization is often referred as the ability to provide content and services tailored to individual customer's needs based on his preferences and behaviour, or on the profiles of others with similar actions (Yu et al, 2006)
- Riecken (2000) defines that personalisation is used to build a valuable one-to-one relationship between the business and the user which takes its needs and wants into account in order to satisfy them by providing services in the right context.

- In a Forrester report Hagen (1999) describes personalisation as the capability to provide services and content adapted for the individual user based on his preferences and their (past) behaviour.

Goldberg et al. (1992) describe their Tapestry approach with belief that information filtering can be more effective when humans are involved in the filtering process. Tapestry was designed to support both content-based filtering and collaborative filtering. In their scenario the users annotate documents which support the filtering process for other user's recommendations. Resnick at al. (1994) introduced a recommendation engine based on collaborative filtering in their GroupLens research project. Hill et al. (1994) uses a virtual community for social filtering of video recommendations. Shardanand and Maes (1995) focuses on the recommendation of music using similarities between the interest profile of that user and those of other users.

Ge et al. (2010) found that in mobile or pervasive environments it is more difficult to develop recommender systems as the factors which have to be taken into account are much more and more complex than in more traditional recommender systems. The main issues which have to be considered are spatial data and intrinsic spatio-temporal relationships, context-aware information which has to be taken into account as well. In addition the systems will offer more and more sensors and therefor data to such algorithm's which could be evaluated as well.

Adomavicius and Tuzlin (2005) present an overview about recommender systems, the research about recommender systems and the different recommendation approaches (Content-based, Collaborative and Hybrid) and recommendation techniques (Heuristic-based and Model-based). They state that most of the current recommender systems deal with single-criterion ratings and that it is crucial to incorporate multi-criteria ratings into recommendation methods. This matches the statements and definitions of Abowd et al (1999), Marmasse (1999), Abowd and Mynatt (2000), Day (2001) for context-aware systems and that there is a lack of such systems.

At the time of writing they found that recommender systems mainly operated in a two dimensional User x Item space and that such systems should be extended to use contextual information (e.g. the users whereabouts) to allow better recommendations for that specific user in his actual situation. In Adomavicius and Tuzlin (2001, 2001b and 2005) and Adomavicius et al. (2005b) it was stated that the traditional approach of User x Item recommender systems shall be extended to a multi-dimensional setting. They proposed the name multidimensional recommendation model for this. In their example about movie recommendation they extend the User x Item (in this case interest in certain movies (types)) to become multi-dimensional by adding the dimensions of "where" and "how". These dimensions would describe "where" the movie will be seen (e.g., in the movie theatre, at home on TV, on video or DVD) and "how" the movie will be seen (e.g., alone, with girlfriend/boyfriend, friends, parents, etc.). An additional dimension would be "when" the movie would be seen (e.g., on weekdays or weekends, in the morning/afternoon/evening, during the opening night, etc.). This adds to the complexity of the approach but they recommend reducing the possible movies by eliminating all movies which do not have a fitting rating. This can be done by other dimensions (or parameters) as well to reduce the space a recommendation is drawn from. As a solution they propose using an extended hierarchical Bayesian method (by adding the other dimensions) for producing the multi-dimensional recommendations.

In case of extending the personalized recommendations from the online to the offline world the system has to become context aware. Lee et al. (2011) admit in their study that an context-aware system would automatically service or push any requirements without requiring user interaction.

The following table (Table 2 Research in context-aware systems) presents a selection of projects in the context-aware recommendation area and their main focus.

Project	Focus	Research work
The Active Badge System	Locating employees and Call Forwarding	Want et al. (1992)
Cyberguide C-Map GUIDE	tour-guide	Abowd et al. (1997) Sumi et al. (1998) Cheverst et al. (2000)
Cricket Compass	location information providing	Priyantha et al. (2001)
PSA (Personal Shopping Assistant)	shopping assistant	Asthana at al. (1994)
The Context Toolkit	Development of Context-Aware Applications	Salber at al. (1999)
Hydrogen	Context-awareness on mobile devices	Hofer et al. (2003)
Gaia Project	framework for context aware application	Manuel and Christopher (2002) Ranganathan, and Campbell (2003)
CASS	Context-aware middleware framework	Fahy and Clarke (2004)
CoBrA	Context-Broker Architecture	Chen et al. (2003, 2004)
Context Fabric	Context-aware system architecture	Hong and Landay (2004)
SOCAM	Service-oriented context-aware middleware	Gu et al. (2005)
Enhanced CoCA	Collaborative context-aware service platform	Ejigu et al. (2007, 2008)

Table 2 Research in context-aware systems

All these research projects deal with certain forms of context-awareness. They provide, for example, frameworks for implementation and sometimes are limited to indoor scenarios (e.g., Active Badge) or single interest scenarios like tourist guides. In the following sections the term context-aware will be discussed more in detail.

Like for the location based information a user has to be sure that the data given to a system shall not be misused or used against the user. Likewise the trust gained by such a service can be easily destroyed if the system acts against the users will.

2.3 Mobile marketing and advertisement

As the proposed recommendations and notifications which the MDP system should provide to the user could be seen as mobile advertisement and marketing these issues have to be taken into account. The user acceptance for such a push based system is depending on the perception of the user. Most of the available research work has been done based on scenarios using SMS (Short Message Service) or MMS (Multimedia Messaging Service). Since the dawn of the smartphones (mainly Android, BlackBerry and iPhone) the capabilities and opportunities to use rich media via fast mobile internet connections has made other technologies available to mobile marketing. For Bauer et al. (2005) the mobile marketing discipline is in an embryonic stage of commercial usage and there has been not much chance for users to see it as an innovation and adopt it for their usage. By this reason for them it is not possible to empirically measure acceptance and (possible) adoption. Therefore the future acceptance could be estimated based on the user's attitude towards mobile marketing. Even if nowadays the situation seems a bit better most of their statements still applies. A promising potential is seen by Bauer et al. (2005) as users usually carry the mobile phone everywhere and everyday around with them and by combining this with location information even a brick-and-mortar company could use the distance to their shop as a trigger for a mobile advertisement. They also see a high potential in mobile advertisement if it is applied right as one of the most powerful one-to-one future advertisement tools.

This statement is supported by Gidofalvi et al. (2007) which is seeing the delivery of relevant mobile advertisement to mobile device users as a very promising business opportunity. They claim that the two important factors are the area / distance the product or service is advertised to the user and that the offering matches the interests of the (potential) consumer. The interests of the user can be stated by the user (explicit) or deduced from the users characteristics. They show that advertisement in a Location Based scenario has a rather large potential but it also leads them to the opinion that the user needs to have control about what mobile advertisement he receives.

A result of Dibdin (2001) research is that the active response to a user's changing location creates opportunities to push information to the mobile client. Using a quote by

Reza Chady (Head of global market research at Nokia Networks) DeZoysa (2002) writes that "Users are receptive to advertising that is personalised and relevant to their lifestyle“.Paavilainen (2002) uses results from Kalakota and Robinson (2002) to reason that LBA is beneficial to push personalised messages such as promotions for products to users which are relevant to the mobile users proximity.

Dickinger et al. (2004) makes a point by defining mobile marketing as time and location sensitive media which serves users with information about services and good's matching the mobile users interest. By doing so it creates a value for all parties involved. By using mobile marketing or mobile advertisement systems it is important to be aware of results from Ducoffe (1996) which found that annoying, offending insulting or manipulative (mobile) advertisement the user considers it as unwanted. This is supported by the claim of Bauer et al. (2005) / Kavassalis et al. (2003) which wrote that mobile users only accept mobile marketing or advertisement if they see it as beneficial to them. . These factors are important to the acceptance of such a mobile advertisement and marketing systems which uses the interest and location of the mobile user.

The research project by Albers and Kahl (2008) describes a pull based system which is supposed to match the mobile user with an advertiser based on an interest profile of the user and its location. The advertiser can define target groups which reflect the location and/or interests of the people they want to reach. Their proposed system dynamically combines the user profiles with contextual information (e.g., current time, user location) and auctions off the advertisement opportunity to the advertisers. If a user wants to satisfy his interests (reflected in his profile) he can pull matching information in form of advertisement from the system.

It covers the advertiser demand for reaching their target audience but rather has a static approach without the dynamic forecasting and use of movement patterns (historic as well as future).

Smutkupt et al. (2010) describe mobile personalisation and marketing based on the works of Junglas and Watson (2003) that you can regard a mobile phone as a very personal item which is usually always carried around with its owner. It can be seen as an extension to the person of the user as it is clearly identifiable by its SIM (subscriber identification module) card which holds a lot of personal information. Considering these factors the mobile phone is perfectly suited to reach a specific user and therefore allows a very personalised way of communications as we can be sure about the identity of the user. Mapping this to the preferences and interests of the user the marketing campaign can be tailored specifically to this user. Based on these statements it can be assumed that a personalised mobile campaign based on the mobile phone or smartphone of the user can be used to target this user directly and using the sensor readings of this device to get information this specific user.

Their definition of "Localization refers to the ability to locate the current geographical position of a mobile user“ is based on Junglas and Watson (2003) and is only partly matching the MDP concept as this is extending this definition to include the prediction functionality, which means, no longer only the current geographical position but also an estimated position in the future will be taken into account.

Bauer et al. (2005) extends the definition of mobile marketing with the attributes personalization, ubiquity, interactivity and localization which have significance for this innovative form of individualized dialogue with the customer. Therefor this form of addressing a potential customer is going beyond mass communication.

Under consideration of the works of Barnes and Scornavacca (2004), Smutkupt et al. (2010) and Bauer et al. (2005) it can be said that the permission of the user is a very critical issue when pursuing mobile advertisement because it directly targets a specific user in a maybe as intrusive considered way. Even more than the other traditional advertisement media.

In their study expresses that only if the customer has expressed his permission to receive mobile advertisement and marketing the perception towards the brand and product is positive. The level of entertainment, credibility (brand / product) and the personalisation towards the user allow it to predict and influence the perception of the received ads for the user.

A growing body of evidence indicates the significance of permission in mobile advertising effectiveness (Tsang et al., 2004).

The research of Sohn et al. (2008) showed that 85% of the participants of their study responded positively to the idea to receive appropriate information matching their interests at the right time. Referring to Duane and O'Reilly (2010) and Duane et al. (2011) the fact that the mobile device as a ubiquitous device can extend the traditional marketing approach to the location and the time when a user is at a certain place the impact of time, location and personalisation became very evident. As modern mobile devices offer a variety of technologies (like SMS, MMS, Mobile Web, GPS navigation, photo, and video cameras) and functionalities in the form of mobile applications the enabling technologies for a wide range of transactional push and pull based mobile commerce products and services. This includes the highly individualised and location based Smart Mobile Media Services (SMMS, based on the definition by Duane and O'Reilly (2010) and Duane et al. (2011)) which are delivered directly to mobile users device.

The main issue for mobile marketing and advertisement is to support the user and not bother him with unwanted annoyances. Again the mobile user has to trust the system and the system has to preserve this trust and shall not lose it for a small and fast win by providing the wrong messages to a customer. Gaining and keeping trust is the main issue for successful mobile marketing and advertisement.

2.4 Privacy, security and trust

The main issue for Location Based Personalised Services is the acceptance of the user. In order to persuade the user to use such a service the privacy, security and the trust relationship of the user to the service has to convince the user so that they are willing to use such a service. Privacy is the claim of individuals, groups, or institutions to determine for themselves when, how, and to what extent information about them is communicated to others (Westin, 1967).

Bettini et al. (2005) defines sensitive data as:

- information on the specific location of individuals at specific times,
- movement patterns of individuals (specific routes at specific times and their frequency)
- personal points of interest (frequent visits to specific shops, clubs, or institutions)

Bettini et al. (2005) describes three ways to anonymise sensitive data: de-identification, obfuscation and the separation on the identifiers from the sensitive data.

Leppäniemi and Karjaluto (2005) summarize in their work that

> "... By utilising location awareness, time sensitiveness, and user’s personal information, mobile advertisements can be highly personalised. This evokes the ‘big brother’ feeling that someone is tracking their movements as well as buying behaviour and then utilising it in m-advertising campaigns. From users’ point of view, invasion of privacy and general security concerns relating to wireless medium have been identified as one of the main obstacles to the success of wireless advertising“

Dibdin (2001) believes that the potential the use of an users location has can prevail the privacy issues and possible negative side effects if handled in a responsible manner supported by legal regulations. Paavilainen (2002) instead focuses on the privacy precautions a user might have and that the user has to be willing to trade location for a benefit. This is supported Haghirian et al. (2005) which refers to Ackerman et al. (2001) in their work as they conclude that the user has to be convinced to accept a felt privacy intrusion or loss of privacy as the trade-off for receiving adequate benefits. Based on Goodwin (1991) and Olivero & Lunt (2004) the conclusion of Paavilainen (2002) work can be summarised that LBA which delivers what was promised, which means only relevant, beneficial and valuable information or service in the right context and at the right time for a specific users profile the user will be willing to disclose very personal information (like his position and therefore privacy). As long as the user feels he is getting more out of this relationship then the data he provides is worth to him the disclosure of the necessary private information will be acceptable. Ackerman et al. (2001) describe that a new privacy challenge is arising related to the collection of data about a user in a mobile environment. This relates to the availability and traceability of the users activities, his movement, and usage of information access (app usage as well), etc. which raises issues not covered by regulatory or legal bodies. The main issue for the user is that he needs to be convinced that the information provided is put to a good use by providing the user with an added value for giving up some of his privacy.

Referring to various regulatory schemes (e.g., HEW 1973, OECD 1980, European Union 1995, and FTC 2000) Ackerman et al. (2001) describes these four basic areas as design requirements:

- Notice: The individual should have clear notice of the type of information collected, its use, and an indication of third parties other than the original collector who will have access to the data.
- Choice: The ability to choose not to have data collected.
- Access: The ability for the data subject to see what personal information is held about him/her, to correct errors, and to delete the information if desired.
- Security: Reasonable measure taken to secure (both technically and operational) the data from unauthorized access.

These points are important to the MDP concept and the proposed architecture so the privacy is by design incorporated in the proposed architecture.

Referring to the Directive 2002/58/EC of the European Parliament, the Council in the European Union (2002) and the Wireless Communications and Public Safety Act in the United States (H.438[106],1999) Weiss et al. (2006) come up with a similar set of requirements like Ackerman (2001) for their Open Zone Services (OZS) research project:

- Choice and consent: Personal information of a visitor may only be processed if she has explicitly agreed on doing so.
- Notice: Before collecting data, the OZS provider has to inform potential visitors about purpose and duration of data collection as well as whether or not collected data is handed out to third parties.
- Interruption: In spite of having agreed on her data being collected, a visitor must be able to (temporarily) stop the OZS provider from doing so without incurred costs.
- Collection Limitation: The amount of data collected should be adequate with respect to the purpose of data collection.

The OZS (Open Zone Services) mentioned are (pre-) defined zone in which their system can estimate which users are matching a certain profile for advertisement dissemination based on collected data about the users visiting or been in a geographical zone. By providing statistical information about these users it is assumed that it is possible to conclude which target audience is most likely in this geographical zone Weiss et al. (2006). This is a very similar approach to the MDP concept and the (anonymised) way data (Tracks) will be provided to the information provider or advertiser as a snapshot in time in order to select their target audience. The OZS concept lacks the unique and advanced features of MDP taking past and predicted future movement patterns into account so that not only for that moment in time a selection can be made. Depending on the time of the day, which weekday, which hour the target audience could be different in a certain geographical zone. This could be predicted by MDP as it takes past (and future) movement patterns of its users into account. In addition MDP does not work with fixed geographical zones but can estimate the number of possible target users on any zone defined by an information provide or advertiser.

Mayer et al. (1995) writes about trust that it is the user is willing to trust another party that it will not misuse the trust relationship while the user gets into a vulnerable position for example by disclosing information (in this case location information) even if the trusted party can surveil the user and only perform actions the user has agreed to. In addition Mayer et al. (1995) states that the "Willingness of an individual to behave in a manner that assumes another party will behave in accordance with expectations in a risky situation“ is an important factor.

> D. Hoffman et al. (1999) writes about gaining the trust of the customer that it is a simple task if the power is shifted from the business side towards the customer (i.e., user) side and allows the customer to work in a cooperative way with the business provider (hence have control in a situation formerly controlled only by the business).

For Shankar et al. (2002) online trust has several dimensions like reliability/credibility, emotional comfort, quality and benevolence which have to be balanced between the needs of both (or more the two) parties and the business has to understand that in an online context it is necessary to prioritize and address all concerns of the involved parties in order to gain, build up and keep the online trust.

By drawing a parallel to e-Commerce it can be said that a lack of trust can be the biggest hurdle for the acceptance of a service or business in the online world, especially if the user has to disclose sensitive information (Hoffman, Novak, & Peralta (1999); Wang and Emurian (2005))..

As users are on the one side very privacy and data protection conscious they are willing to trust a system as long as the benefits are worth it. Trust, privacy and data protection issues are important to a system which knows not only the whereabouts of a user but also his interests and where a user will be most likely at a given day and time. This might be spooky for some users but as long as the user trusts a system or its provider it will be a reasonable approach.

2.5 Architecture related

In this section a basic groundwork and understanding of the important architecture related literature and related works will be presented.

Some of the technologies used are nowadays commodity technologies (like GPS, Web Servers, Firewalls, GIS or geospatial databases) so that they not mentioned here explicitly.

2.5.1 REST

The term REST ("REpresentational State Transfer") was coined in 2000 in the doctoral dissertation by Roy Fielding (Fielding, 2000). Fielding describes REST in his PhD thesis as architectural constraints which emphasize the scalability of component interactions, the generalisation of interfaces; it allows the independent deployment of components, and intermediary components in order to reduce interaction latency. In addition it allows to enforce security. This allows a system to provide a lightweight and flexible interface for a use in a mobile environment which minimises the amount of data and the complexity of the interface compared to more complex protocols and interfaces. Large web sites, standards and even hardware vendors nowadays offer at least one REST based API for their services. Examples are: Amazon (e.g., S3 - Simple Storage Service), Twitter, Facebook, Ebay, Google, Yahoo, Developergarden (Deutsche Telekom AG) or standards like CMIS (Content Management Interoperability Services), Cloud Data Management Interface (CDMI) and, as a hardware based example, the storage system Hitachi Content Platform.

REpresentational State Transfer (REST) is an architectural style supporting stateless client-server architectures based on web services which are treated as resources (Fielding, 2000; Fielding and Taylor, 2002)).

In 2008 McFaddin et al. wrote that compared to web services REST restricts the access operations against a data providing resource to a limited number. In addition it uses a simple protocol. By doing so it has similarities to a reduced and more generalised design style like RPC's (Remote Procedure Calls).

The description of REST by Riva and Laitkorpi (2009) describes it that by its architectural style, design and elements it allows a scalability in a web based environment. As any client which can support the HTTP protocol can use REST it is easier to integrate then web services / SOAP without having to rely on additional messaging frameworks. Neither the client or the server need an extra additional infrastructure to use or provide a uniform REST interface as long as the HTTP protocol is supported (and a program logic to understand or use the REST calls).

Pautasso (2009) adds that REST builds up on a set of architectural elements (user agents, proxies, gateways, and origin servers) to build large and scalable systems by combining them in a architectural style which easily allows to build layered and scalable systems. By using this approach such a system can grow to support a large number of clients accessing the resources published by a single server.

As REST is using the HTTP protocol the interface has to be established using operations based on the standard HTTP GET, PUT, POST and DELETE methods to make or invoke changes to the resource. This is done by using standard HTTP calls addressing the resource which invokes methods defined for the resource. The result of the method and the form of the returned value can negotiated with the REST / web server (e.g., text/html, application/xml, etc.). This extends besides the return value to the payload of the returned message or metadata. Every resource can be implemented to deliver its results in different formats Alacron and Wilde (2010).

For a mobile environment Riva and Laitkorpi (2009) have identified some challenges and constraints like Network latency (e.g., long response times / time out has to be set accordingly), Data formats (mobile devices require lightweight data formats rather then, e.g., XML), Caching policy (either protocol or application level), Offline/Online behaviour (strategy for offline) and Thin vs. Thick clients (where is the application logic located). HTTP based REST resources are identified:

- name and address identified by a URI (RFC 3986, Berners-Lee et al. (2005))
- one state at a time defined by a set of attributes and their values
- at least one representation that encode the current state in a particular content type

Pautasso et al. (2008) describe the four technology principles on which REST is build:

- Resource identification through URI
- Uniform interface (CRUD – see below)
- Self-descriptive messages
- Stateful interactions through hyperlinks

A constrain of REST is that the interface of a resource is predefined by its generic uniform interface which invokes predefined methods. Resources are identified by URIs. Via REST the necessary functions for Create-ing, Read-ing, Update-ing, and Delete-ing (short: CRUD) are implemented using HTTP methods or verbs like DELETE, GET, POST and PUT Pautasso et al. (2008).

CRUD	**Description**	**REST** Hi-REST	**REST** Lo-REST	**SQL**
Create	Create a resource	Post	Post	Insert
Read (Retrieve)	Retrieve a resource	Get	Get	Select
Update (Modify)	Update a resource	Put	Post	Update
Delete (Destroy)	Delete a resource	Delete	Post	Delete

Table 3 CRUD and REST mapping

The table shows how the CRUD functions are mapped to HTTP methods. Usually the HTTP methods listed in the Hi-REST (High-REST) row are used. Lo-REST (Low-

REST) is used if firewall or proxy configurations are blocking the use of HTTP PUT and DELETE verbs. As the REST URIs are known to a certain extend the firewalls or application firewall could be configured to block every other URI based attempt to attack the server. As example the CRUD mapping to SQL are shown as well. A client uses REST calls to transfer information to the server and initiate or trigger methods which then are performed on the server.

As an example here are some URIs for REST calls:

/users/<UID>	returns, for example, profile information about the user with the <UID> (User ID) – depending on the representation, for example, as XML or JSON
/users/<UID>/status	status information about the user with the <UID> (User ID) – for example, busy, offline, online, off

These REST URIs calls would be preceded by protocol, server name, path to the REST application, for example, by http://<server_name>/<REST_Applikation> (or https as protocol).

If the second REST call would be called with an http method GET (Read / Retrieve) it would return the status. If called with an http method Put (or Post if Li-Rest) the user status for the user with the <UID> user id would be updated / modified. Naturally in the architecture (and implementation) of the system only authorised users are allowed to do so.

This gets supported by McFaddin et al. (2008) as REST is using nouns which represent the operation a user wants to execute. REST defines data types, for example, a simple data record having a user name, id, and status fields, this data then can be added, deleted, retrieved or updated (the verbs for REST) via the HTTP REST calls. All these verbs can be used for all data types of the designed REST based system.

Besides the proposed REST style URI calling it is also possible to use Matrix parameters (e.g., instead of Key/value pairs expressing Boolean values) and query parameters (e.g., for filters or complex (multiple parameters)) (Tilkov, 2009; Jakl, 2005). Some might argue that these URI are not pure REST but Tilkov argues that it still delivers what is expected from the resource and mainly has historic reasons (in the older versions of squid the proxy server could not cache content from URIs which contained a "?“). Jakl refers to it in an example to update metadata for a resource via a PUT (update) request via a REST URI call. Mäkeläinen and Alakoski (2008) describe REST URIs with parameters and CSC8417 (2006) uses a similar REST call example with parameters for a flight search. Lo-REST can be seen as another deviation because of technical reasons (filtering of http method calls by firewalls or proxies).

RESTful Web Services as defined by Richardson and Ruby (2007) are compliant to all REST criteria's. Filho, and Ferreira (2009) define that a RESTful approach is build upon the five concepts and three principles:

Concepts:

- resource
- representation
- uniform identifier
- unified interface
- execution scope)

Principles:

- addressability
- statelessness
- connectedness

RESTful services will handle a request which defines the procedure which shall be executed and returns after the execution a result of the execution as response.

Hatem (2010) defines RESTful web services based on Fielding (2000) that they are web applications which are built using REST architecture. The expose resources deliver data and functionality (in form of REST verbs and nouns) by using URIs. In order to do so the four main HTTP methods are used to create (POST), retrieve (GET), update (PUT), and delete (DELETE) resources.“

The strengths of RESTful Web services are perceived to be simple as REST uses W3C/IETF standards (HTTP, XML, URI, MIME). The infrastructure is widely available and know how to run and optimize Pautasso et al. (2008). In addition HTTP (client) libraries are available almost on every platform. As this very light architecture is based on existing technologies it is very easy to adopt and develop for. In addition it can scale quite easily by using known and tested systems for caching, clustering / farm and load balancing. As rest can supply the requesting client with a number of different data or message formats a lightweight format, fitting a mobile infrastructure, like JSON (Crokford, 2006) can be chosen. REST is also suited to be used for a web interface, for example, a web based client interface.

For REST uses the HTTP protocol as the transport media for remote communication. This has a very low overhead for the communication when compared to SOAP/ web services. SOA / web services are supporting loosely coupled systems by using a message bus and using a REST client for its rather RPC like synchronous resource calling. This causes that the client has to handle the queuing by itself if the server is not available or reachable (e.g., timeout, network problems ...) by doing so the time / availability aspect of loose coupling could be implemented as well (Pautasso et al., 2008).

For a mobile environment REST has the advantage to be stateless which allows it to cope with mobile internet connections which might temporarily loses connection. In addition it requires only a small bandwidth as it does not use the overhead of SOAP and its XML payload (Tyagi, 2006). REST implementations can easily scale like other web servers. Data requested from a server via REST can be cached and limits the necessary transactions on the server. A slight disadvantage of REST is the lack of a standardised way of describing resources, methods and data even if there is a proposal for WADL (Web Application Description Language) which is similar to SOAPs WSDL (Web Services Description Language). Since WSDL version 2.0 it became easier to describe REST in WSDL as well.

Hatem et al. (2010) have done some experiments and from their results they conclude that they can recommend using RESTful web services for the communication with mobile devices. Their experiments results (comparing SOAP vs. REST in a mobile environment by testing their implementations of String Array Concatenation and Floating Number Array Addition) show that:

- Message sizes for a RESTful web service are usually smaller than the message of standard SOAP web services.
- The response time of a RESTFUl web services is much faster then the response time of the standard SOAP web service. This is one of the biggest advantages using REST.
- The smaller messages and the faster response time results in a shorter transmission time and allows a more efficient processing on the client. This leads to faster services which supports the use on mobile devices. Especially on mobile devices where power and processing power is a constrain this can support a reasonable response time and quality of the service.

The results of Hatem et al. (2010) support that RESTful web services are recommended for the use with mobile devices. Therefore, REST offers a perfectly good solution for the majority of implementations with greater flexibility and lower overhead then SOAP / web services would offer in such scenarios.

To summarise the results of Hatem et al. (2010) it can be said that their evaluation shows that there is an advantages of using RESTful web services over standard SOAP / web services for mobile devices scenarios. The advantages include the smaller message sizes and therefore faster response time. Their performance comparison showed that standard SOAP / web services are slower and need larger message sizes compared to RESTful web service show that the latter one is more performant. This justifies that RESTful web services are a good choice for the implementation in a mobile scenario because of its higher flexibility and low overhead.

Pautasso et al. (2008) found that the REST interface design is far simpler by using a constraint set of operations then the more complex interface design necessary for the implementation of a web service.

McFaddin et al. (2008) see that REST has advantages in its high efficiency because the load on the processor and the network is lower. This is due to the fact that REST designs are lightweight so that they can be used on mobile devices with lower computing resources even if the REST interface can be the same as on a server.

For Triffa et al. (2011) scalability is based on the usage of well-known web protocols which allow it to use all the mechanisms like caching, load balancing, indexing, and searching. Another point which adds to the advantage of REST is that it can use the stateless HTTP protocol to connect the devices via the lower level Internet protocols. Even if Rest at this time only supports http / https as transport protocol (and the proposed Waka protocol on the way) this is sufficient for a fast, lightweight and stateless connection between a client and server. Especially when using https most of the privacy and data protection requirements can be meet. Esp. as smartphone mobile phone internet connections are sometimes restricted in the protocols and ports supported for a connection.

Considering the nature of embedded devices (or in this case the similar mobile devices) Triffa et al. (2011) state the a requirement is to use optimized protocols for the data exchange which suites the usage of REST because of its nature and design.

Compared to the standard web-services, which are by their design have a rather high demand for memory and computing power Christensen (2009) REST is much more usable for the limited resources available in mobile devices. As the RESTful web-services can be easier processed. The result of their research is supporting the use of REST in a mobile scenario because of the following reasons:

- RESTful Web Services are easy to invoke, produce an easy to parse XML based response and therefore they are less memory consuming while parsing the XML.
- As the client and the server communicate via a simple invocation and response protocol there is no need for expensive meta-data parsing.
- Mobile platforms and clouds make a nice match especially if they are connected via HTTP as the requests can be made in a simple form and do not require expensive memory and CPU time consuming complex XML handling.
- The use of the established HTTP protocol makes it easy to handle errors via well-known error codes and the response to an invocation can be delivered in a minimal form saving memory on the mobile device (and server).
- As predefined resource based responses can be used in the REST communication this reduces the time, processor and memory usage while processing a REST response in order to be used by the application.
- In order to extend the computing power, available services and storage of mobile devices the coupling with servers via REST can enhance mobile application significantly.

For Makelainen and Alakoski (2008) the implementation of REST or a RESTFul API is defined as an interface to the functionality providing server system which can be seen separated to the processing back-end which allows architecturally simple designs. They define the following requirements when accessing a server system from a mobile device:

- All users and their request must be able to authenticate and authoris themselves to the system
- An access control system must be in place to control the access to all resources exposed by the RESTful API
- The access to the data of the end user must be controlled by the end user so that he can allow which external party can access their data to what extend

For their proof of concept (PoC) implementation they analysed various options and choose the OAuth framework. In order to manage permissions for their proof of concept implementation they implemented a web based interface to allow the user to administer the PoC system regarding the data access. The result of the PoC was that they could not find technology based hurdles to create mash ups using mobile devices.

As REST is using a lightweight approach and an approach which consumes a small number of resources on the client as the server it proves a feasible alternative in a mobile environment with devices which are not as powerful like a notebook or desktop PC. The simplicity of the REST architecture combined with the use of well-known protocols allow to scale out such a system with well-known and proven technologies. Which makes it ideal for larger and rapid growth scenarios like an interesting mobile service can expect when it gets widely adopted.

2.5.2 "Chinese Wall" approach

In various industries like banking, consulting or advertisement the "Chinese Wall" policy is used to keep information from one client separated from persons or teams which are working on projects or tasks for a competitor of first client. By doing so the organisation can work for two companies which are competitors and can (in theory) still keep their clients confidential information separated. In the banking industry, for example, the analysts and the investment bankers are divided by such a "Chinese Wall" to prevent, for example, insider trading. Some countries (e.g., the United Kingdom) have laws in place which enforce such policies, for example, in the financial services industries. This "non-computer" security policy attracted the interest of researchers in the security area as it is a rather real-word related information access policy compared to the usually referred or used military / governmental policies (Sandhu, 1992).

In a paper by Brewer and Nash (1989) the "Chinese Wall” is described that:

> "It can be most easily visualized as the code of practice that must be followed by a market analyst working for a financial institution providing corporate business services. Such an analyst must uphold the confidentiality of information provided to him by his firm's clients; this means he cannot advise corporations where he has insider knowledge of the plans, status or standing of a competitor. However, the analyst is free to advise corporations which are not in competition with each other, and also to draw on general market information. Many other instances of Chinese Walls are found in the financial world.”

Brewer and Nash´(1989). wrote that based on a Chinese Wall policy users cannot access information which would cause a conflict to information the already have access to. From their definition "Chinese Walls“ are a security concept which is combining mandatory and discretionary aspects of access control.

Lategan and Olivier (2002) describe the need for the usage of a "Chinese Wall” in the way that in Internet for business scenarios users are usually concerned about what happens to their data. The risks of fraud or exposure of the privacy could be dissuasive to the users of a service. By using privacy policies (like a "Chinese Wall") the services can provide the user with a security concept to guard their private information.

Brewer and Nash (1989) explain the function of the "Chinese Wall” that a user can choose freely which data he wants to access but once the domain of data is chosen (or in a business context assigned to the user) the "Chinese Wall" will prevent the user from accessing any other data which would cause a conflict of interest with the data the user is already accessing (e.g., in a business environment a user in a consulting office would not be able to access and therefore gain knowledge about two competing companies). This "Chinese Wall" around the access rights of the user would be extended every time the user accesses a new / different set of data to include this new set of data as well. The "Chinese Wall" allows free access to data as long as there is no conflict with other data sets the user is already accessing. (Brewer and Nash, 1989). A conceptual point for this model is described by Look and Eloff (2005) by writing the figuratively speaking no conflict causing data set can be at the same side of the "Chinese Wall". Sandhu (1992) writes that the "Chinese Wall" prevents that the information flow to a user that it contains any data which access would cause conflict in the access policy. In 1989 Lin identified an error that data cannot be partitioned without overlapping interests in the works of Brewer and Nash (1989) and defined a modified version of the "Chinese Wall" approach called the "Aggressive "Chinese Wall" Security Policy". Loock and Eloff (2005) extended the "Chinese Wall" model by adding a new access control model. For these models, which are based on the "Conflict of Interest" (CoI, i.e., a user is not allowed to access objects which would cause a CoI) they work with access control methods on the data.

These are descriptions of the "traditional" usage of a "Chinese Wall" in industries like banking or consulting. In the Lategan and Olivier (2002) paper it was expressed that:

> "The privacy of information used on the Internet is a very real and important issue. Many users have concerns about the security of private information supplied to organisations on the Internet, and rightfully so, as tales of compromised information abounds".

Cranor (1999) has defined three ways to prevent that private information leaks out on the internet:

1. Private information is not disclosed at all.
2. The source of the private information is hidden, that is, anonymity is preserved.
3. Privacy policies are in effect that promise the responsible usage of private information.

By applying the first way it would not be possible to offer personalisation services at all, in other words, when the user does not trust anybody it will be difficult to offer personalisation services as no private information will be disclosed.

A personalisation, adaptive or recommendation system is only possible if the user trusts at least one organisation that they will do no harm to him based on the (private) information disclosed to them. For a personalisation concept which would work with multiple sources for the recommendations a solution is to store the profile of the user anonymously (see way no. 2) with the middleman and pass a representation of this data without a real reference about the user to the participating / requesting servers. This would be a data-separation security policy based extended version of the "Chinese Wall" instead of using only access controls. Such a type of middleman approach can act as an extended "Chinese wall", in other words, acts as in-between between the user and the service provider. By doing so the organisation that wants to offer a service or recommendation to the user will only deal with an anonymous profile hence been able to provide a service but been prevented from accessing the private data of the user. By doing so the privacy of the user and its data can be preserved. This makes it necessary that the middleman follows the point 3 stated above by Cranor (1999).

This approach would work if there is a trusted relationship between the user and the service provider (a.k.a. as the middleman or the extended "Chinese Wall"). The middleman would handle the storage, collection, maintenance, protection and handling of the profile data of the user.

There is a specific trust and privacy issue for the recommendation part as there are data protection laws in place which can cause problems for such a function. Besides that the users are very conscious about their privacy when they are using a service. The wish to stay anonymous or having their privacy protected is vital for the success of such a personalisation system. This function can only be successful if the user trust the entity which provides this service and passes on the recommendations. Similar trust relationships already exit to organisations like banks, mobile phone companies or credit card companies. This seems odd at the beginning but if we consider that all these organisations have information about their customers and their behaviour, their location when using the services provided and a kind of knowledge about their interest (e.g., from their shopping pattern (bank & credit card companies) or mobile phone companies (e.g., numbers called or services requested and paid for). Nowadays these organisations do not directly provide any real form of personalization or location based services. The only way this existing data about the users is used is, for example, when a credit card company is analysing the "normal” behaviour of a credit card customer to identify "abnormal” behaviour, that is, usage of the credit card to prevent fraud. This analysis of the behaviour is usually based on the usage location as well as on purchasing patterns.

A stateless lightweight protocol for the communication which also fits the mobile devices which are not as powerful as a notebook or desktop computer suites an approach which relies on a server system which does the most of the processing in the background and delivers only the results to the mobile user. In order to protect the data of the user from a breach the described "Chinese Wall" will provide a way of allowing data processing without breaking the privacy of the (mobile) users data.

2.6 Summary

The chapter provided an overview of an excerpt of the existing literature and the related research projects and works. As the topic spans across so many domains of science or fields (not only in computer science) it is rather difficult to cover everything into the smallest details in the available time.

The concepts of frequently visited locations or places, routes (between places), the higher level activities of a user and the transportation mode and their meanings and ways to detect them have been described in the presented literature and by projects of other researchers. All this information about a mobile user can be gathered by using sensors nowadays build into smartphones and can be processed on a (central) server. As long as there are no other technologies available like GPS this type of satellite based positioning systems have to be used (like the planned European Galileo system). On a small scale or indoors other sensor or sender based technologies could be used as well to increase the reach of such a system. This necessary input is therefore made available for prediction of the users actual (and future) whereabouts, what he is doing (in a certain extend) and how he is getting there. All this information can be used to estimate a situation and the predicted location a user will be in at a given time in the future so that this can be used to provide the user with matching recommendations which fit his interests (at that moment and location).

The pull vs. push based personalisation in a location based scenario discussion is a good indicator of the privacy conciseness the mobile user have which has to be addressed in order to make such services acceptable to user's. This is mainly about the trust that their privacy of their data is guarded to the highest standards and that the mobile end users are in control. Especially as location data can be considered as something very personal. This data can be used in a positive context, for example, for (extended) location based services or mobile marketing / advertisement but has to be protected in order to ensure the privacy of the user. The necessary building blocks have been identified and the related research projects have been presented.

The architectural concepts for the communication have been based on a technology which is not only lightweight but also powerful and allows providing scalable services. Besides the REST technology a "Chinese Wall" is from the perspective of separating data and been able using it an interesting choice.

The next chapter introduces to experiments conducted about user movement patterns and how they can be used in the MDP context.

3 Movement patterns of mobile users

This chapter will present and discuss the concept of using a mobile users daily routine movement patterns in order to predict its whereabouts to provide meaningful recommendations based on these places (and the ways in-between). The chapter will show that based on the evaluation of the past movement patterns it is possible to get a good prediction of the future movement. If the scheduled appointments form the user's schedule (besides the time also including their location) can be incorporated even non regular locations can be served.

Multi-Dimensional-Personalisation (MDP) is based on several dimensions. One of them is the location of the user during a certain time bracket. Almost every person has a certain (daily) routine during the working week (and sometimes even at the weekends). The weekly cycle human a living in is an artificial construct of the society rather then made by nature. Weekdays of working persons show a more restricted and regular distribution of visited places and routes between them and common visited places like home and workplace based on the schedule and timing of the user (Mountain ,2005). The movement patterns which occur rather frequently during the everyday life at weekdays can help to identify frequently visited places and what time the user is at these places or is traveling on which routes between them (Hanson and Hanson,1993). Golledge et al. (2001) found that there are significant differences in the movement patterns on weekdays and weekends (which are usually at the free disposal of the user). Their research also showed that there is also a difference between Saturdays and Sundays. Compared with other days of the week including Saturday at Sunday there is the lowest travel activity. The differences shown in the movement patterns are connected to the variability of the flexibility associated with the noon, early afternoon or the evening time slots of the user. Places visited, which can represent activities of the user, during these times are more related to social, recreational, shopping or eating activities which are less compulsory then the work schedule (shifts). Their research shows that constrains like the definition of a working week and the mandatory schedule derived from it have an influence at the users decision which place will be visited at what time and which activities are performed at what time and where.

This is not limited to the work or study place but even to regular recurring activities like sport, entertainment or social activities. This is usually regardless if you are a scholar, student, blue or white collar employee. The way to work, school or university happens during certain time brackets. The same can be applied for regular visits to a sport ground, fitness centre or the local pub for a pint and some pool or dart games.

Moving from one place to the other can be done, for example, by foot, bicycle, public transportation (e.g., bus, subway, train etc.), motorcycle or car. This is information needed to adjust the notification served by the Multi-Dimensional-Personalisation services.

For the MDP client the widely available technology GPS equipped smartphones shall be used. The MDP client (application) collects and sends this location information to the MDP server for the storing and use in recommendation and notification scenarios. In addition the user could support this by either setting manually a transportation mode (e.g., bus) or this could be done automatically (e.g., by putting the device in a cradle in the car).

In order to evaluate the feasibility of this approach in 2009 a limited experiment was conducted with some volunteers recruited among the friends, family and co-workers. To track the movement of the volunteers a small GPS tracking device was used. The hardware device used for the experiments was a GPS Data Logger / Trip Recorder model iBT-GPS Bluetooth GPS Data Logger 747 by TSI (Transystem Inc., Taiwan, technical details available via the FCC ID "OUP-940760101") with a MTK (MediaTek) GPS chipset with 51 channels which could be programmed / configured to react on different changing conditions (e.g., time, speed, and distance) for triggering the recording of a coordinate and could store up to 150,000 way points.

Figure 1 Transystem Inc.'s GPS Logger iBT 747

This inexpensive hardware was chosen as in 2009 the smartphones penetration and the availability of GPS tracking apps was not that sufficient, so that the route was chosen to provide the GPS tracking device to the volunteers. For the experiment a time based approach was chosen. Every minute the position of the user was recorded. This approach was chosen to get for every run of the experiment comparable recordings by using the same configuration. If the location mode (recording if the user moves, e.g., 10 meters) would have been chosen for the recording we would have gotten different number of readings if the user would not have moved for a longer period of time. The volunteers have been asked to carry the device for one working week as the weekends would have been a stronger intrusion of the private live and would not have given results which could be used to estimate the feasibility during a timeframe which is more likely to show a regular behaviour. The most working adults work approximately 220-250 days a year as this could be an environment targeted. A similar assumption can be made for scholars and students alike as they have to attend their school or university.

The experiments conducted recorded the normal movement patters of a volunteer during a normal or average working week. This way of collecting mobile user data can be seen as a representative sampling in order to evaluate the basic idea behind the MDP concept.

3.1 GPS Trajectories recordings and their evaluation

The experiments have the purpose to collect data during a typical working week to show that there are regular (daily / routine) movement patterns. The volunteers had been informed about the purpose of the recording experiment and how the data would be used. A little GPS tracked had to be taken every (work) day in order to record the movement patterns or in this case data like the longitude and latitude. After the week was over the device was handed back and the data was downloaded from the device. The basic settings of the device will be described later in this section.

Besides the trajectories of the author the GPS tracks of the other volunteers have been anonymised[1]. The first tracks shown single days including some alternative roots whereas the tracks of the other volunteers will show a whole week of recordings. The data was dumped from the GPS tracker in the KML (Keyhole Markup Language) format and visualized using Google Earth / Maps (all maps respectively their images used are © 2011 & 2012 AeroWest, © 2011 Tele Atlas, © 2011 Europa Technologies, © 2009 & 2012 GeoBasis DE/BKG and © 2009 & 2012 Google[2]). The recorded data is provided on a CD / ZIP file.

[1] The anonymisation is not "perfect" as the location of the home and workplace could be used to try to identify the volunteer. All volunteers agreed that their data is used for this purpose.
[2] The attribution follows the rules and guidelines found on the Web pages of Google – see "Google Maps and Google Earth Content Rules & Guidelines" link: http://support.google.com/maps/bin/static.py?hl=en&ts=1342531&page=ts.cs last accessed March 2012

Figure 2 Using a car, way to and from work, (Day 1)

An excerpt of the data for this recording (**Figure 2**) is show in the table below.

INDEX	RCR	DATE	TIME	VALID	LATITUDE	N/S	LONGITUDE	E/W	HEIGHT	SPEED	HEADING	DISTANCE
1	T	07.01.2080	05:37:06	No fix	90.000.000	N	0.000000	E	150.000 m	0.000 km/h	0.000000	0.00 m
2	T	10.10.2011	05:37:29	No fix	90.000.000	N	0.000000	E	150.000 m	0.000 km/h	0.000000	0.00 m
3	T	10.10.2011	05:38:30	SPS	50.179.962	N	8.659.396	E	150.058 m	2.262 km/h	194.986.664	4352383.67 m
…												
51	T	10.10.2011	17:03:45	No fix	50.181.096	N	8.659.949	E	161.667 m	0.000 km/h	329.714.844	36.76 m
52	B	10.10.2011	17:04:18	DGPS	50.180.531	N	8.659.414	E	171.406 m	2.376 km/h	261.079.468	74.14 m
53	T	10.10.2011	17:26:13	No fix	50.180.570	N	8.659.523	E	172.208 m	0.000 km/h	0.000000	8.93 m

Table 4 Day 1 - way to and from work - GPS tracks (excerpt)

The Table 4 Day 1 - way to and from work - GPS tracks shows the following columns:

Column	Explanation
Index	The number of the recording
RCR	ReCord Reason – necessary to visualize the track with Google Earth / storing as KML file (dependency of the software) T – time recording of the position and B – position recorded by a push of the button of the device
Date	Date of the recording
Time	Time of the recording in UTC (Coordinated Universal Time)
Valid	Was the recording valid: No Fix – the recorded position is not valid SPS - "Standard Positioning service mode“ – the recorded position is valid DGPS - "Differential GPS“, SPS-Mode – the recorded position is valid
Latitude	Position on the earth measured from the equator – positive values go towards north, negative values go towards the south
N/S	Indication for North or South
Longitude	Position on the earth measured from the Prime Meridian (Greenwich, UK) – positive values go towards east, negative values go towards west
E/W	Indication for East or West
Height	Height above ground (value from the GPS satellite)
Speed	Speed of the object when measured by the GPS tracker
Heading	Heading on the compass in degree
Distance	Distance from the last measured point

Table 5 Explanation of values from the GPS tracker

The Table 5 Explanation of values from the GPS tracker with the GPS tracks shows some problems of such systems. It has to be mentioned that after switching the device on (i.e., cold start) the GPS logger system needs sometime to locate and receive information from the GPS satellites. In the example this is the reason for the "strange” date, latitude and longitude value in line 1 of the sample. If the reception is bad or the system cannot read the data provided by enough GPS satellites the column "Valid” shows "No Fix”. The last row (No. 53) was created when the GPS Tracker was connected to a computer in order to download the data (the logging switches automatically on when the device is switched on). During the experiment a special logging button was pushed when the trip started and ended to mark this position. Additionally it is visible that fast driving on the autobahn (motorway – yellow road on the image) results in GPS points which have a wider distance as GPS points recorded with a lower speed on "normal” roads which result in more and closer GPS points. The way to and from work differs as the way back to home is chosen because of the better shopping possibilities.

The next days of the working week look as shown in the following figures:

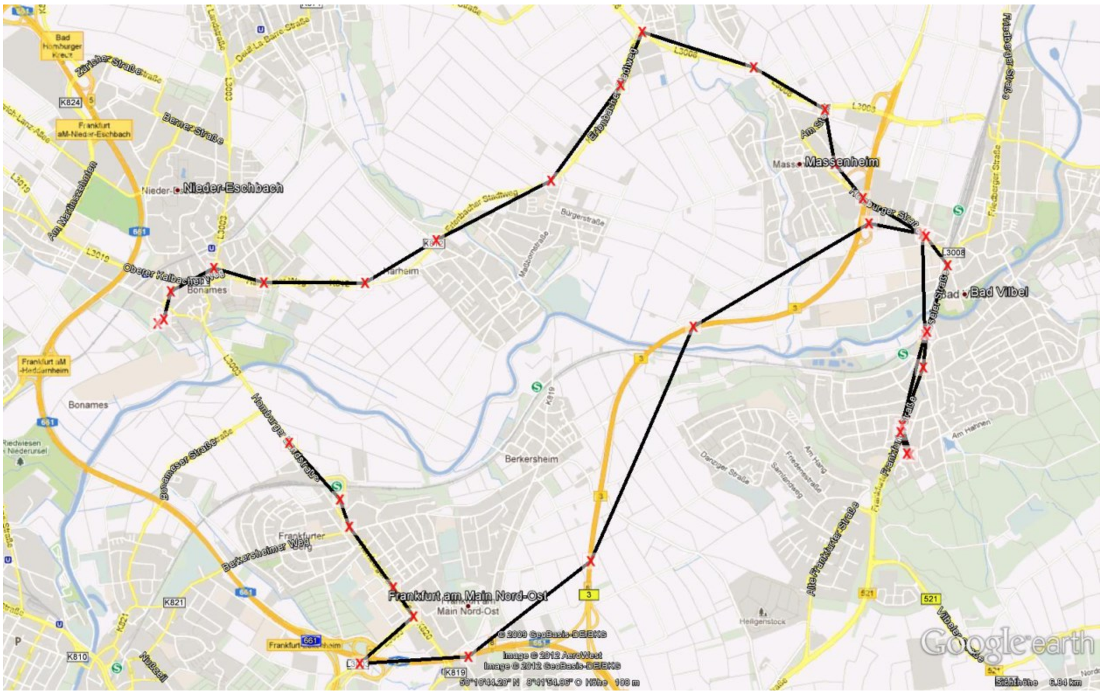


Figure 3 –using a car, way to and from work (second day)

In this GPS track (**Figure 3**) it is clearly visible that the device as not received enough GPS satellite information after the cold start for some time. This might be caused by a start of the trip in a underground car park which prevents the system from catching the signals of the GPS satellites. GPS signals also have a reception weakness indoors.

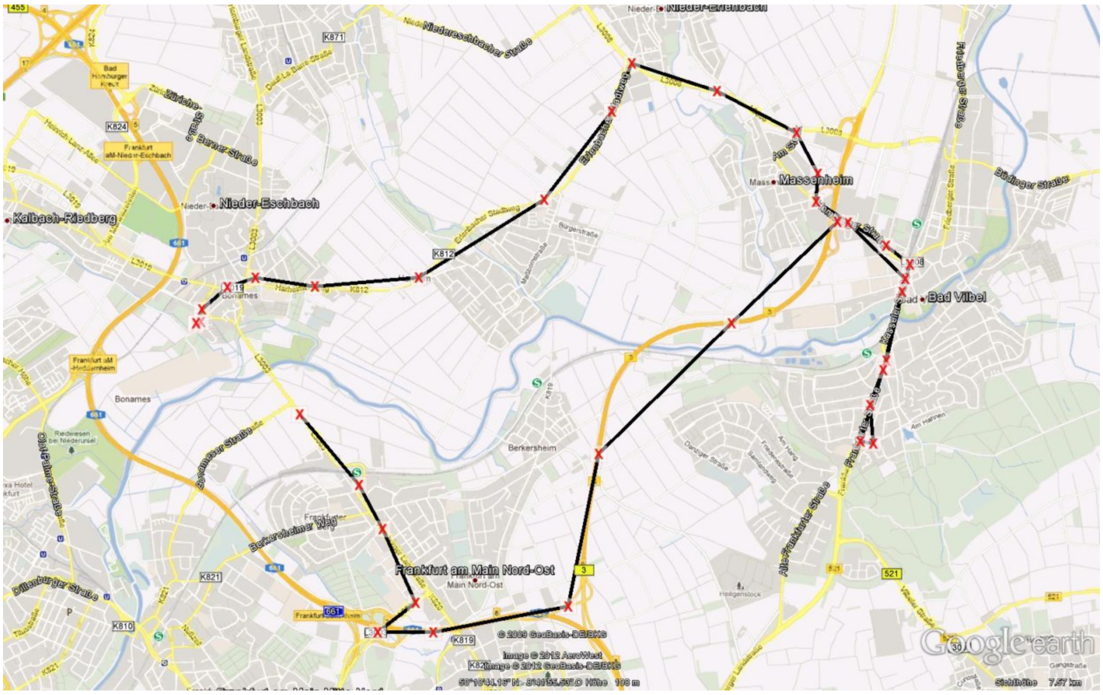


Figure 4 –Third day using a car on the way to and from work

Once more in **Figure 4** the cold start took longer hence the recording lacks GPS points from the start of the trip.

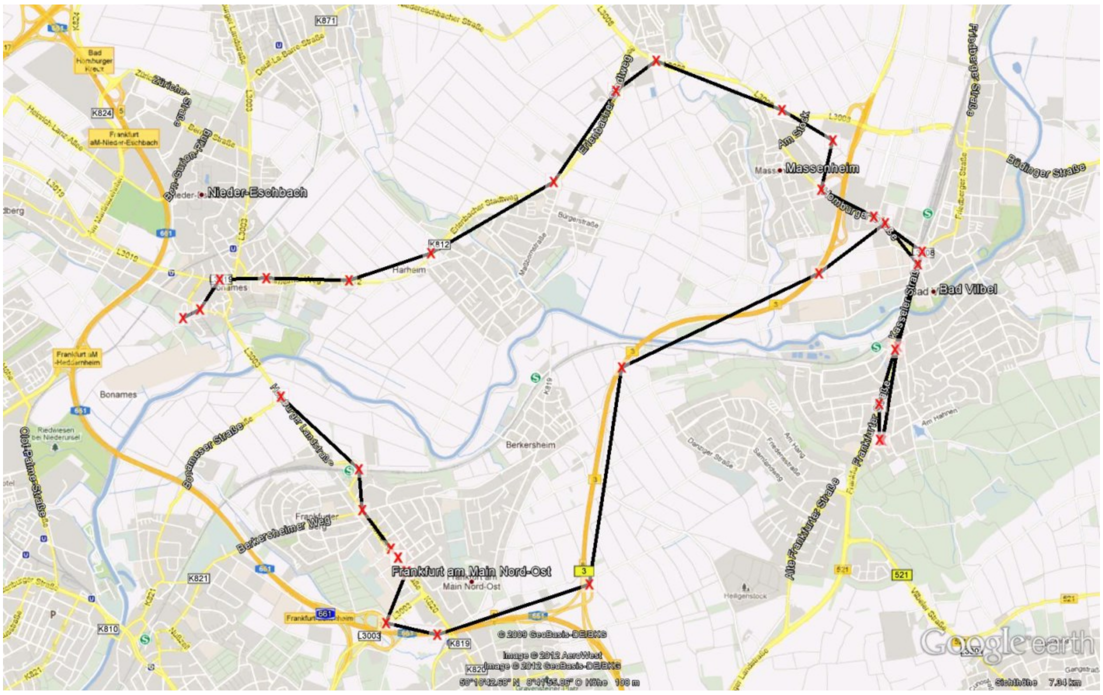


Figure 5 –Forth working day showing the way to and from work by using a car

The cold start of the GPS device took again sometime which resulted in a lack of GPS points after the start of the trip (**Figure 5**). But this gap could be compensated by the system if using historic trip data of the user.

Figure 6 –Last working day of the week using a car for the way to and from work

During Day 5 (**Figure 6**) the fix of the GPS device worked earlier so the route is recorded from the beginning like at Day 1.

The next figures (**Figure 7** and **Figure 8**) show some alternative routes from and to work:

Figure 7 Showing the first alternative route to and from work using a car

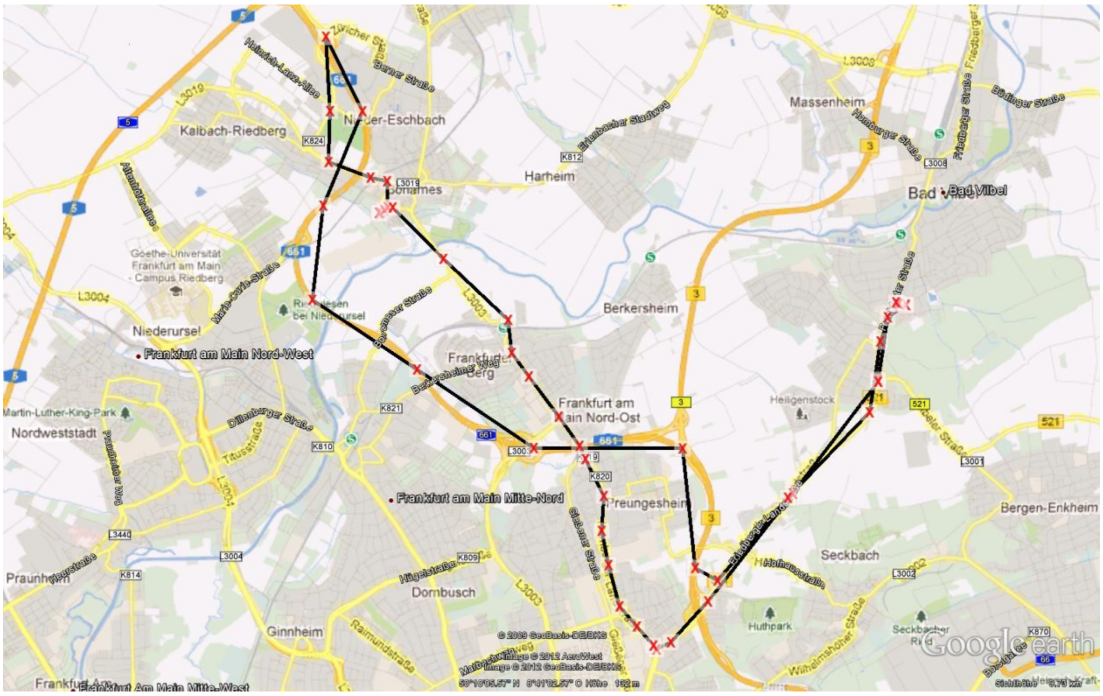


Figure 8 The second alternative route using a car to get to and from work

Even as the way from the home to the workplace sometimes differs (e.g., construction sites or traffic jam) they are geographical close to each other. This is visible if we put the daily routes together on one image (**Figure 9**):

Figure 9 Combined GPS tracks day for the working week (days 1-5)

Even after adding the GPS tracks with the alternative routes (**Figure 10**) it is clearly visible that there is a daily routine / regular movement pattern which can be used to provide location based recommendations even ahead of time as it can be estimated at what time the driver will be in which area. This is due to the fact that most employees have fixed working hours / core time.

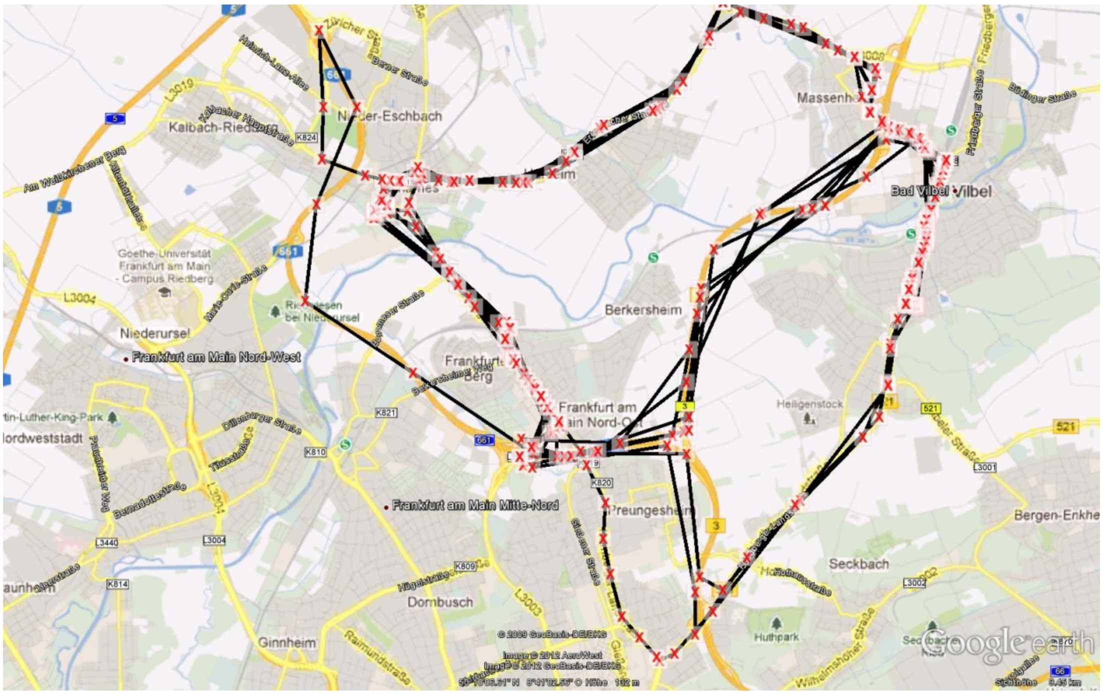


Figure 10 Combined GPS tracks for the working week plus the alternative routes

By adding the alternative routes it is visible (**Figure 10**) that the geographic distance is not to big that the "average" way used can be used for location-based-services recommendations as the car driver can divert his way if the recommendation is really interesting. The GPS tracks also provide information about the time the trips happened so that a time bracket for the way to and from work can be stored and used in the recommendation process.

The following GPS tracks show one (working) week of the volunteers (**Figure 11** - **Figure 19**):

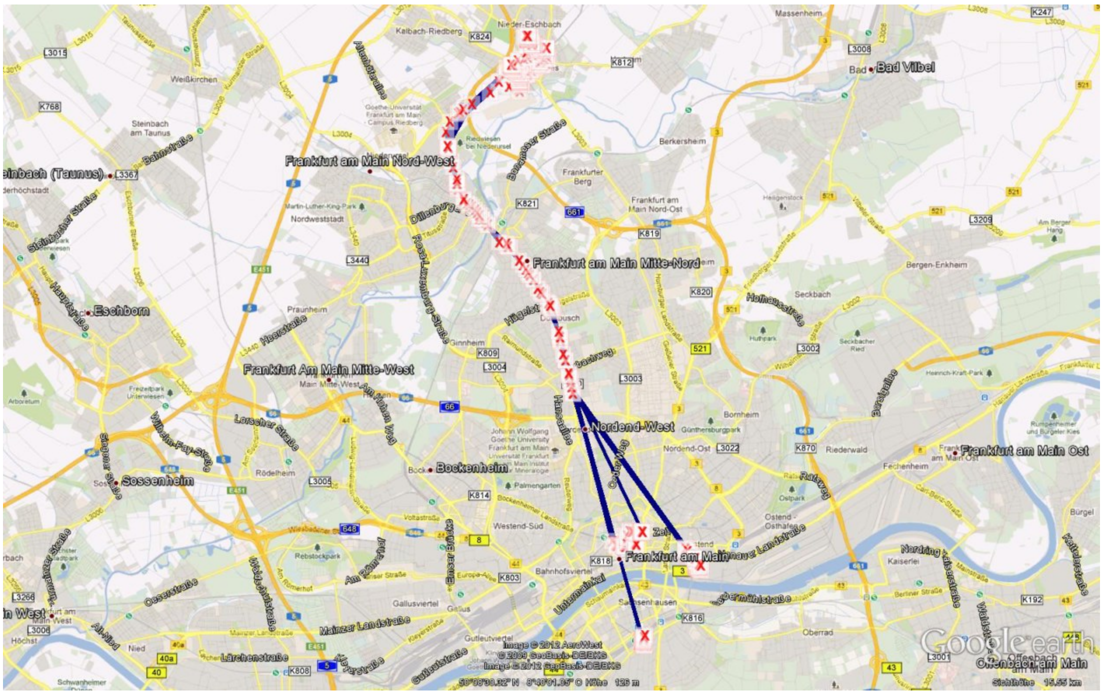


Figure 11 Volunteer 1 – studies in the City of Frankfurt

The next volunteer (**Figure 11**) is using the subway on a daily basis to get into town. The endpoints of the trips differ a bit but this is due to different places the work happens. The majority of the way is the same. If the different endpoints happen regular on the same days this could be used as well for location based recommendations based on the historic movement pattern stored by the system. The same volunteer at a different time shows again very similar movement pattern plus a movement between the sites in the town (**Figure 12**):

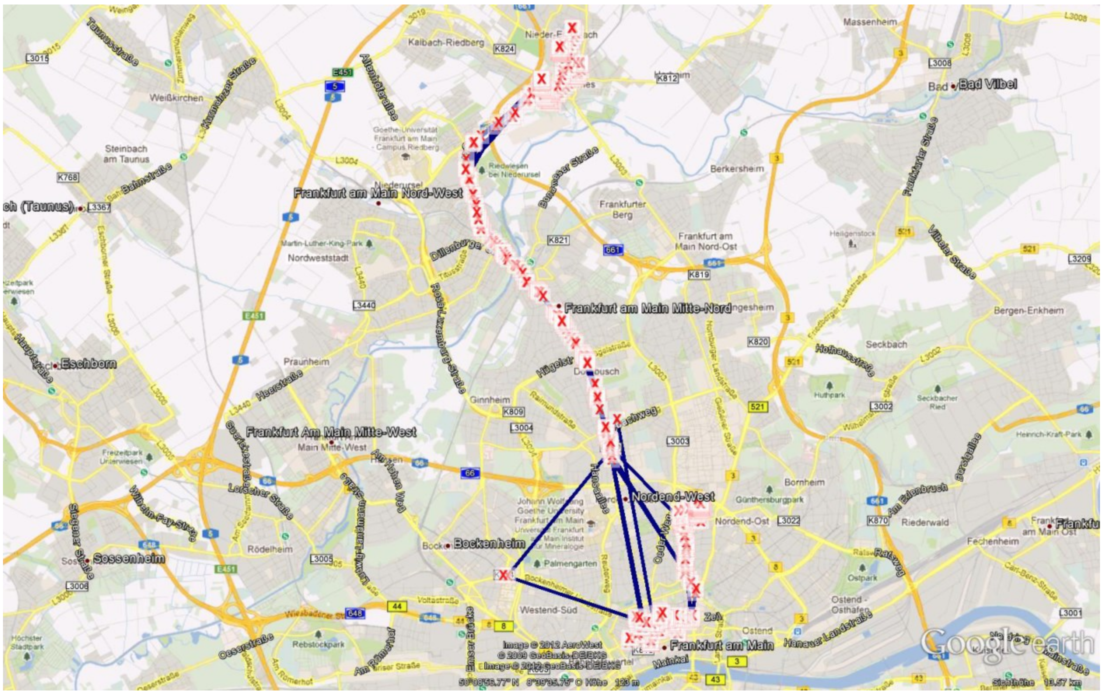


Figure 12 Volunteer 1 second recording – changes in schedule / locations

The next volunteer recording (**Figure 12**) has a very long way to work which is resulting in the use of the German autobahn which ties the volunteer to a certain route used daily:

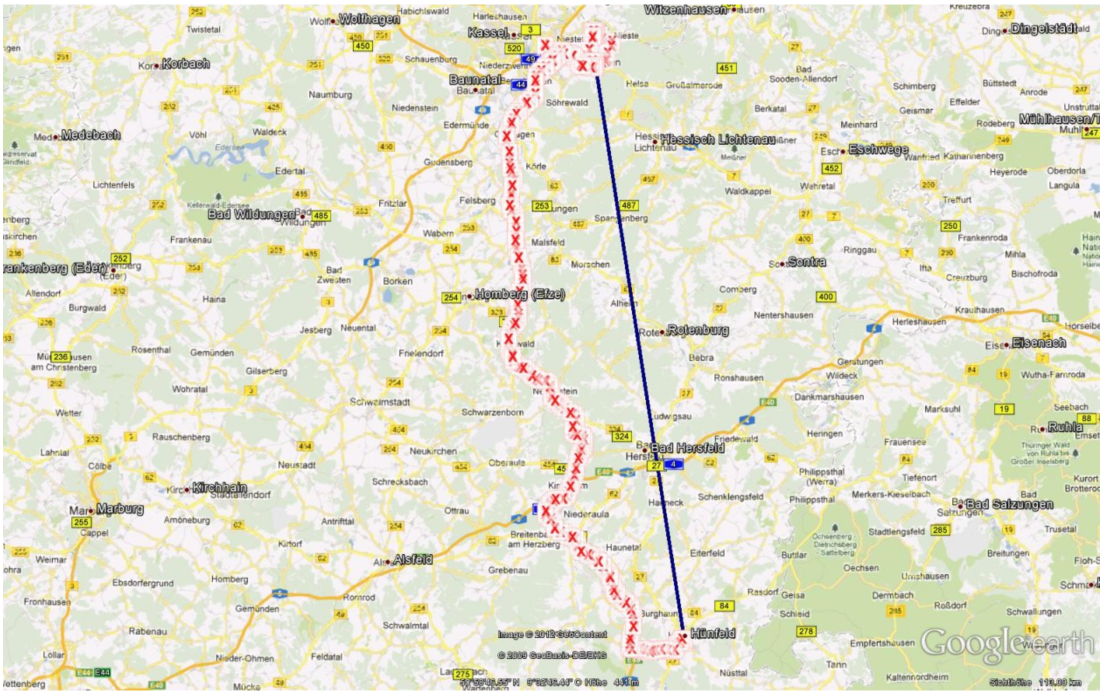


Figure 13 Volunteer 2 – office worker – daily use of the Autobahn

The following volunteer (**Figure 14**) is also heavily depending on the use of the public transportation. The main differences are the fewer endpoints. The two extra endpoints areas could be a sports ground or other social site visited on a regular basis.

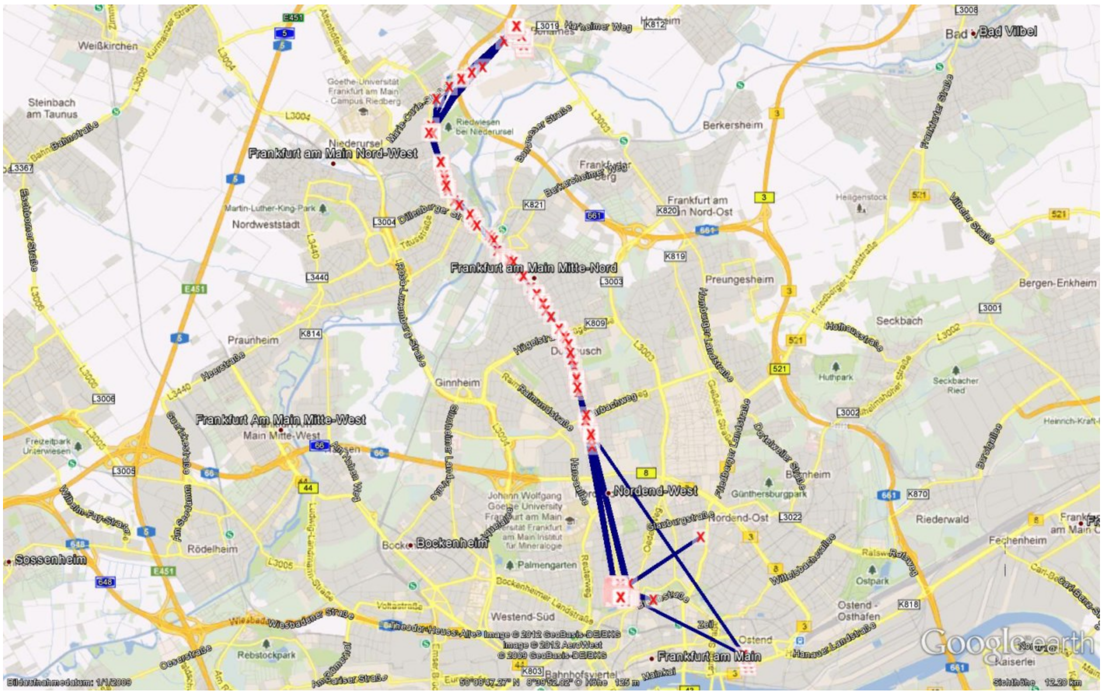


Figure 14 Volunteer 3 – IT administrative worker – daily use of the Autobahn

The next image (**Figure 15**) shows the tracks of two volunteers which have the same workplace but live in different locations. They both used the GPS device for one week. The image again shows clearly the usage of the autobahn.

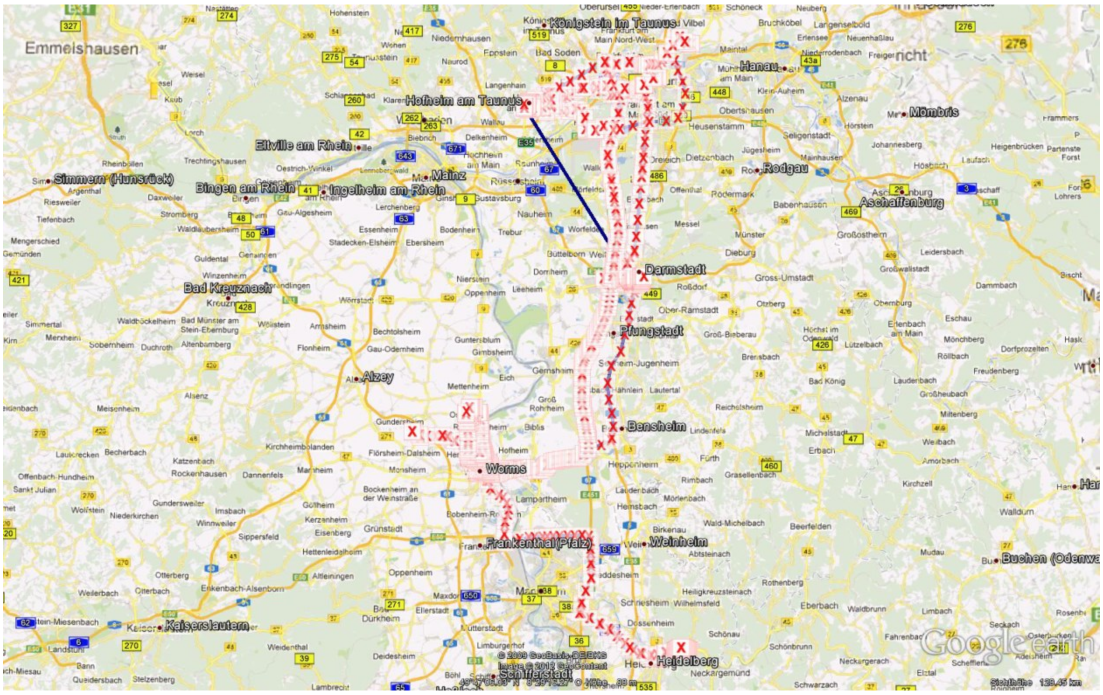


Figure 15 Volunteers 4 & 5 – students in the same degree programme

The following volunteer is also a user of the autobahn and has only a slight variation the daily way to and from work (**Figure 16**):

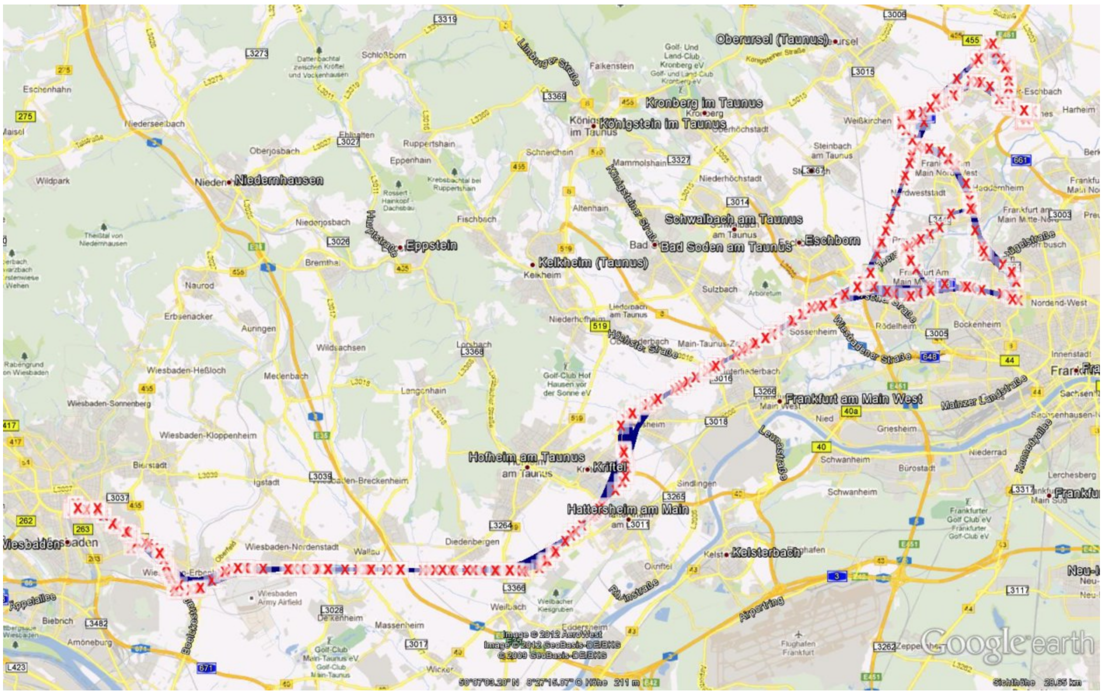


Figure 16 Volunteer 6 – project manager working onsite

If we have a closer look at the variations it is visible that this alternative way is used only once and might be caused by shopping or other after work activities (**Figure 17**).

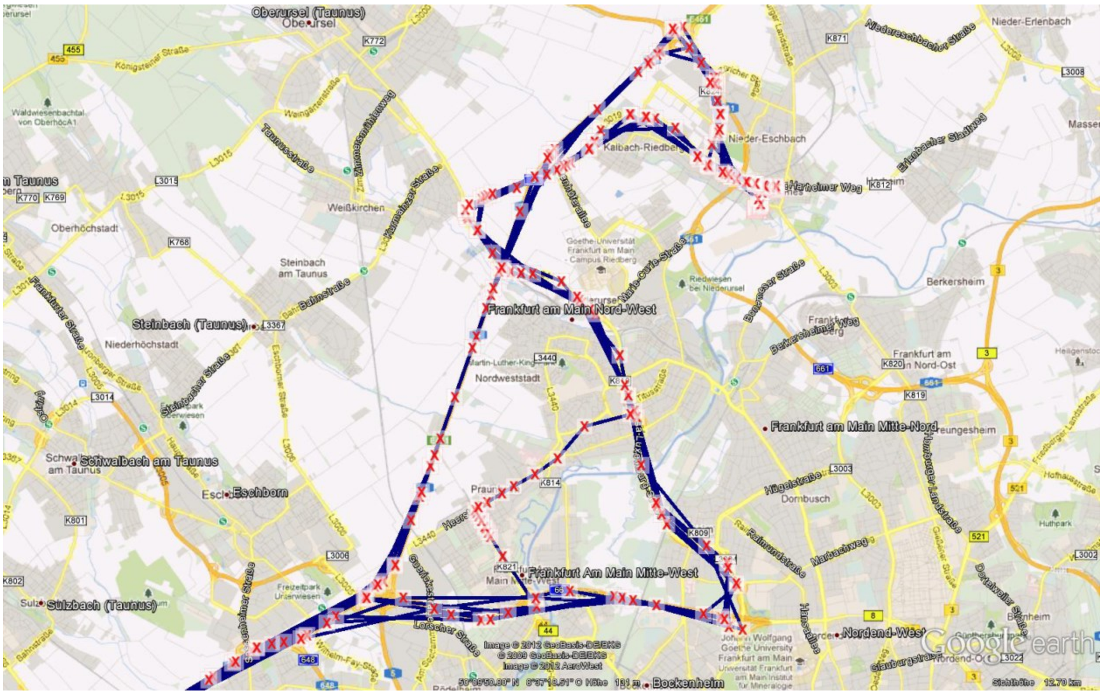


Figure 17 Volunteer 6 - close up of variations around the home (e.g., shopping)

Another volunteer is also a user of the German autobahn (**Figure 18**). The "outbreak” at the last day of recording of the routine GPS tracks was caused on a Saturday when the volunteer forgot to turn of the GPS tracker device at the weekend. This is the single route leaving the routine tracks towards the north and leaving the shown map.

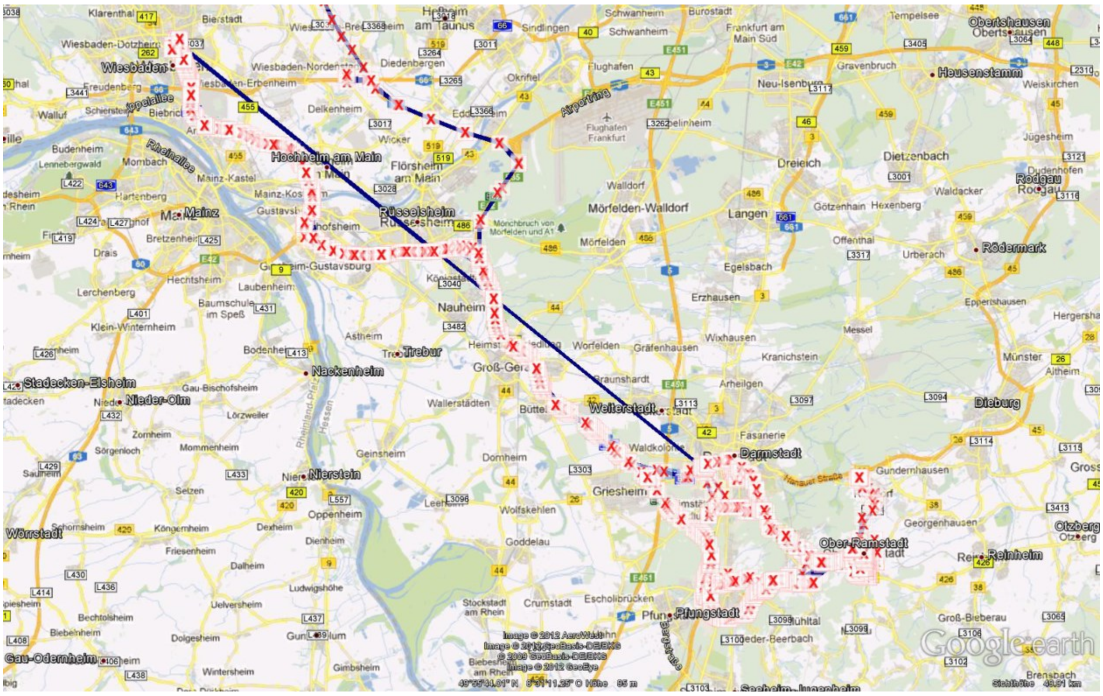


Figure 18 Volunteer 7 – IT programmer – working at development center

The last volunteer (**Figure 19**) is also using the German autobahn for going to work. As the recorded GPS data shows the volunteer is driving on a very regular schedule.

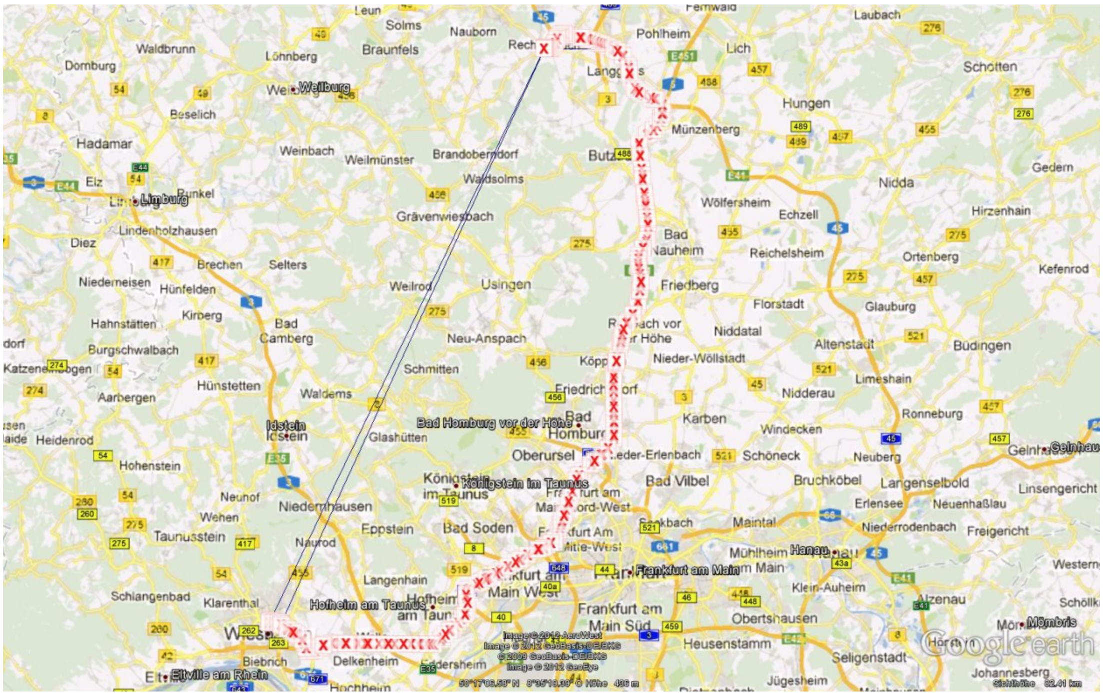


Figure 19 Volunteer 8 – office worker

Convincing people to participating in such an experiment is rather difficult as it requires a person which is willing to record his weekdays in a responsible way. At the beginning an open call for volunteers took place but did not yield any volunteers. In order to conduct the experiments the volunteers had to be recruited among friends, family and fellow research students.

The experiment shows that these eight volunteers show a rather regular daily routine movement pattern in their working week. In addition the experiment shows that the movement pattern also happens in regular time brackets which would allow providing recommendations based on the two dimensions time and location.

Other researchers have conducted similar studies or experiments and have drawn very similar conclusions (see section 2.1).

3.2 Transportation mode

A second experiment has been undertaken to evaluate if it is possible to estimate the mode of transportation based on the recorded GPS tracks. The GPS device used was the same as used in der working week recordings. Also the settings have been the same. Every experiment took approximately 5 minutes and different ways of transportation have been used. After the start of the device there was a one minute waiting time to allow the GPS device to start and receive information from the GPS satellites. The button of the GPS device was pushed to mark the start point. The route used was the same for the first experiments based on the streets in the neighborhood. For the public transportation tests the routes have been fixed by the train tracks or the route of the bus route used.

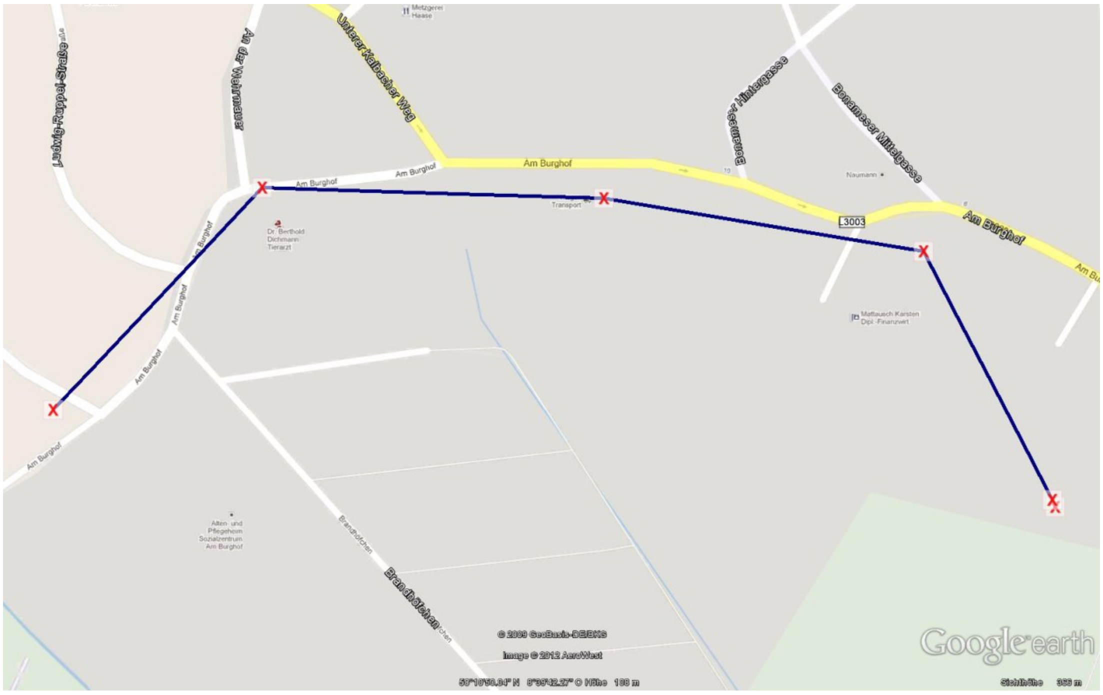


Figure 20 Walking Volunteer 1

The **Figure 20** shows the recordings of the 5 minutes normal walking by a volunteer. The time was taken by a stopwatch. The distance walked and the speed, in addition to the route taken, allows identifying a person walking.

The speed of the recorded GPS tracks is between 2.8 and 5.2 km/h. By using the geo coordinates the path can be distinguished between the street or a footpath (if they are available to the map application). By the speed alone the pedestrian transport mode cannot be clearly distinguished. There has to be support by using information from the map or by the user setting the mode. The same speed could occur by using a bicycle or car but a car could not drive on a walk way.

The next picture and table show the same experiment but performed by another volunteer (Figure 21).

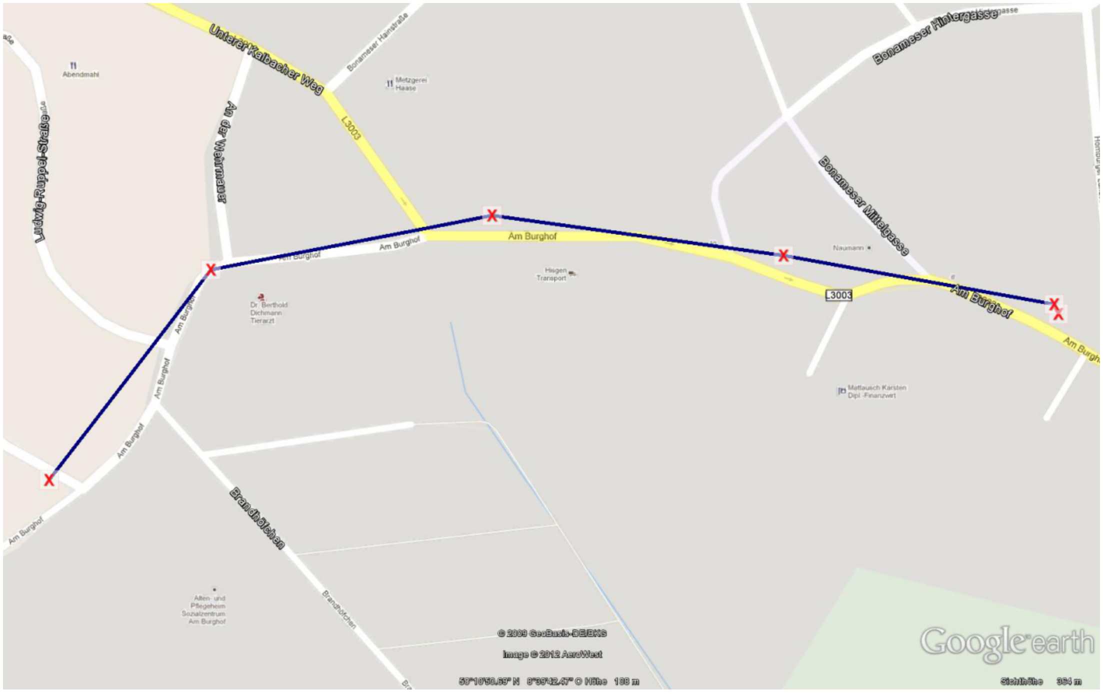


Figure 21 Walking Volunteer 2

As the speed is different the distance walked is different from the first experiment as well. The speed is between 2.1 and 3.8 km/h. The other factors mentioned above also apply here. Some other factors like the way used or footpath used can support to distinguish if the GPS track is from a person walking or riding a bicycle very slow.

The next image (Figure 22) shows the experiment performed by using a bicycle.

Figure 22 Bicyle

This experiment was conducted using a mountain bike. The speed was between 18.1 and 21.9 km/h. On the image (Figure 22) it is clearly visible that the latter part of the ride was done on a bicycle lane which runs parallel to the street. If the data of bicycle lanes and footpaths are kept in the map database it is easy to figure the use of walking or riding a bike. Besides the user set transportation mode a cradle on the bicycle handlebars could help to set the mode. In addition the speed is faster than a person walking or jogging. A small motorcycle or a car handicapped by traffic could produce a similar speed pattern but could be distinguished by a manual or system supported change of the transportation mode (e.g., phone in the cradle in the car, driving on the street instead of bicycle lane).

The next image (Figure 23)shows the experiment conducted with a car which was slowed down by the traffic conditions.

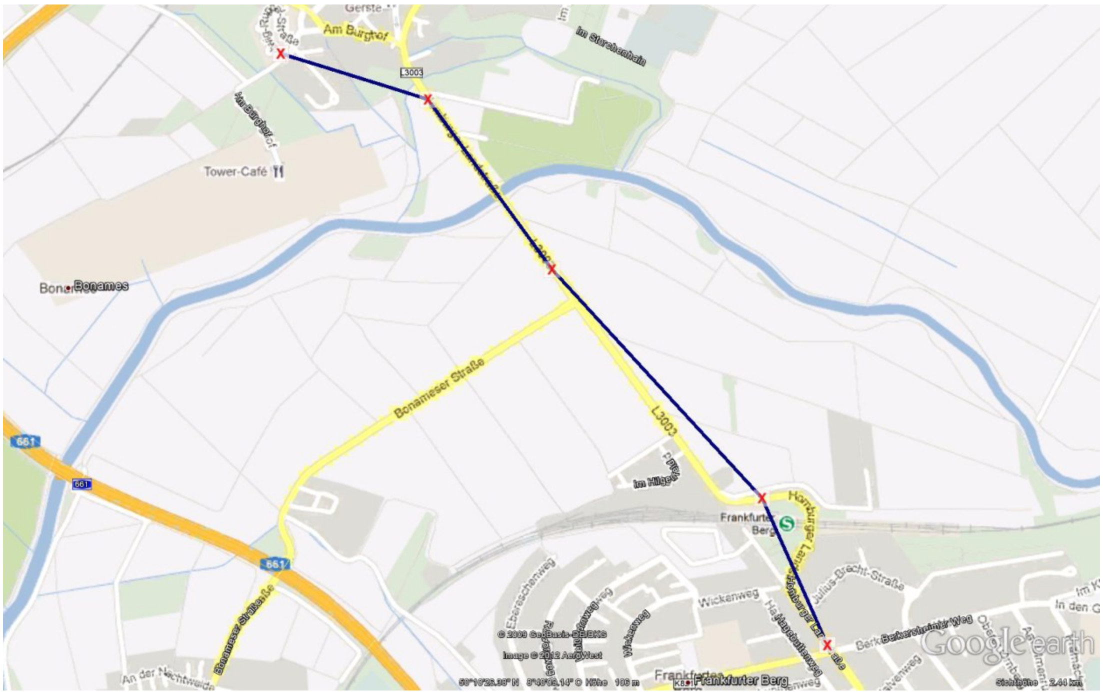


Figure 23 Car (with traffic disturbance)

The top speed of the car is 49.4 km/h and the slow speeds are the results of waiting at a crossing, traffice light or been slowed down by the traffic conditions. The distance between the recorded points are much larger then by walking or riding a bike. In addition the drive was on the street which would be an available information to the map applocation. Again a manual mode change or supported, for example, by the phone cradle in the car would support the setting of the transportation mode. After this experiment the same route was driven again but this time without been slowed down by the traffic.

Figure 24 Car (without traffic disturbance)

In this experiment the highest speed was 57.1 km/h and even the lowest speed was higher than the average speed of a pedestrian. The recorded GPS coordinates for the route are solely on a street.

The next image (Figure 25)) shows three short trips on the public transportation system. Two subways and one bus have been used.

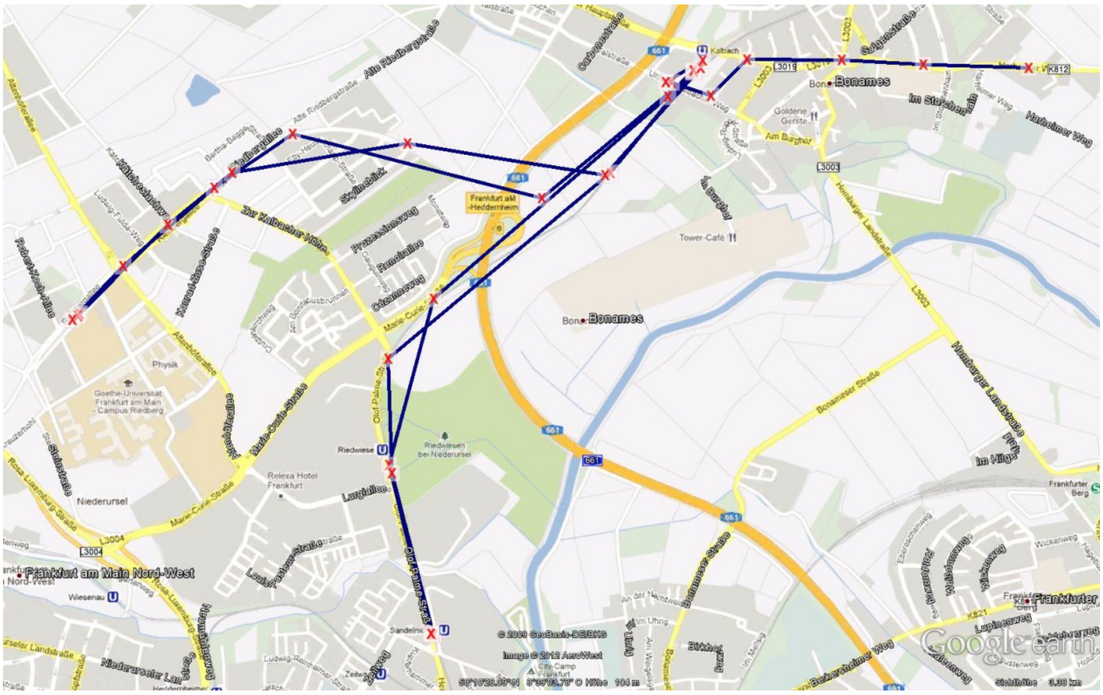


Figure 25 Public Transportation (Subway U2, U9 and Bus)

The button of the GPS tracker was pushed at every stop of the trip. In the average five minutes experiment a distance equivalent to two stops could be reached. The GPS tracks show for the train / subway a trip in both directions whereas for the bus ride only one direction was recorded. The speed is varying and the subway can be distinguished by the use of the train tracks, that is, geo coordinates, or by the use of an eTicket or manual setting the mode by the user. Similar to the bus the train tracks sometimes run on or parallel to the street which could make it difficult to decide if the user is using a car or the bus / subway. Another factor to consider is that recommendations for the user should only be located within walking distance of a station as it usually is not possible to hop off the bus or train.

3.3 Summary

Based on the experiments or recordings and the work of other researchers or research projects (see 2.1 User location and recommendation services) it can be shown that not only the regular (daily) movement patterns but also the mode of transportation for a user can be detected and therefore used in a recommendation system. For a real world implementation the algorithm's used would have to be fine-tuned and optimised for this usage but based on the existing research works it is fairly possible to get not only promising but also useable results for a real world implementation. For the prediction of the whereabouts of the user the past movement patterns can be based on time-brackets and estimated for future time-brackets to predict where the user might be at that point in time.

Detecting the transportation mode, the speed and whereabouts is important to allow the system to tailor the delivery of the recommendations or notifications to the situation of the user. If someone is driving the handling of incoming information has to be treated different as if someone is walking or using a bicycle or the public transportation system. This includes the distance a notification has to be send ahead of been in the area of the recommendation. For example a car navigation system announce a turn or motorway exit several meters or kilometres ahead to give the drive a chance to react. The experiments showed that, under consideration of the literature and research works mentioned, the idea of using GPS trajectories can be utilised for identifying the transportation mode, the speed, route, regular (daily) movement patterns and direction. Therefor these variables can be used for a proactive recommendation based on the predicted (future) location of the user. Even if the (mobile) user does not travel every day at the same time the (daily / regular) routine support the prediction of the (future) whereabouts. Based on these results, the presented literature and the research projects the concept of MDP gets the necessary groundwork and support that it is feasible.

The next chapter investigates the awareness and acceptance of end users towards such a system via an internet based survey.

4 Surveying user awareness and acceptance of LBS

In order to find out the users perception towards a new and unique concept called Multi-Dimensional-Personalisation (MDP) which is an extension to push based Location Based Services (LBS) recommendation services which adds more dimensions like the use of historic (daily and regular) user movement patterns and the interests of the user a survey of potential mobile end users was conducted. The aim of the survey was to investigate the extent to which users are aware of 'location-based' recommendation services and their perception of such services. At the time of the survey (in 2009) there have not been may pull or pushed based LBS available. Some services offered location based pull services for restaurants or taxis or have been in experimental stages (like virtual tagging / sticky notes). Other academic research projects have been described earlier.

Nowadays there are different categories of pull and push services like location check in games (Facebook / Gowalla, Foursquare, Google Latitude etc.). These apps or web sites can also be used to notify friends (and followers) about the whereabouts of the user (or automatically spread this information via social networks). Other services are built as location based reminders for the users which issue a notification when a user reaches a certain area or destination (as describe earlier, based on geo-fencing (user or application sets reminders), for example like Georeme). There are services like Xtify (Xtify, 2012) which offer for application developer a platform so that they can enhance their applications with location based or geo-fencing functionalities. The tools provided allow the application to collect user movement and preferences so that MDP like applications could be build. The main difference of MDP is that it is proposed as a platform which allows multiple advertisers or information providers to address all users with a matching profile then rather having these functionalities build into every single application itself. In addition the user would have to take care of the settings and security issues for every Xtify-ied application by itself whereas for MDP there would be one place to control many sources of information.

In order to do so the questionnaire of the survey was developed by the research in discussion with fellow researchers and sent to the Faculty of Science and Technology Research Ethics Committee from the University of Plymouth for approval. The survey was undertaken completely anonymous. On the analysis of survey results, all participants will be referred to as User1, User2 etc. or in the form of an aggregated result set spread over the possible answers. The survey questionnaire can be found in the appendix.

The volunteers, in other words, the participants have been invited by word-of-mouth recommendation, topic specific mailing lists, special interest groups & forums, and the invitation from / by fellow researchers.

The survey was divided into the following five sections:

- General Questions about the participant (Questions: 1 - 7)
- Technologies (Questions: 8 - 10)
- How is your trust relationship to ... (Questions: 11 - 20)
- How is your privacy preserved at ... (Questions: 21 - 30)
- 'Location-Based' Service (LBS) awareness and interest (Questions: 31 - 36)

The thirty-six questions consisted of controlled vocabularies (Drop down boxes, questions: 1 and 4), single choice question (radio button, questions: 2 - 3, 5 - 6, 11 - 30) and multiple choice questions (check boxes, questions: 7, 8-10, 31 - 36).

For the trust relationship questions (11 – 20) a Likert scale with the following five Likert items (Likert, 1932) have been used:

- ++ is a strong trust relationship
- + you have some trust
- 0 is neutral
- - you have some doubts
- - - no trust

For the privacy preservation questions (21 – 30) a Likert scale with the following five Likert items (Likert, 1932) were used:

- ++ strong protection of you privacy
- + you privacy is protected
- 0 is neutral
- - you have some doubts about the protection of your privacy
- - - no protection of you privacy

The answers to the questionnaire have been collected over sixteen weeks, between 3rd of August and 16th November 2009. A total of 125 volunteers answered the questionnaire. In the discussions that follow, unless noted otherwise, all volunteers answered all the questions.

During the evaluation of the results of the survey it became clear that the questions regarding the eLBS (Emergency Location based Services) did not add much value to the survey, to the requirements for MDP and this work so that these questions have been left out from the evaluation.

4.1 General Questions about the participant

This section is used to ask a few demographic questions to find out more about the anonymous participants. The questions covered age, gender, occupation, from which area (country / region) the person is from, their mobile phone and some information about their daily live (was from to work / study).

For the age question age ranges have been provided as a controlled vocabulary.

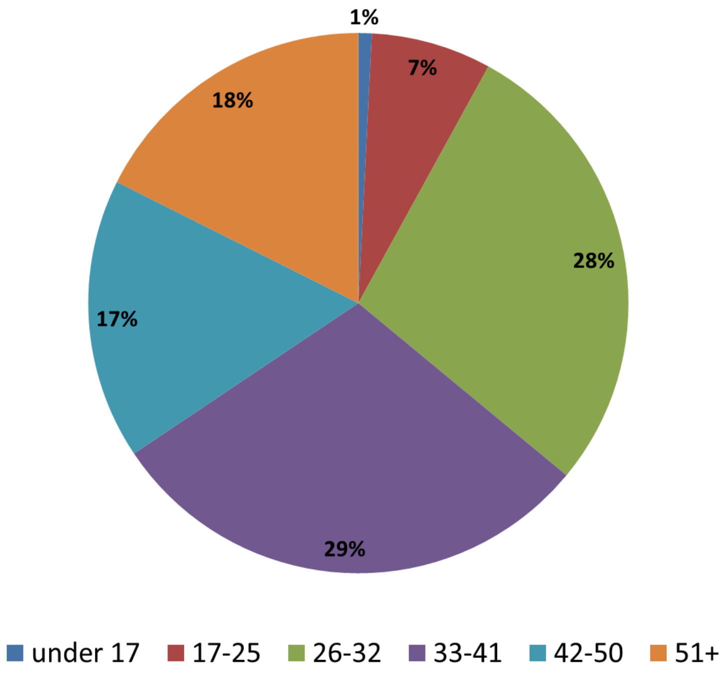


Figure 26 Age distribution of the participants of the survey

An interesting fact about the participants of the survey is that the younger potential users (aged below 26) have been represented by eight per cent whereas the more mature users present more than 50% of the participants. Even the so called silver surfers (in this case 51 years and above) have participated with more than twice the number then the younger users. This fact might have been caused by the unwillingness to participate in such internet based surveys. In addition the survey might more appeal to a more mature audience working in the mobile commerce and location based services research field. Another factor could have been the choice of the mailing lists, special interest groups and forums used for the distribution of the announcement of the survey.

The second question was asking to the gender of the participant.

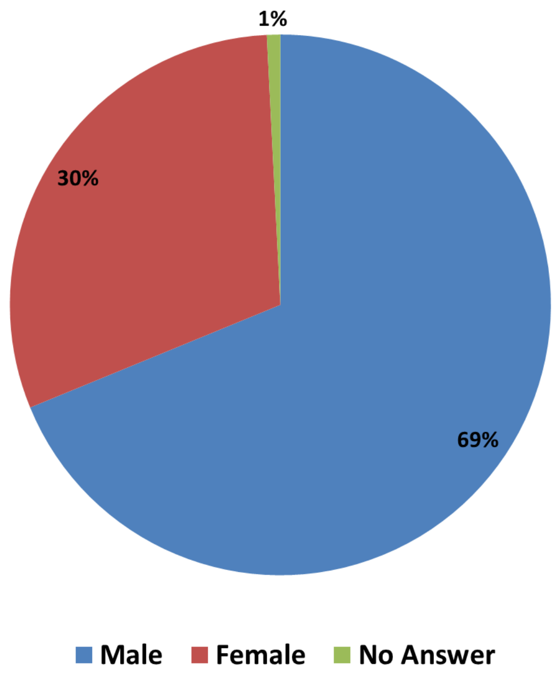


Figure 27 Gender distributions of the participants

A 30% share of female participants in Figure 27 Gender distributions of the participants does not represent their share in the population but might be also caused by the ways chosen for the announcement of the survey.

The next question requested a statement from the participants about their occupation.

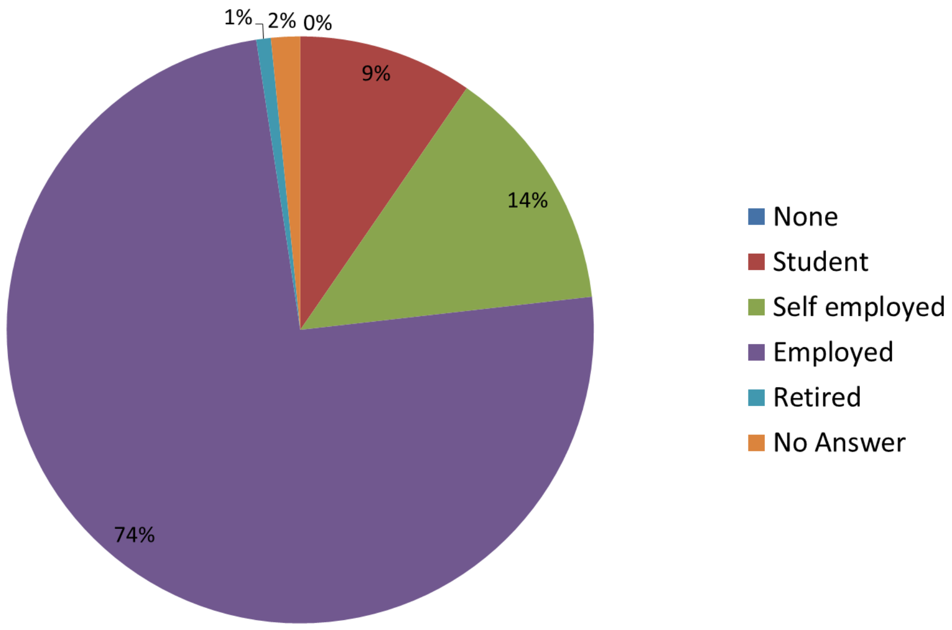


Figure 28 Occupation of the participants

The majority of the participants are employed or self-employed which would match the age ranges. In addition this could be seen as a target audience which could have a certain budget spare for, for example, smart phones and location based services.

The next question asked for the area the participant is from. A more detailed chart / table which is listing all the countries and the possible choices in the controlled vocabulary can be found in the appendix. A Chart summarizing on a higher level is presented here (**Figure 29**).

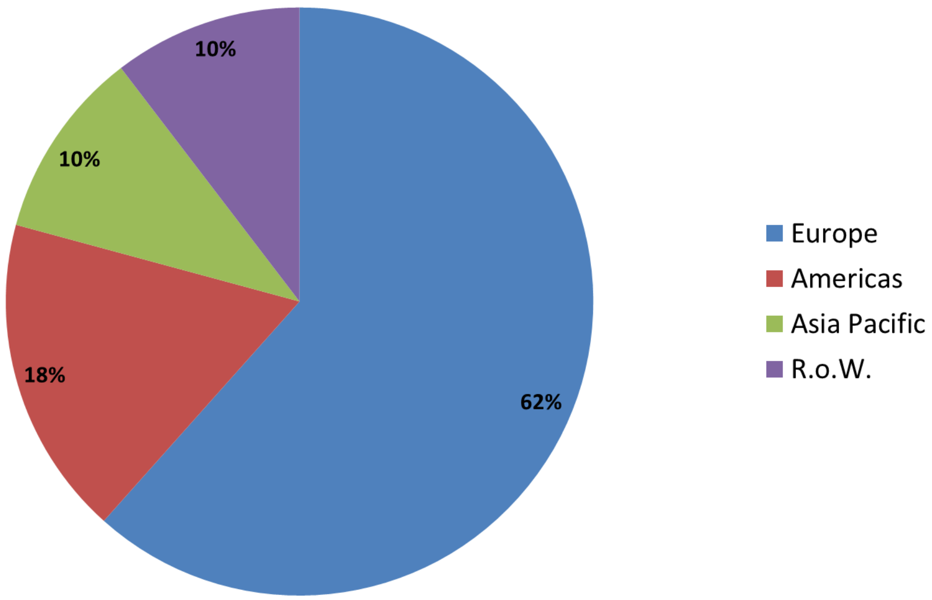


Figure 29 Origin from the participants (areas) - high level summary

The main region for the participants is Europe with 62%. This could also result from the way of promoting the survey. The next large areas are the Americas (18% - North and South America etc. combined). Asia Pacific and R.o.W (Rest of World) account for the last 20% of the participants of the survey. The drawback for the results of the survey could be a stronger focus on ideas and the actual situation in Europe then on the other regions of the planet.

The next question tried to find out if the participant is a possible client for the proposed service by asking for their phone usage (**Figure 30**). The controlled vocabulary allowed the following choices to the question if the participant owns a mobile phone and about their average phone usage. This question was answered only by 124 of the participants.

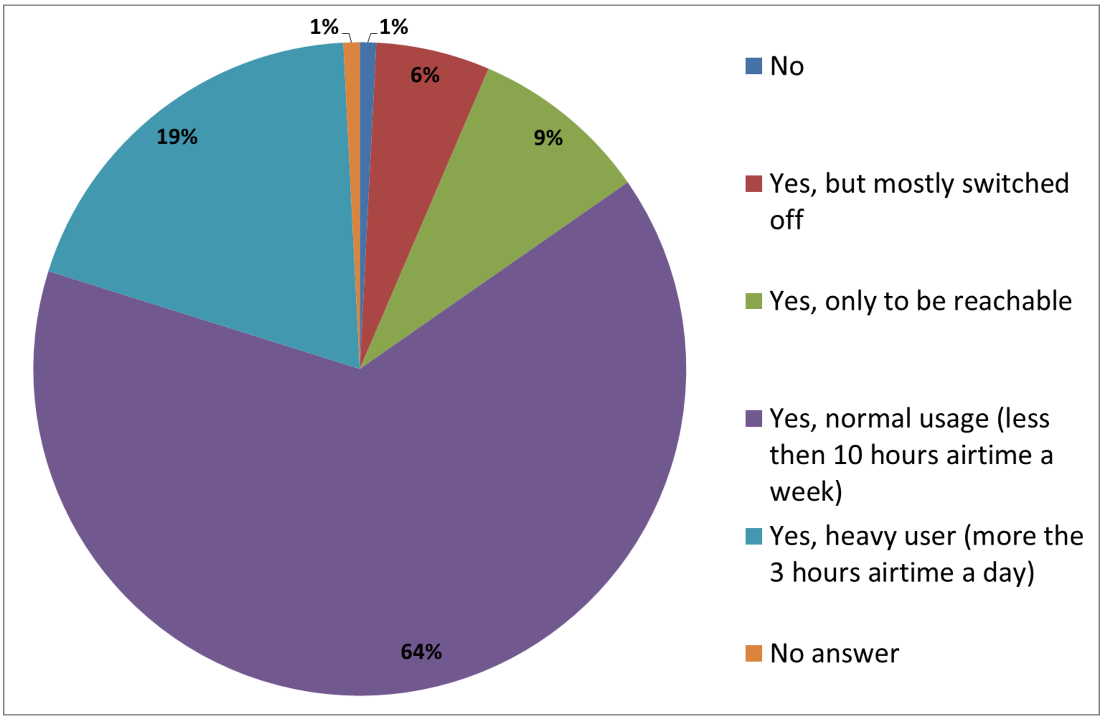


Figure 30 Phone usages of the participants

Judging from the results the most participants consider themselves as normal users of the mobile phone. 19% even consider themselves to be heavy users. Another interesting question which was needed as background question about the participants was to find out about their way of moving, for example, between home and work / school or university (**Figure 31**).

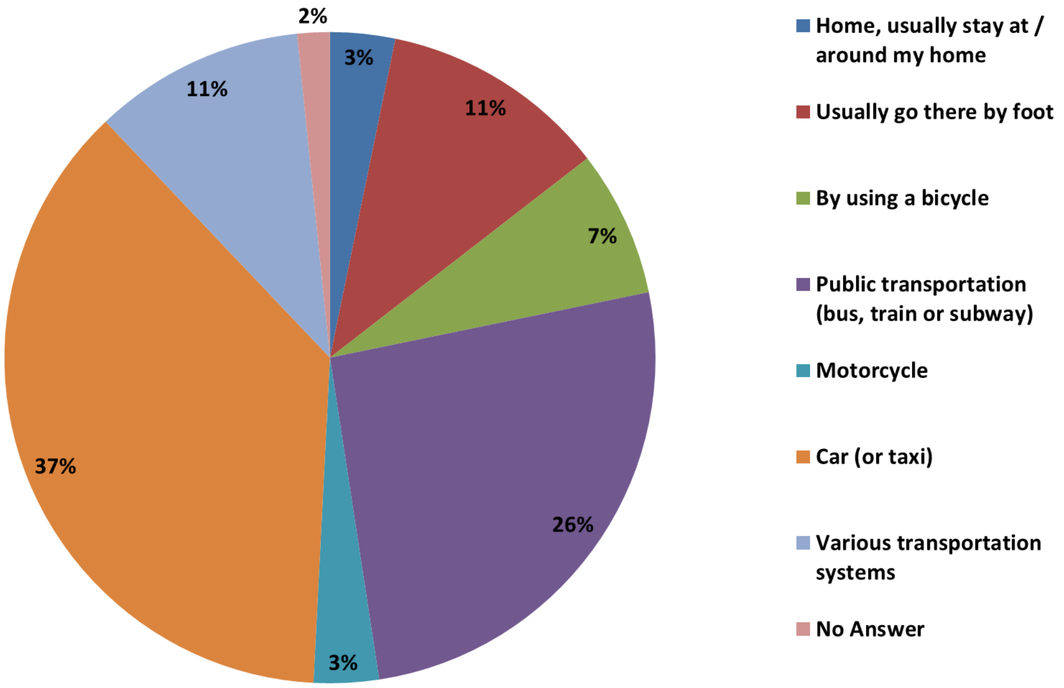


Figure 31 Transportation mode

This question was answered by 124 participants. This distribution of the available or used transportation mode shows that the different transportation methods are all good represented. This will allow us to use the results from the survey as a representative sample.

In order to know which features of their mobile phone are available to the survey participants the next question allowed them so select none or more features for the following list. The percentage is calculated from all answers given (see **Figure 32**).

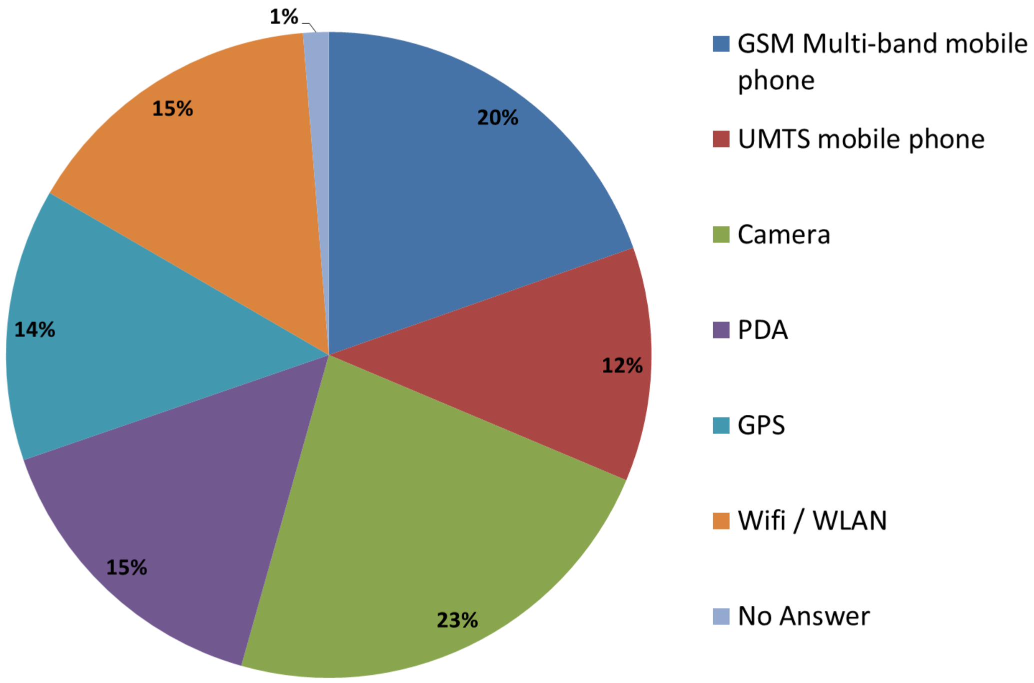


Figure 32 Available (mobile phone) Features to the participants

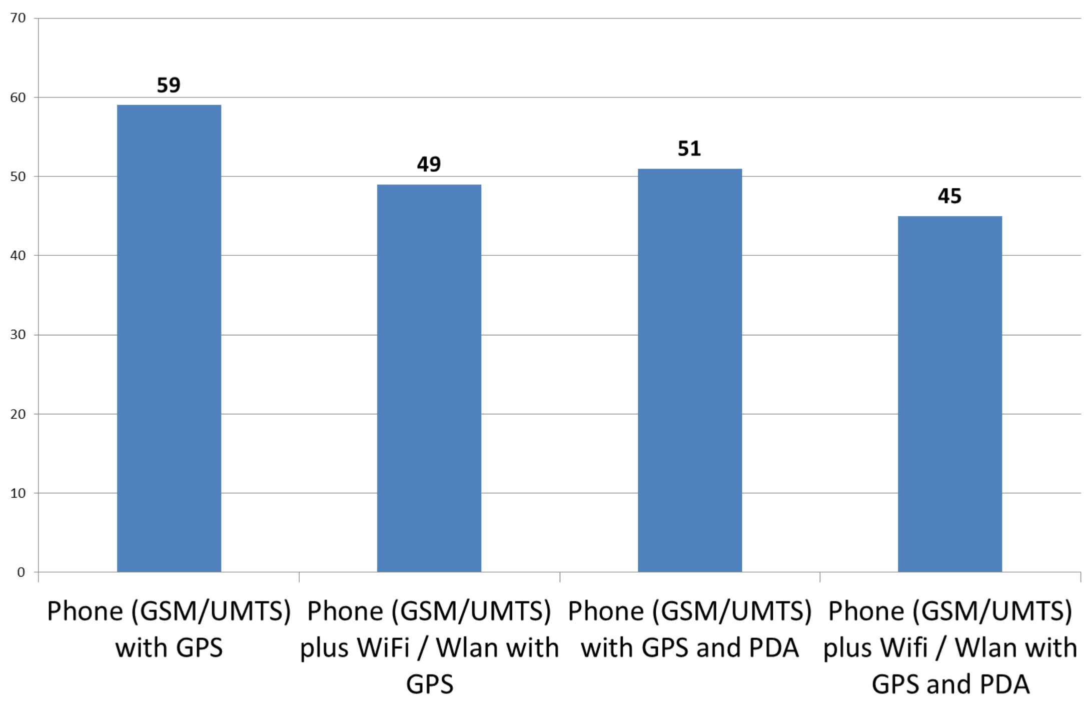


Figure 33 Feature combinations of the Mobile devices

The chart (**Figure 33**) tries to group the answers together in a form that it is visible which of the phones could be described as a smartphone. Therefor qualifying for the use as client for Multi-Dimensional-Personalisation (so at least a location devices (like GPS) and an internet connection (regardless of the speed) is available via the device to the user).

The chart clearly shows that even in 2009 the number of mobile devices, that fall into the smartphone category, and would qualify for the use as Multi-Dimensional-Personalization client because of the available features is high. Nowadays the number of smartphones in the market is increasing in six digit figures everyday (counting only the Apple iPhone and Android devices, see **Figure 34**, **Figure 35** and **Figure 36**). In general the trend in the mobile phone industry is going more towards powerful devices like smartphones and tablets. Especially value added services require the use of smartphones. A new value stream are nowadays, for example, the mobile app(lication) sales.

The technological platforms needed for MDP are smartphones or similar mobile devices. If we look at regional or global sales figures (see **Figure 34**, **Figure 35** and **Figure 36**) a positive trend towards a dominant position for smartphones and mobile technologies like tablets can be identified. Therefore, from a business case point of view, the market is prepared and the technologies needed for MDP are available to potential end users.

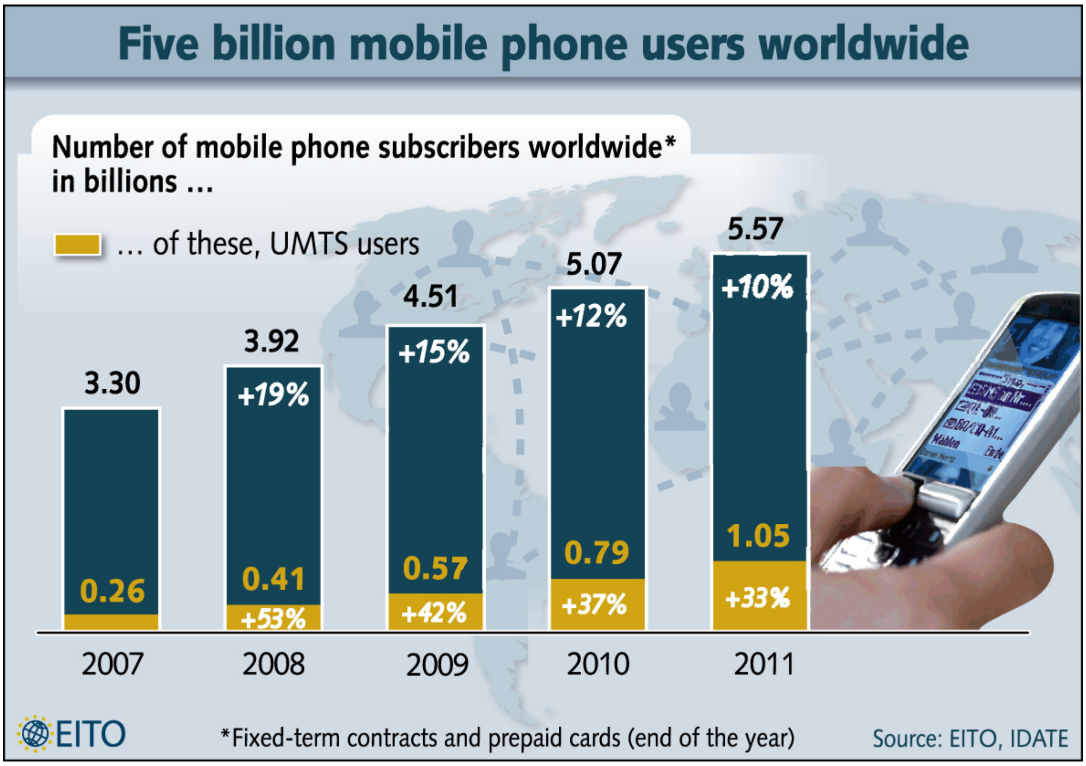


Figure 34 Number of smartphone user is rising

Source: Press release EITO ((Shahd, 2010), permission for use granted)

The number of mobile phone users is increasing with more than 10% every year and the number of these users which have a high speed mobile internet connection is increasing at an even faster speed (at least 33%). In 2011 more than a billion users would have been able to use MDP.

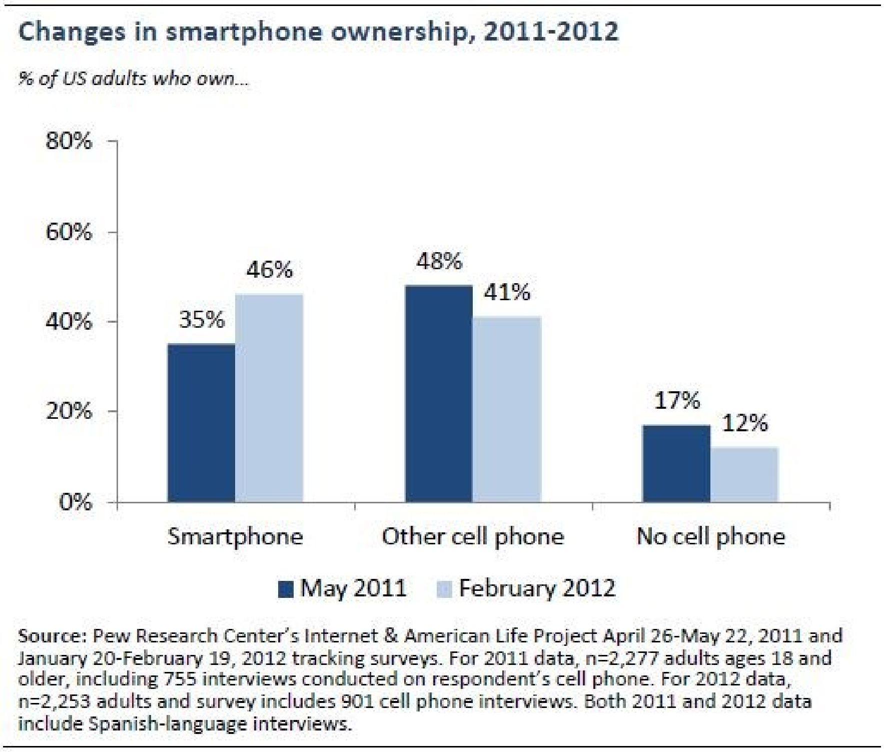


Figure 35 Number of smartphone owners is rising (US)

The Pew Research Center (Smith, 2012, permission for use granted) shows that in their study (by doing a poll) that in the US nearly 50% of all mobile phone users have a smartphone and therefore could be potential users of the MDP app.

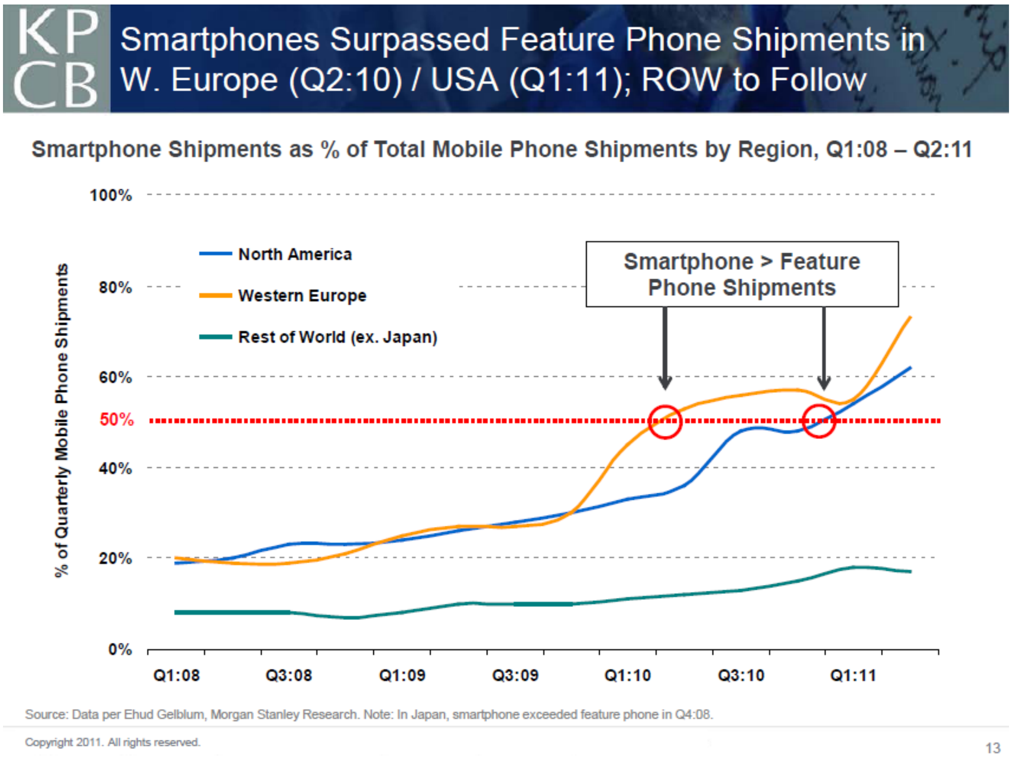


Figure 36 Smartphone penetration of the market

Source: Meeker, 2011, permission for use granted)

In **Figure 36** the market share of smartphones in Europe and the US are displayed. Since Q1 of 2010 Europe has a 50% market share for smartphone and the US followed in Q1 of 2011. Both market share curves are climbing and therefore the number of potential users for MDP as well.

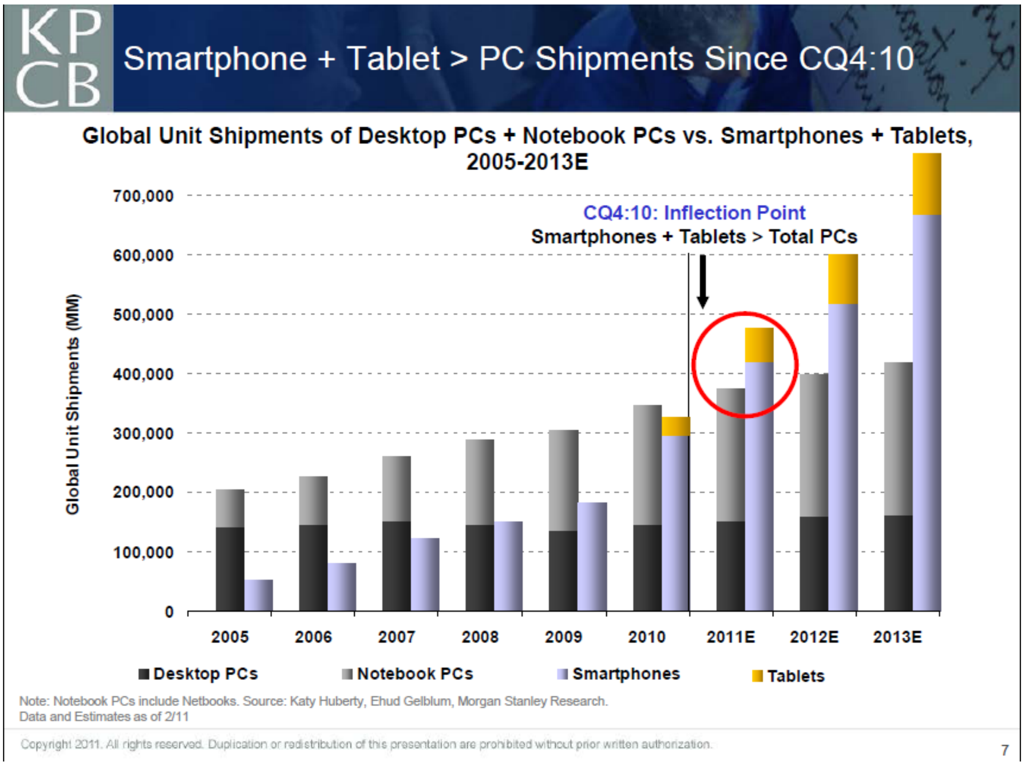


Figure 37 Mobile smartphone sale exceeds PC sales

Source: Murphy and Meeker, 2011, permission for use granted

The sales numbers of mobile devices (smartphones and tablet PCs) are increasing even above the sales numbers of desktop and notebook / netbook PCs (**Figure 37**). As tablet PC users are another target audience for MDP it is safe to say that there is a market potential. Considering that a user could use MDP on a notebook / netbook as well (maybe with some limitations) as a web site or application the potential market share extends even more.

4.2 Awareness of Technologies

In this section the aim was to determine the survey participants' knowledge about mobile phone technologies and services. They have been asked about the technologies that are available to them, the technologies the participant is actually using, and the technologies that the participant plans or wants to use in the future. A combined chart (see **Figure 38**) of the results is shown here and the separated charts for each question can be found in the appendix. The figures show the number of participants which have answered the question that they have a feature available, use it or plan to use it.

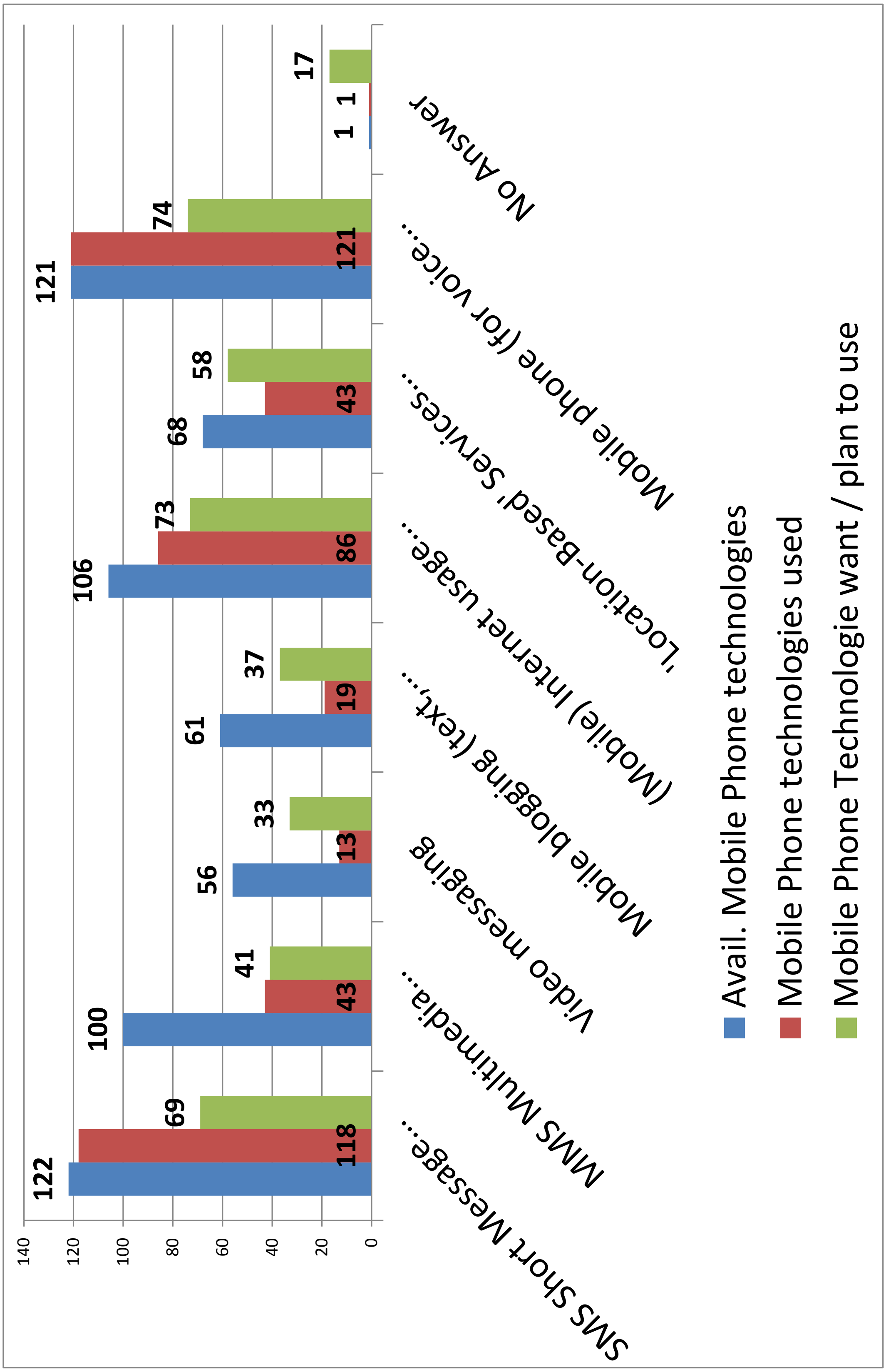


Figure 38 Available, used and plan to use Mobile Phone technologies

Some features or services show a clear increase in the demand or wish to use it by the participants (e.g., Video Messaging and Mobile blogging) whereas other services seemed to be less interesting in the future for the participants (e.g., SMS, MMS, mobile Internet and Voice Calls). During the survey the participants showed a clear interest in increasing their existing usage of location based services. This puts the participants in a good position to answer questions about such a new service like MDP.

4.3 Trust and privacy relationship

In order to provide such a service like MDP it is important to have a trust relationship to the user. This is necessary so that the user is willing to unveil personal data like location at / during a certain time and interests so that the MDP service can function and provide personalized location based recommendations. The organizations which have been presented to the participants are:

- Bank / credit card company
- ISP Internet Service Provider
- Web sites / ecommerce shops / portal
- Email provider
- Phone company (fixed / land line)
- Mobile phone company
- Search engine
- Location-Based' Service provider
- Public services or government organizations

The following chart (next figure) shows the combined results from the survey participants. The single charts for each organization can be found in the appendix. The participant could express their trust relationship on the following Likert scale by choosing the Likert items (Likert, 1932):

- is a strong trust relationship (dark blue)
- you have some trust (red)
- is neutral (green)
- you have some doubts (violet)
- no trust (light blue)
- No Answer (orange)

The lower parts of the bar in the chart (**Figure 39**) represent the positive / trustworthiness of the organization (blue and red) whereas the upper part of the bar presents less trust or a negative impression (violet and light blue) of the organization regarding the trust of the user to them. The green part of the bar represents a neutral position of the user in trust aspects towards the organization.

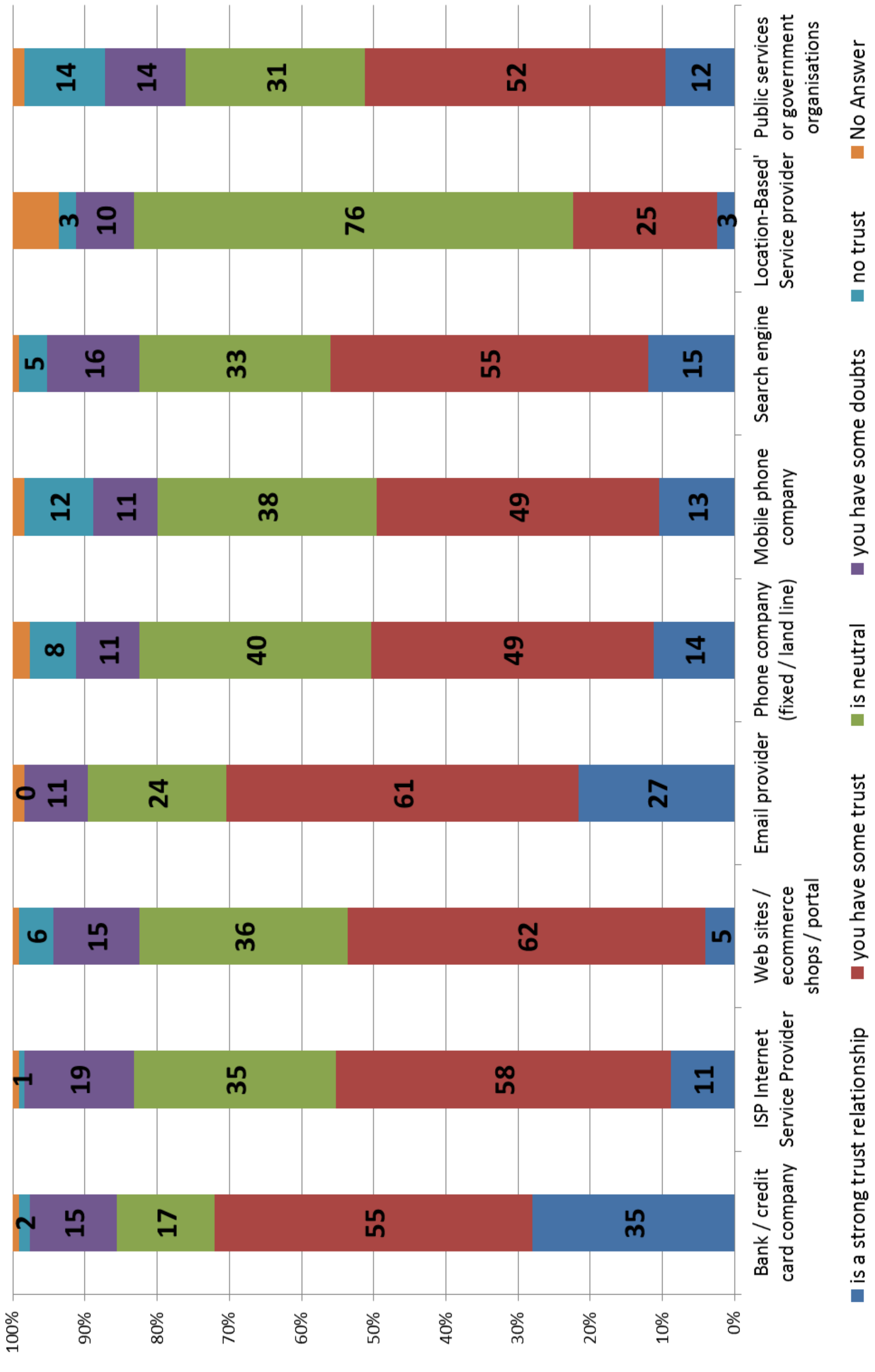


Figure 39 Trust and the Organizations

If we rank the organizations based on their combined positive trust rankings we get the following list:

Rank Organisation

1. Bank / credit card company
2. Email provider
3. Search engine
4. ISP Internet Service Provider
5. Web sites / ecommerce shops / portal
6. Public services or government organizations
7. Phone company (fixed / land line)
8. Mobile phone company
9. Location-Based' Service provider

This ranking shows that the participants rather have a strong trust in their bank or credit card organization. This might be the reason as this area is traditionally a trust based business and an essential for everybody. It can be assumed that the Email provider shares some secret and personal information with the user so that there has to be a certain deep trust relationship between the user and this service provider. As the major search engine (worldwide) is Google it can be kind of safely assumed that the participants had them in mind when they gave their marks in this section. As Google and others provide more services then search nowadays the provisioning of MDP services could be done by them as well. The ISP (Internet Service Provider) is providing the connection into the internet with all actions of the user can be logged and therefore monitored. This goes beyond the ISP as target audience and interested based (i.e., analysis of the content of a page where the advertisement is presented) advertisement is very common nowadays.

A lot of users today have a kind of trust relationship with certain web sites or portal (e.g., forums or bulletin board systems) and shop frequently at ecommerce sites which also require a trust relationship to the company which runs this online shop. So it seems to be a possible service extension for this type of organization to offer MDP services in the product portfolio.

Public Sector was included to see if a government organization could act as provider for a MDP service. It seems that this sector does not have the necessary reputation in order to provide such a service.

At the lower end of the chart we find the phone provider organizations with a nearly similar score but with a 17% / 18% per cent lower level of trust then the leading organization. But still with acceptance values about 60% it seems to be feasible that this companies could be a possible provider for MDP services especially as these type of companies nowadays provides both types of services (mobile as well as fixed / land line). In addition the knowledge about the mobile phone business and technology is available so that the provisioning of MDP services would be a feasible extension.

A surprising result is that the participants in the survey gave the worst marks to the Location-Based Service provider. It is can be assumed that this was caused by the fact that during the time of the survey in 2009 no real advanced LBS provider was available widespread or working and available LBS services have been in early stages. The high mark on the neutral answer (76/125), the second lowest rank in the have some doubts / no trust section (13/125) and the rather high number of "No answers" (8/125) would support this assumption. Some of the participants claim they do not like certain functionalites but later in the survey the results show that these funtions are nevertheless used by them.

The users have been asked how their perception is towards the protection of their privacy with these organizations.

On a Likert scale the possible answers, that is, Likert items (Likert, 1932) have been:

- strong protection of your privacy
- your privacy is protected
- is neutral
- you have some doubts about the protection of your privacy
- no protection of your privacy
- No Answer

The combined chart (**Figure 40**) is shown here and the separate charts for each organization are located in the appendix / CD. The lower parts of the bar in the chart represent the positive / privacy protectiveness impression of the organization (blue and red) whereas the upper part of the bar presents less protection of the privacy or a negative impression (violet and light blue) of the organization regarding the protection of the privacy of the user to them. The green part of the bar represents a neutral position of the user in privacy aspects towards the organization.

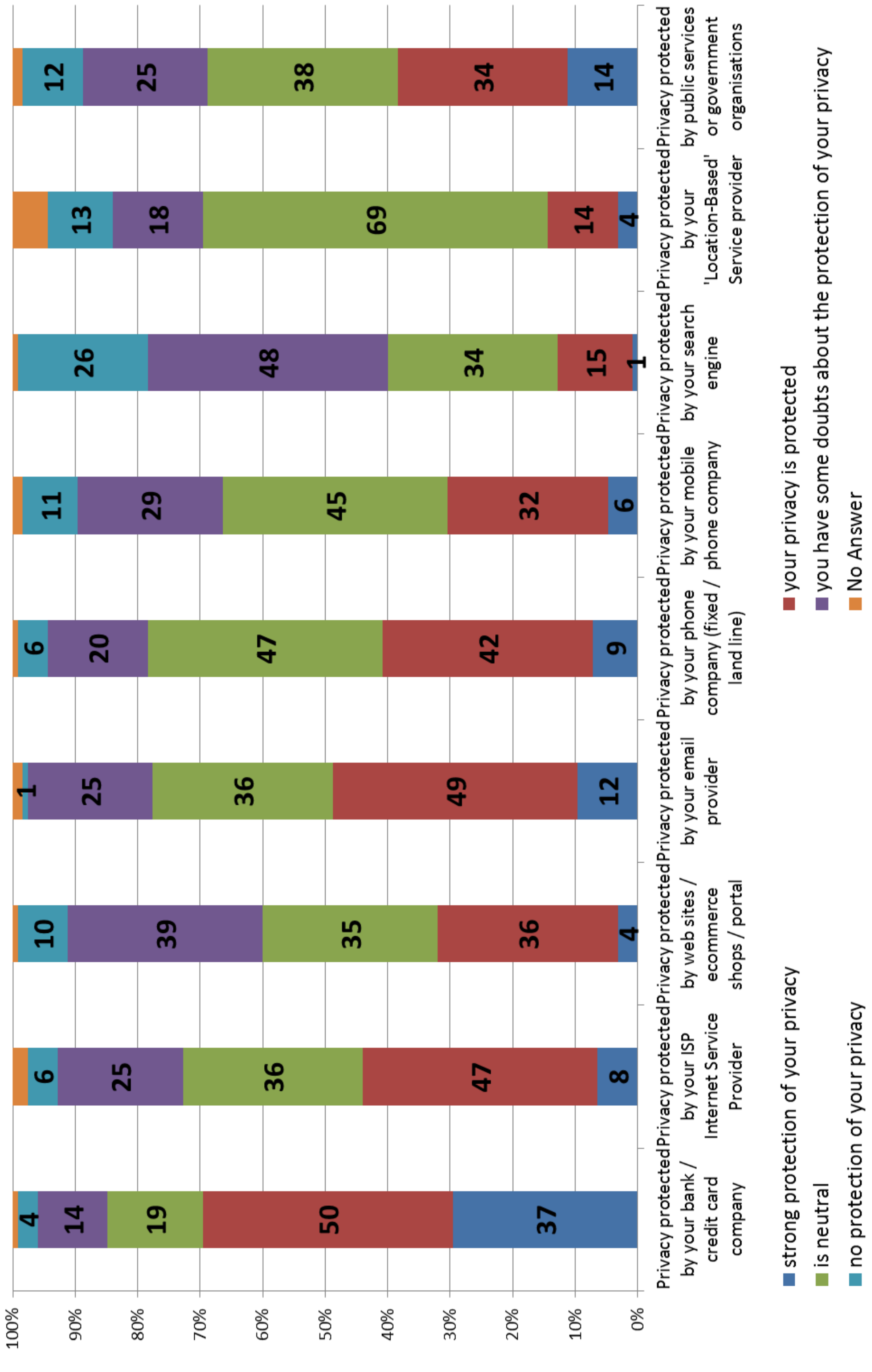


Figure 40 Organizations and privacy protection

After ranking the organizations based on their combined positive privacy rankings we get the following list:

Rank Organisation

1. Bank / credit card company
2. Email provider
3. ISP Internet Service Provider
4. Phone company (fixed / land line)
5. Public services or government organizations
6. Web sites / ecommerce shops / portal
7. Mobile phone company
8. Location-Based' Service provider
9. Search engine

It seems that the perception of the participants towards the "brick and mortar" organisation Bank / Credit Card company is that they are not only the most trustworthy organisation but also protect the privacy the best. The second choice is the Email provider which might be caused by the assumption that the privacy of correspondence is preserved as it is in the real world with the postal service. The infrastructure provider gains one rank whereas the search engine drops down to the last place. As the ISP transports every "move" the user makes in the internet it seems that even if sometimes "unspeakable things" travel via the connection the participants have the feeling that there privacy is protected. The phone provider actually gained three places so from this perspective it seems that the users have the feeling their privacy protection is stronger than their trust into this organisation. Web site / ecommerce shops / portal and public sector switched places. Mobile phone provider and Location-Based' Service provider gained one rank each but still rank rather low among the organisations in respect to the protection of the privacy of the user. Again the bad ranking for the LBS provider might be caused that the participants never have been in touch with a pure LBS service provider which solely works in this business.

In the next question the participants have been asked in which "world" their privacy is more protected.

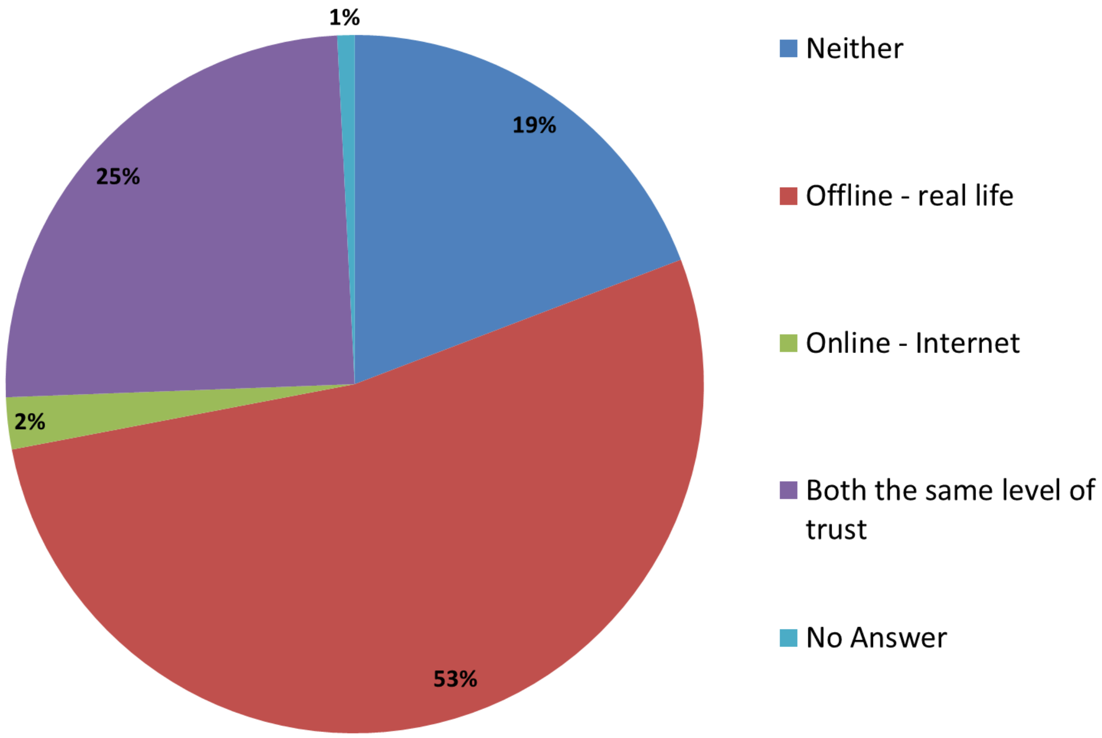


Figure 41 In which World the privacy is more protected

The majority of 53% has the opinion that in the "offline world" / real life their privacy is more protected than in the online world (2%). 25% have the impression that their privacy is protected in both world, that is, the online and offline world, at the same level (**Figure 41**).

If we take the results from these questions and rank the results for the trust and privacy question side by side we get the following table (Table 6 Ranking Trust / Privacy):

Rank	Trust	Privacy
1	***Bank / credit card company***	***Bank / credit card company***
2	***Email provider***	***Email provider***
3	Search engine	***ISP Internet Service Provider***
4	***ISP Internet Service Provider***	Phone company (fixed / land line)
5	Web sites / ecommerce shops / portal	Public services or government organizations
6	Public services or government organizations	Web sites / ecommerce shops / portal
7	Phone company (fixed / land line)	Mobile phone company
8	Mobile phone company	Location-Based' Service provider
9	Location-Based' Service provider	Search engine

Table 6 Ranking Trust / Privacy

If we assign a point value (from Rank 1 equals 9 to Rank 9 equals 1) for each position we can create an overall ranking for the Trust & Privacy reception of the users which have participated in this survey.

Rank	Overall Rank	Points
1	***Bank / credit card company***	18
2	***Email provider***	16
3	***ISP Internet Service Provider***	13
4	Web sites / ecommerce shops / portal	9
5	Public services or government organizations	9
6	Phone company (fixed / land line)	9
7	Search engine	8
8	Mobile phone company	5
9	Location-Based' Service provider	3

Table 7 Overall ranking Trust & Privacy

Even as banks are getting more engaged into online banking they are still seen rather as "brick and mortar" businesses. The first rank is supported by the impression of most of the users that their privacy is more protected in the offline world. In the past the bank was rarely changed so that a long lasting relationship between customer and bank was formed.

As the most users have at least one email account and they exchange everything from business to academic and very private contents (e.g., pictures, audio, and videos) via email the trust and privacy reception is the second highest. As the highest ranked online services it could be seen as best suited services to act as SPOT *(Single Point of Trust,* introduced in Schilke et al. (2006*)*. This (extended) "Chinese Wall" acts as the Single Point Of Trust (SPOT) for the user and acts as a privacy hub for many applications freeing the user from having to take care of its privacy protection for every single application. The user would have to trust at least this SPOT that it is safeguarding his privacy. Especially as usually email addresses are kept longer and will not change that often the email provider could use this as the SPOT account for providing these services.

The ISP ranked lower in trust and therefore has a lower total number of points as these services converge to either phone (mobile and landline) or cable companies this service becomes easy replaceable depending of the price and service offerings. It can be assumed that mobile phone and "normal” phone companies are in a strong competition for the users and might be seen as easy exchangeable so that the trust into them regarding their trust and privacy offering is not so strong.

The overall rank for Web sites / ecommerce shops / portal is the fourth with a lower ranking in the privacy sector. For Public services or government organizations, which have a 5th overall rank, the difference to privacy Web sites / ecommerce shops / portal is that here the privacy is ranked higher. With same number of points the phone company is ranked at the sixth grade because here the difference between the trust rank and privacy rank is higher than for the others with the same number of points.

The number seven in the ranking is the search engine which has a 3rd rank for trust but scores the last place for privacy protection. If we consider the large market share of Google it can be safe to assume that this was the search engine the most users had in mind (source: comScore, 2011) and the constant discussions about privacy issues (for a collection of these issues see e.g., Wikipedia, 2012).

As mentioned above the mobile phone company's rank 8th as they might seem, in the eye of the user, to be the easiest to exchange service provider among the choices offered in this survey.

As there where literally no real and independent Location Based Service providers in business at the time the survey was running and the LBS services provided at this time have been pull services it can be assumed that this is the reason for the poor ranking of the LBS provider as the end users participating in this survey could not have had a positive experience with them.

As this part of the survey tried to evaluate which organisation might be the best to offer the services necessary for MDP and act as the SPOT *(Single Point of Trust,* Schilke et al., 2006*)* the ranking can be used as guideline. Banks will probably not offer such services but for an email provider this could be a feasible extension of the business model especially if bundled with a mobile email application. As the traditional ISPs already move towards the business of the phone companies (e.g., VOIP, SIP, NGN) as well there is a move towards the fields of mobile phones and mobile internet these services provides are moving closer together. As these services are on a market which is more and more driven by the services offered and the prices it might be a chance to offer an advanced service like MDP to lure in more customers.

This material and the results can be seen or used as a guideline but the decision who offers such a MDP service could be researched deeper or has to be decided during a real world implementation. The next point in the survey shall give an impression which LBS Technologies the participants are aware of, use and plan to use. The following possibilities have been given:

1. 'Location-based' or 'location-aware' advertisement, mobile Coupons (discount) or messages
2. Navigation support (car and non-car)
3. Recommendation of the closest / nearest point of interest (restaurant, hotel, shop, historic site, ...)
4. 'Location-aware' recommendation services (based on interests, e.g., sales, movies, food, ATM, ...)
5. 'Location-aware' personalisation (filtered information based on interests)
6. Locating missing or stolen mobile phone, car, goods, animals, ...
7. Locating or tracking (mobile) people (e.g., kids or friends)
8. Emergency support services / Emergency 'Location-Based' Services (ELBS), i.e., panic button / emergency message (e.g., e911 or e112 support)
9. Integration with your schedule and location of events (pro active LBS personalisation / recommendation)
10. No Answer

During the time of the survey in 2009 GPS driven geo coordinate or location based "check in" games or web sites as well as other LBS where not (widely) available and in early stages of market penetration (see **Figure 42**).

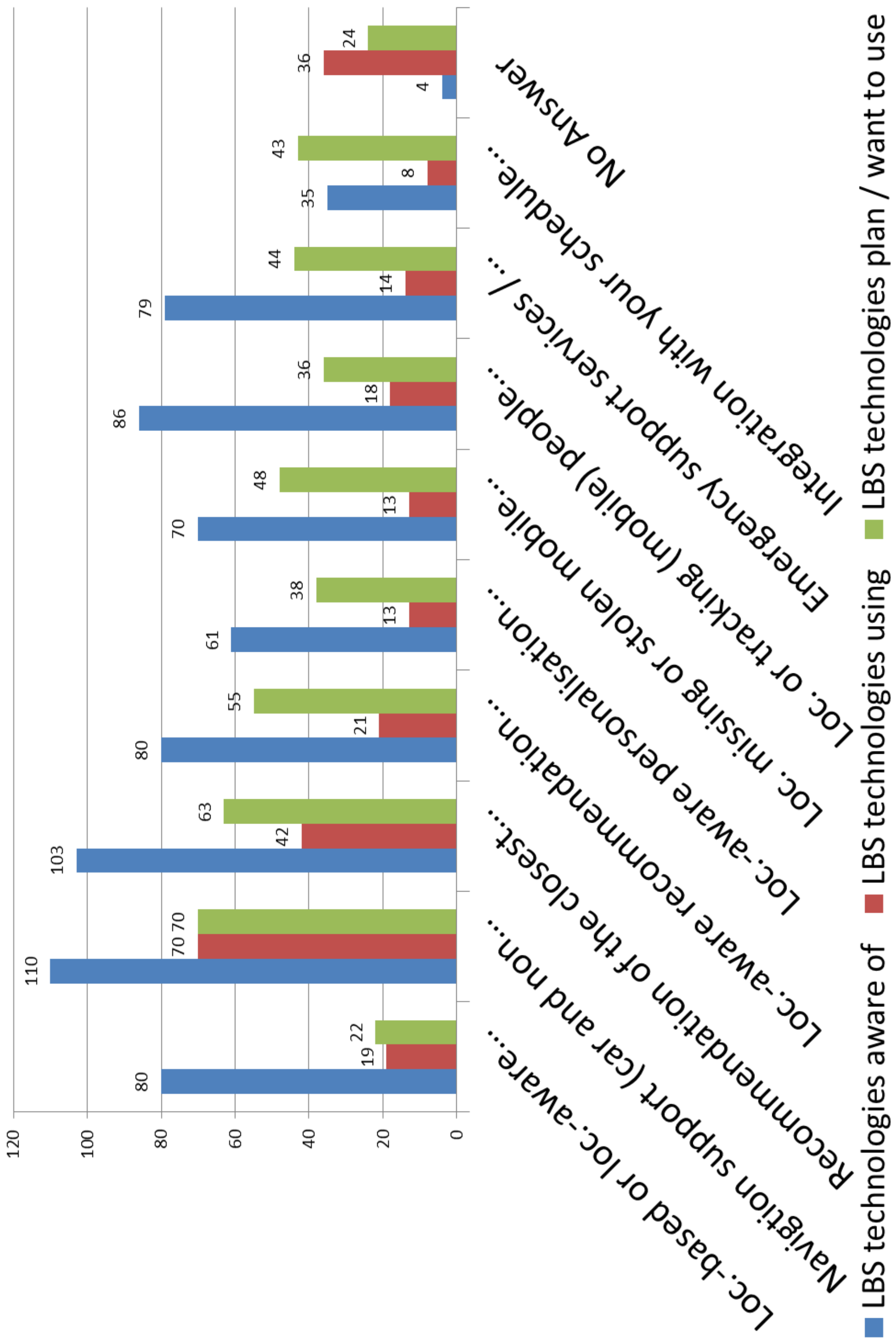


Figure 42 LBS Technologies

For the most of the LBS technologies more than 60 (out of 125, see **Figure 42**) participants were aware of them. Only the integration with the schedule of the user for using the location of the events was known to 35 participants. But this function seems to be interesting for the users as the growth is more the fivefold compared to the number of users which are using this technology already (No. 9). This is a very strong signal that the forward planning of recommendations based on the users schedule is an acceptable way to provide the user with an added value.

The navigation support (No. 2) was known to 110 participants. This functionality is used and will be used by 70 participants. Another, already widely used, technology is No. 3 which is the recommendation or navigation to a nearby point of interest is also widely known (103 participants), used and also the interest in using it is growing.

It seems that No. 1 is known to many (80) but not very accepted. The number of users and the growth rate is rather poor. Maybe the reason is the nature of a purely marketing driven approach which does not necessarily give the user an added value. Looking at the other points it seems that personalized recommendations are more interesting for the potential users. The strongest growth in the demand to use new services was in the recommendation area where the number of potential users at least doubled (No. 7) if not tripled (No.'s 4-6, 8). All these functions can be delivered by the proposed concept of MDP. These results show that there is a demand for such functionality in a group interested in technology like the participants.

The overall impression is that the participants are interested in using such a MDP service which combines the different functions into one complete package as long as it offers an additional value to the user.

The potential LBS payment models are more important for a business case then for a research work. The participants have been asked to choose their preference for a payment model (see **Figure 42**).

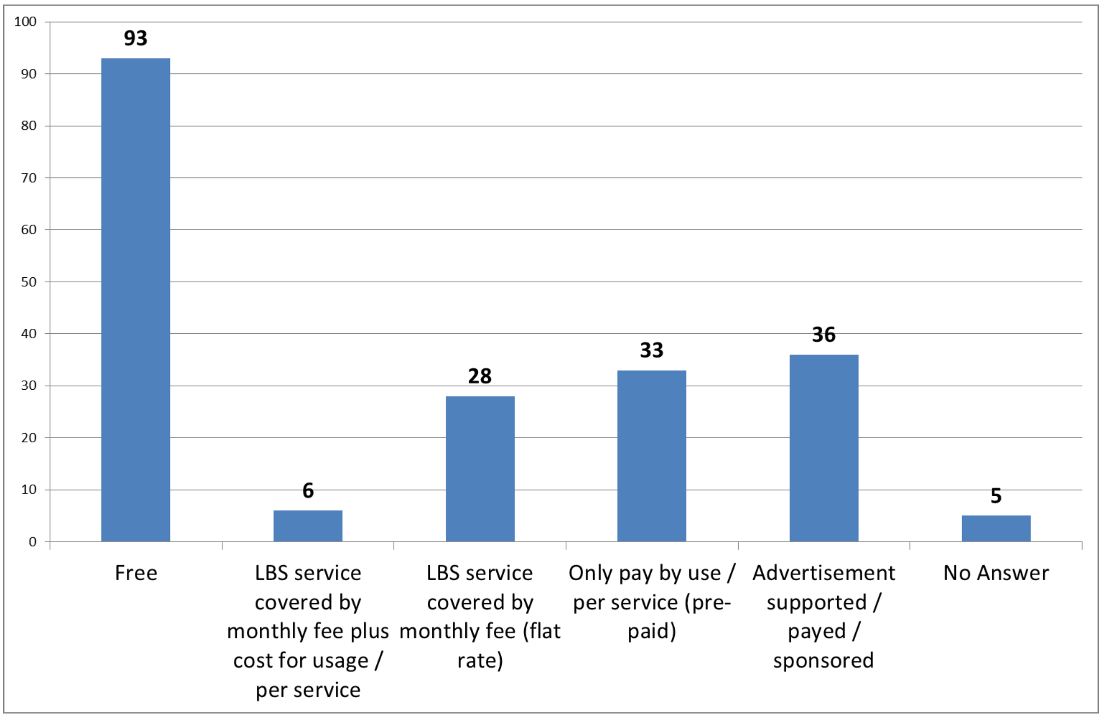


Figure 43 LBS payment model

The result is very clear. The most participants (93) prefer that such a service is offered free of charge. For a business model this is a tough requirement as such a service as to be financed. This might be done by charging the information providers or advertiser and maybe employing a kind of affiliated marketing strategy in order to participate from the profit of successful recommendations. As more than one payment model could be chosen the second most popular payment model was advertisement supported or sponsored services. For a business model this would make sense as it allows besides charging the information provider or advertisers to open an additional revenue channel. The other payment based models got lower numbers but it seems that 33 respectively 28 responders are willing to use a prepaid account or a flat rate for MDP. A monthly basic fee plus usage fees for MDP seems to be the least attractive payment method for the participants. Again this is an interesting fact for an implementation or further research work about a feasible business case. Even if the most responders prefer that such a service is offered free for them many of them have been willing to accept a kind of payment discussion.

The participants have been asked which their preferred LBS technologies are. The choices given have been:

1. 'Location-based' services pull
2. 'Location-based' services push
3. Mobile personalisation services pull
4. Mobile personalisation services push
5. Services based on information from your schedule pull
6. Services based on information from your schedule push
7. Mobile personalisation services based on location – pull
8. Mobile personalisation services based on location – push
9. Mobile personalisation services based on location and your schedule pull
10. Mobile personalisation services based on location and your schedule push
11. No Answer

See **Figure 44**

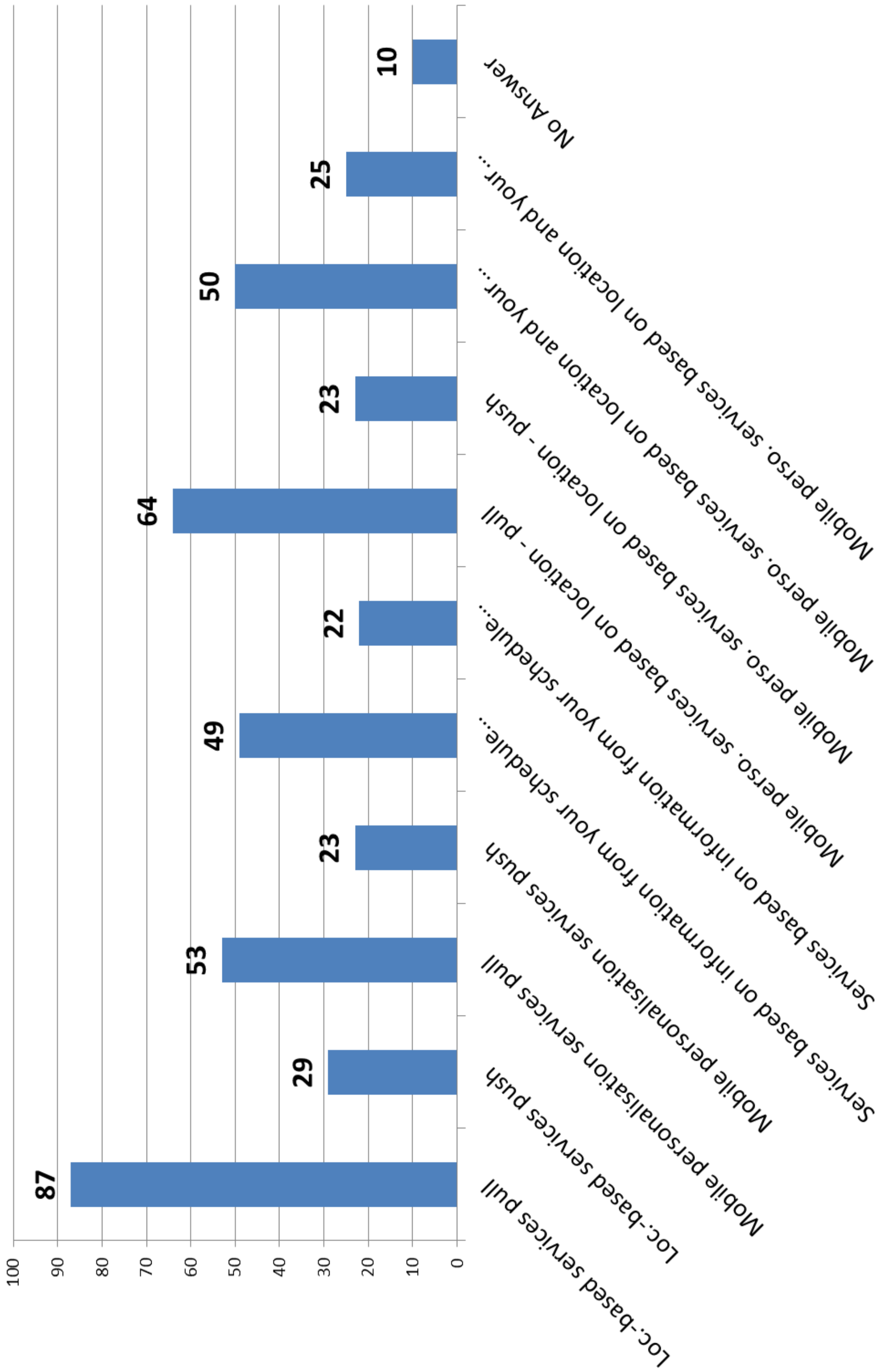


Figure 44 Preferred LBS technologies

As far as known to the author there was, during the time of the survey in 2009, no real push based LBS provider available on the market. This has to be kept in mind when interpreting this chart. It could be compared to the times before RIM revolutionised the market with the introduction of the Blackberry push email service. As formerly the email had to be fetched from the client (pull via POP3/SMTP) or actively had to be "read" (IMAP) this was quite a difference. The email appeared on the devices once it was received by the device without the need for the user to interact with the device / email service. Once this push email service was introduced people started to think they can no longer live without it.

This might be the reason why a LBS pull service received such high marks (No.1, 87 users, see **Figure 44**) and the push service received much lower marks or has a lower acceptance. It seems that the survey participants prefer to poll opportunities rather than to have them forced on their mobile phones.

In total the pull offerings (No.'s 1, 3, 5, 7, and 9) rank much better than the push offerings (No.'s 2, 4, 6, 8, and 10). As MDP could potentially also be used as a pull service as well it could be used to offer pull services in the beginning and then try to convince users about the potential and advantage of the LBS recommendation push services.

4.4 Summary

The results of the User survey are showing a high awareness and acceptance respectively interest in this topic. A little drawback for this research project was the poor perception of the push services in the survey from 2009. It can be assumed that among the potential users an interest for a MDP system is there. The technologies (smartphones with GPS and mobile internet) are available. The only issue is to promote the push based LBS as something the users can trust and that their privacy is protected.

5 The MDP Concept

In this chapter the idea and concept of the Multi-Dimensional-Personalisation (MDP) will be described with its main functional areas. It builds up on concepts and works already presented in earlier chapters.

The proposed MDP concept could be seen as LBS Generation 3+ or even 4 as it builds up on the other LBS Generations (Hendrey, 2001, see 2 Contemporary technologies for LBS personalisation) and gives it an extra edge by incorporating the past and future movements and time brackets as well as the interest of the user in a (preferable) push based manner including a feedback loop.

5.1 Personalisation as a MDP concept

Personalisation should not be mixed up with customisation. Customisation usually deals with the appearance of a web site (e.g., colours, fonts or the appearance of the site, in that case, which information goes where – in other words, how information will be displayed), for example, for a customization the user can control a (web) site or product based on his preferences (Mobasher et al. 2001). In a summary by Allen et al. (2001) the customisation and personalisation are differentiated by the control of the content. For the customisation the user is in control of the appearance and not in control of the content. The user usually can only control which and where to place certain content by customising (e.g., my.yahoo.com). Nowadays there are groups referring to personalisation and customisation as "interface adaptation” instead. The term adaptive is used quite a lot today but still the differentiation between personalisation and customisation is a valid approach.

Following Schwartz (1997) the web is in the end a very personal medium in which every user has a different experience as another user. The term can be also be defined as making the output of web based information systems adapted and available to the needs and interests of an individual user, or group. The system needs to recognise the user and serves the content and services matching the user's needs and interests based on their preferences (Pierrakos et al. 2001). In 1998 the idea of an adaptive Web sites was defined as sites which improve the organisation and presentation by adapting the content for the user (Perkowitz and Etzioni, 1998). In 2003 Pierrakos et al. stated that the automation of the content or services adaptation could dilate the personalisation. The personalised selection of the most relevant content for the user from all content of the system will support the user by this personalisation (Kahabka et al. (1997)). Personalisation is for the internet an increasingly important factor to support the user's needs by tailor made information and service offerings especially if it is done based on the user's past behaviour, the interest profile (and information gained by including the user profiles of other with similar interests in a collaborative fashion). (Mobasher et al. 2001).

Unfortunately most Personalisation systems are mainly driven by a one dimensional approach. This is expressed by a statement from Abowd and Mynatt (2000) which states that that context awareness did not necessarily meant that temporal and historic information, a collaborative approach or other information about the environment of the user are not used by the engine of the context aware system. In this statement one issue is left out as the system could use information about the future of the user by actively using information from a diary or schedule.

Common sense leads to the thought that a system which is offering the most relevant information for the user in a given situation (e.g., determined by location, time, interests of the user, etc.) will be more successful than another system offering only a standard view on the information. In addition it seems necessary to expand the reach even further from the online to the offline world.

This is where the new concept called Multi-Dimensional-Personalisation (MDP) can provide significant benefits to the user. It is an approach to support the user in coping with massive information overflow. The online world as well as the offline world provides a vast array of opportunities, information and services or events the might be relevant to the user. The main problem nowadays is to get the right information at the right time at the right place and in the right format.

5.1.1 The location dimension

Mobility has become a buzz word, much like personalisation. It has to be taken into account that in a mobile environment applications (or sites) have to adapt dynamically to the current location of the user (José and Davies, 1999). Location awareness can be seen as a key factor for mobile commerce as it supports the user in using the system based on the context (location) he is in (Zipf, 2002). Bob Egan, Vice President Mobile & Wireless, from the Gartner Group has said that:

> "The Internet will not be successfully translated to the mobile world without location awareness which is a significant enabler in order to translate the Internet into a viable mobile economy“.

In 1999 José and Davies have stated that the internet paradigm used is not supporting location awareness and lacks a model for supporting the capabilities of smartphones and therefore the needs of mobile users.

As stated above the location can be an important parameter which is necessary to offer the user the appropriate information or services. Even when used from a desktop system it can be necessary to provide location information to successfully use the offer of a web site. For example, a price comparison web site allows the user to search a DVD from a catalogue and request a price comparison which includes the shipping information. In order to do so the system needs information about the location of the user to identify the shipping costs from each shop.

5.1.2 Time as dimension

The temporal dimension has not been recognised or used / supported in earlier approaches. One well known scenario is a TV guide web site which offers information on TV shows ahead of time by combining the interest of the user with a given time frame. Newer systems are mainly based interests and collaborative filtering of, for example shows, to improve the viewing experience with recommendations (e.g. TiVo, Ali & van Stam, 2004). Other examples are event guides or a database with "Calls for Papers". The time dimension is an important component for this approach as it allows the tracking of typical user behaviour together with the location dimension. Extending the reach into the future is possible by using the (planed) schedule and appointments listed to offer information about events in the "neighbourhood" of the event scheduled by the user and the location of this event. This is especially true if you consider events like presentations, lectures, concerts or other events in the "real world".

It seems obvious that the dimension time does not make sense applied alone. It is usually used directly or indirectly combined with one or both of the other dimensions.

5.1.3 Examples of the application for the different dimensions

My Yahoo! is a mixture of customisation and personalisation whereas Amazon has a personalisation system for book recommendations which depends on the user's profile and the purchasing patterns of users with a similar purchasing and interest history. Personalisation of book recommendations has been performed in the past by bookshop staff that remembers the preferences of the customer and proactively offers books which suit the taste of their customer.

My Yahoo! Is a version of Yahoo! The user can customize to his likes choosing the information he likes and wants to see following his personal taste and mix it with information from other sources as well. For each of the sources the content will be automatically updated so that the user can see what he wants and when he wants to see it. By limiting the information wealth the user gets his personal view on the information./ news (Manber, 2000). It allows a user to customise his page depending on his interests. Some of the personalisation happens within the personalisation modules. This allows, for example, the user to choose the TV Channel's which are available to him (e.g., via sat or cable) and include them in their own TV Guide (Manber, 2000). By choosing the for example TV Channels from the local cable system a second dimension, location will be included by considering the TV interests and the location of the user. A similar approach was taken in the PTV project. The basic idea of the Personalised Television (PTV) is that it works as an online personalised TV guide. The PTV is listing programme viewing details just like any other guide, but with an important difference: every user sees his own TV guide based on his preferences like preferred programs / TV shows, the time the user usually watches and the channels available to the user. In addition the PTV can make suggestion about available programmes the user might wants to watch based on the profile. (Smyth et al. 1998).

5.2 The Multi-Dimensional-Personalisation concept

Multi-Dimensional-Personalisation (MDP) is an approach to support the user in coping with massive information overflow. In 2003/2004 this was a new approach of personalisation which not only takes the interests of a user into account but also his schedule and the past and possible or predicted future locations of the user (first published: Schilke et. al, 2004). These parameters are referred to as dimensions hence the term. Personalization or adaptive systems can change the appearance of their content or the way or structure the content is presented to fit the needs of individual users or groups of users with the same requirements. If these needs are changing over time the system changes the way of presenting the information as well. (Benyon and Murray, 1993, p. 199). Oppermann (1994, p.456) writes that an adaptive system is automatically changing its characteristics depending on the changing needs of the user.

In the MDP context based on mobile users there are the main dimensions: time, interest and location, and minor issues or constrains like:

- Latency,
- Bandwidth (e.g., data transfer via low bandwidth General Packet Radio Service (GPRS, e.g., with a download speed of 57.6 Kbit/s) or via a high bandwidth Universal Mobile Telecommunications System connection (UMTS, up to 1920 Kbit/s), 3G services, LTE)
- Format / medium (from plain text format to rich media formats depending on the client, available bandwidth or hardware)
- Priority (how important is an information)
- Cost (costs associated with information or an event).

Besides these main dimensions and issues there are security and trust concerns which have to be considered. As mentioned above the main dimensions for such a new personalisation approach are:

- The time dimension: comparable to a calendar or schedule. The user has a certain repeating behaviour (always in a similar time frame, e.g., the way to / from work, lunchtime, etc.) or schedules some trips ahead. The MDP would build up on this information and would allow a permission based recommendation taking into account the interest of the user and the location of the user. This would allow to recommend future events as well as events which fit the regular schedule of the user;

- The location dimension: taking the movement pattern of the user into account. Regardless of whether the user is using a desktop PC, a notebook, a mobile device like a PDA or smart phone, he will always be "somewhere". Either at home, at work or on the road there always will be interesting things or information related to this user. Combined with the other dimensions it is possible to offer recommendations "just in time" at the right place. Even planning ahead in time would be possible. Reoccurring moving patterns of a user can be tracked and used for recommendation based on the users location;

- The interest dimension: (termed "personalisation” in prior approaches) addresses what the user is interested in. This can range from business or commercial interests which are related to the job or studies to private interests like hobbies. These interests can be grouped in profiles to allow switching and prioritising between them.

The minor issues which have been mentioned above can be taken care of during the implementation of the system. For example, issues or constrains like the bandwidth of the communication, technical capabilities of the device used to participate, etc. For example the bandwidth issues would limit the amount of information which could be sent to the user’s device. The service would have to limit the amount of information transferred from a rich media message down to text messages depending on the available bandwidth.

The next figure shows how the introduced dimensions fit into the real life. In this form the extended form of personalisation combines the interest, time, location and the (regular / routine) movement or behaviour pattern. This will allow tracking or mapping the user behaviour to offer pro-active personalised services.

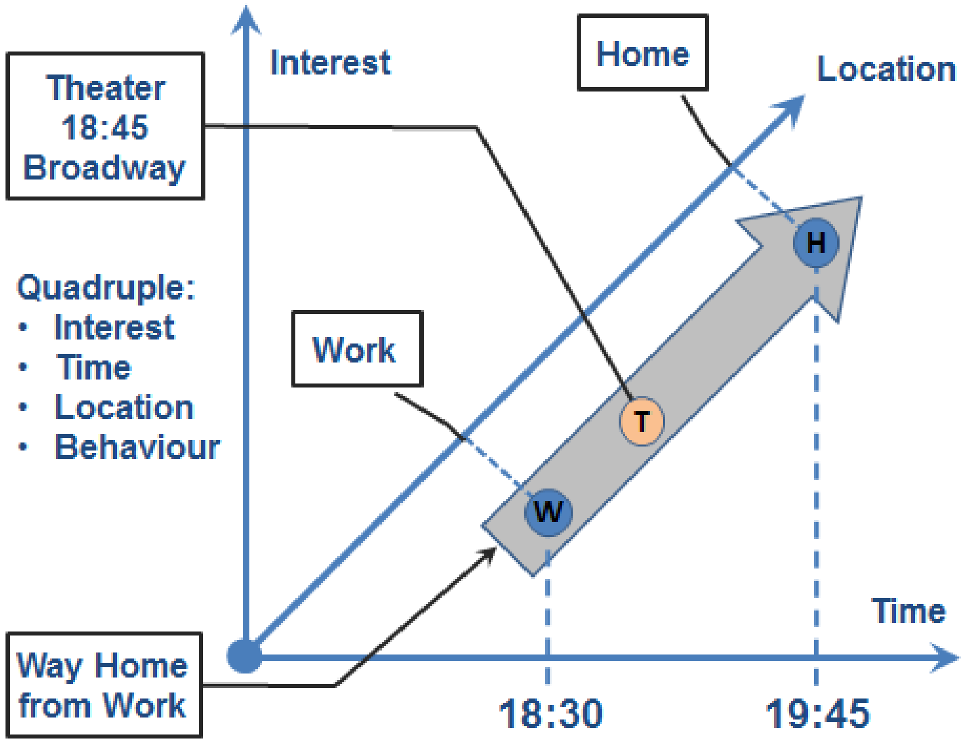


Figure 45 Extended form of personalisation based on interest, location and time

Additionally the user might want to have different personalities or modes (in standard mobile phones nowadays know as profiles, i.e., for the local personalisation of the mobile phone itself) which allows him easily, for example, to switch between a private or business profile. Within such a MDP profile the user can distinguish between his private personality and interests and the business person with the matching interests. Naturally a user can define more than these profiles. These profiles would keep the information of the interests of this profile to allow targeted delivery of recommendation to the active profile. Obviously there would be some kind of intersection of active and inactive profiles, for example, the time and location component would apply to all profiles of a user at the same time. A user might want to choose that even if he "is" a business person certain recommendations based on the "private" profile should be brought to his attention. This could be based on a scoring / prioritisation system or time frames (e.g., during lunch time the recommendations for the "private" personality will get promoted).

Besides the context the user should be able to define a kind of "Mood” or "Situation” (user model / personality / profile) which acts as a threshold or prioritisation, for example, to prevent to be disturbed during an important business meeting. In addition these profiles can contain information about the device used, the bandwidth available to the device and the capabilities of the device to distinguish between the types of media provided. In addition different user personalities can be used depending on the users preferences and usage patterns (Ryu and Smith-Jackson (2005), Ryu and Smith-Jackson (2006), IDC (2003) as quoted by Newman (2003)).As the traditional mobile phone user patterns do not fit the MDP the different user personality have to be extended to match the possibilities of the MDP scenario.

As the different technologies come closer together there might has to be an automation which adapts to the environment where the user is in. For example, if the user is in the countryside his device can function only with a GPRS based connection resulting in limitations in bandwidth. By moving towards a bigger city the device can log on into a UMTS cell or WLAN / Wi-Fi hotspot to have a higher bandwidth available. In another case the user is located inside of a building which allows him to utilize, for example, a blue tooth or WLAN connection for his device which provides higher bandwidth. Another issues which has to be taken into account is how the person is moving at the time, which means, a person walking around as a pedestrian has a greater resistance to walk more than a mile to a recommended event then a person riding a bicycle, whereas if the person is using a car the temptation to go to a recommendation which is five miles away would work (see Figure 46). These cell sizes are a factor which is important for the recommender as well as the user of such a system.

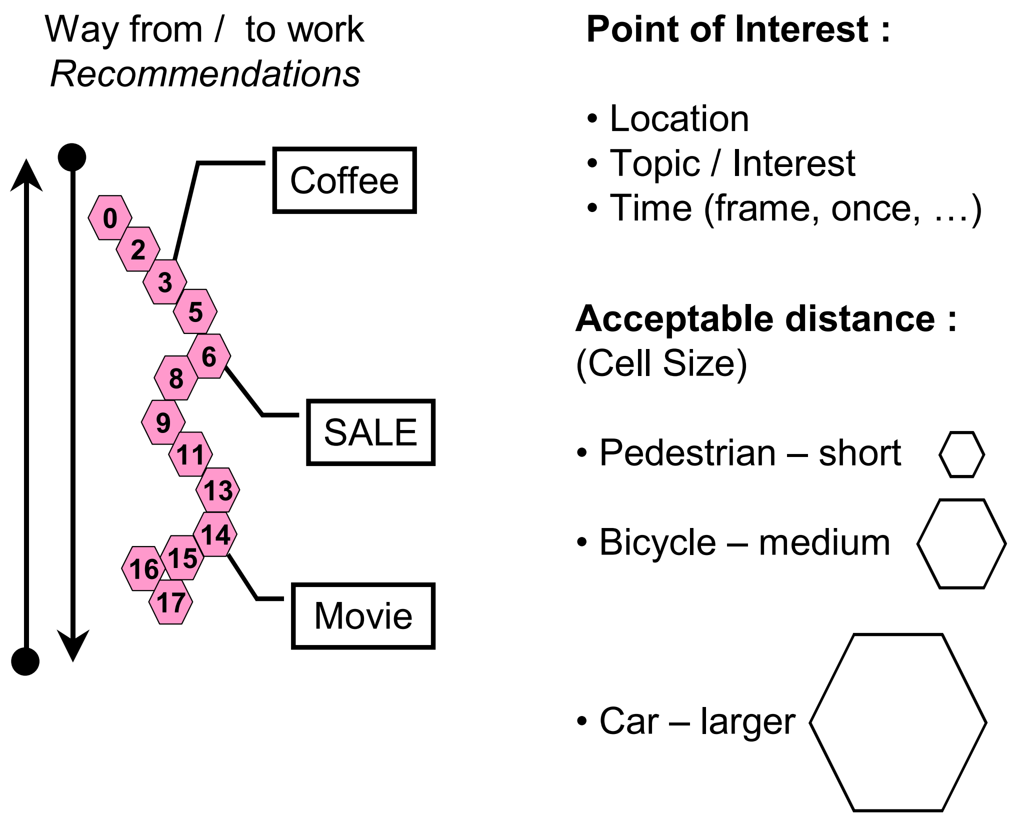


Figure 46 Cell based MDP recommendation - Cell size depending on movement type

It seems that in existing systems, and in previous work or literature, such an MDP approach has not been taken before. There are usually the two main dimensions in existing personalisation systems - interest and location. The interest based personalisation usually uses filtering techniques like content filtering, collaborative filtering, rule based filtering, content mining, monitoring of the surf behaviour or by selection of interest topics through the user for the personalisation or recommendation to the user. For the location-based services or personalisation information request, a pull style implementation is usually the standard approach in current systems (for example, the user has arrived at a certain location and has to request the information he wants). Furthermore, some systems nowadays deliver / push information to a client if a certain program (e.g., routing / navigation) is started or a certain services is requested.

These methods have to be extended to be applied in the Multi-Dimensional-Personalisation context and have to be taken into account for the proof-of-concept or implementation phase. Users shall be provided with the expected information they need or want at that moment in time without having to ask for it. (Mulvenna et al., 2000). Besides that the content or services are presented when needed the presented content should be adapted individually to the users likes based on their preferences and previous behaviour. (Hagen et al., 1999). Nielsen wrote on his web site that the main issue for smart personalisation techniques are that the system or application needs to recognise an individual (user) and no longer to recognise it as a computer. (Nielsen, 2002). By taking into account to server the user as individual and considering that personalisation usually happens only on one web site or within a portal (e.g., in an intranet) the requirements should be clear. This new approach proposes services which will provide the user with the possibility to use his profile across all participating web sites. Schafer et al. defines different delivery methods as pull, push, and passive (Schafer et al., 2001). Pull requires the user to take action and ask for information (like the first LBS applications). Whereas push is delivering the information at the right time (and place) to the user. The passive way of delivering information is incorporates the information for the user en passant into the information delivered to the user. In order provide good pro-active services for the user the solution shall be an interactive solution providing the result of the Multi-Dimensional-Personalisation in form of a proactive push to the user. Such a requirement was described, for example, by Chavez et al., 1998 which wrote that "an optimal assistant provides the required information autonomously and independently, without requiring the user to ask for it explicitly“. Another issue raised by Chavez et al., 1998 is that such a system has to provide "… the right information at the right time and place - with minimal interaction“ .

As mentioned before the location-based services approach is nowadays generally used for mobile devices like mobiles or smart phones. In such scenarios the information is generally used to navigate the user to a service or information provider. This is connected to a certain need or demand of the user (e.g., a pizza restaurant, a hotel or such things). This is mainly an "on demand” scenario, which is, the user requests / pulls the information and has to select "what” he wants. The location-based personalisation provides the "where” information for the "what”. Another term used in this domain is Geo-fencing which does, depending on the implementation, not fit here, as it is either a "notify me" service if the user enters his (predefined) geo-fence (like entering the supermarket = a notification to buy milk) or a notification service if a participating friend of the users the enters a geo-fence (the user is at Starbucks and a friend using the same system is entering the Starbucks the user gets a notification that he can go an meet his friend). Such Geo-fencing services could be provided as a by-product to the MDP server if, for the latter scenario, both users agree that their whereabouts are shared and for the first scenario an user interface would be provided which allows the user to create a geo position depending leaflet (reminder) which would be provided by the MDP system as a notification at the right place (depending on the issue a time component could be added as well).

A literature search at the start of the research project had not found a system proposed which really combines these two dimensions in a personalisation engine. At present, there is no approach or platform known to the author that combines the third or more dimension, time, with the two other main dimensions which serves more than one information source / provider. Another issue is that there are no real approaches known that try to bridge personalisation between the online and the offline world stretching out from an internet based system into the real world. In addition the present day LBS lack privacy protection for the user. The user has to request information related to its current position and is revealing his position and actual interest. Besides this the LBS is not proactive and does not learn the user’s movement patterns takes the future schedule of the user into account.

5.2.1 Recommendation for the Multi-Dimensional-Personalisation scenario

Kyoung-jae (2011) defines a recommender systems based on the MDP concept describing that it is using information important to the user to allow recommendation matching the user's needs. The information they propose to use for personalisation is information based on the mobile user's context like location, time and interest for personalization.

An addition to the approach described by Adomavicius and Tuzhilin (2001, 2001b, 2005 and Adomavicius et al, 2005) would be to add a user based weighting for the parameters / dimensions used in the recommendation algorithm to allow the user even more control, for example, he would rank interest higher then distance (location) because for something interesting the user would be willing to travel some distance.

Referring to Ge et al. (2010) it can be said that MDP as recommendation and personalisation system is built for matching recommendations and notifications of information provider and advertisers with their potential target audience based on their interests and (actual or predicted) location. The user feedback allows the user to tailor the material he receives by using a feedback loop. A possible future extension could be to apply other personalisation or recommendation algorithm's which are based on the interest and feedback as well based on the material which had a positive reception from user's with a similar profile regarding their interests (and maybe even location or movement patterns).

The definitions presented in 2.1 User location and recommendation services" describe parts of the MDP concept which extends LBS, recommendation and context aware system, for example, by taking information of the schedule of the user into account for predicting their whereabouts for timely and location depending recommendations and notifications and by allowing the user to get interested based information.

There is a specific trust and privacy issue for the recommendation part as there are data protection laws in place which can cause problems for such a function. Besides that the users are very conscious about their privacy when they are using a service. The wish to stay anonymous or having their privacy protected is vital for the success of such a system. These functions can only be successful if the user trust the entity which provides this service and passes on the recommendations. Similar trust relationships already exit to organisation like banks, mobile phone companies or credit card companies. This seems odd at the beginning but if we consider that all these organisations have information about their customers and their behaviour, their location when using the services provided and a kind of knowledge about their interest (e.g., from their shopping pattern (bank & credit card companies) or mobile phone companies (e.g., numbers called or services requested and paid for). Nowadays these organisations do not directly provide any real form of personalisation or location-based services. The only way this existing data about the users is used is, for example, when a credit card company is analysing the "normal" behaviour of a credit card customer to identify abnormal or fraudulent behaviour, in this case, of the usage of the credit card to prevent fraud. This analysis of the behaviour is usually based on the usage location as well as on purchasing patterns.

In order to be able to base recommendations on future events of the user, which means his schedule it is necessary to extend the scheduled events with a location attribute. This additional attribute should conform to the ISO 6709 standard. Except for the altitude value which should be optional for an event in the schedule. The calendar entry has to be extended with a field which holds the geo position of the event, for example, longitude, latitude and the optional altitude (27.987778, 86.944444, 8850). In addition to this form an extra field for the description of the location (if not covered by an address field in the schedule) shall be available. By extending the standard fields for a scheduled event the events can be used to "plan ahead" and taking the future plans of the user into account.

The "cold-start" problem for personalisation or recommendation engines is, in the case of MDP, rather a geographical one then based on the interest dimension. As long as the user provides some interests in his profile the bigger challenge is the routes and location part for the recommendations. But within a short time frame (e.g., one or two weeks) the system should have recorded the routine and daily movement patterns and therefore be able to use this information for the prediction part of the MDP recommendation selection functionality. If the user does not provide any interests the system could only recommend something based on the routes and locations visited by this user.

5.2.2 In "whom” we trust

The perception of trust and privacy varies with every user and the individual experience in using online services. An interesting fact is that people have developed a distrust towards online services which has been caused by illegal activities like phishing, identity theft, and the suspicion that "somebody” does "something” with their data.

In the general perception it seems that users feel saver in the "offline” world then in the "online” world. This interesting fact has to be considered when introducing a service like Multi-Dimensional Personalisation. Another interesting fact is that a study has shown that even if an internet user describes himself as privacy concerned they give out more information about themselves as they initially wanted to do (Berendt et al, 2005). So the MDP could protect users from themselves.

As this service works across the borders from the "online world” to the "offline world” (i.e. real world) it might be affected by the privacy and trust concerns of the users. As the offline world is the everyday environment in which everybody is used to live, most people do not longer see that in this world the same risks apply.

5.2.3 Online versus Offline worlds

In the online world there will be the same or similar services available as in the offline world. By the "bad” reputation the internet has gained recently there is this "distrust” towards online transactions whereas it seems that there is a higher level of trust towards the same transaction in the real brick & mortar world. As a part of this research a survey took place to gather more information on the perception of users (see 4 Surveying user awareness and acceptance). The questionnaire for the survey is available in the appendix as reference for the reader. In the following paragraphs we will compare online, offline and MDP transactions a user might experience.

As the MDP approach takes factors like the interests of the user, their location and a temporal component into account the user might think that this information could be misused.

The reality is that all these information are available in the offline world as well. If a user is using a credit card he reveals information like his interests (the purchase), the location (where the purchase took place), a monetary value (the purchase price and their account balance) and the time (when the purchase was done). All these information are available online and in real time to the credit card company. Some credit card companies constantly evaluate the transactions to protect their customers from fraud. But besides this the can also use the information for marketing purposes.

Similar data is available to a bank where all the bank account data is kept. Similar to the credit card company the bank will get all the information about where, when and what a user is purchasing. Again this data can be misused as well.

To establish the link from the offline world to the online world we have a similar scenario by a mobile phone provider. Like in the other examples the mobile phone provider has a constant and real time access to the location of the user, it’s movement patterns and some form of payment and interest information as well (micro payments via the mobile phone, numbers called, ring tones or wall papers).

It can be assumed that it is safe to say that most users are not aware of the data which is kept in the offline world about them. All this information could potentially misused. In some form certain organisations already take advantage of this situation. The user might not be aware of it but banks and credit card companies are actively evaluating their customers based on the account balance and spending pattern. This leads to advertisements on account statements, offerings for a credit / mortgage or investment plans which are all depending on your account information.

This type of information is very similar to the data needed to provide the user with the services provided by Multi-Dimensional-Personalisation. If we consider this we have to convince the user that the services provided will not harm the users' privacy if he would use the MDP service. In order to do so the MDP service provider has to gain the same level of trust as the traditional offline organisations mentioned above.

A way to achieve this trust by the user is to put the right protection of the private data in place. An implementation of an extended "Chinese Wall" is a way to implement such a barrier which protects the privacy and anonymity.

One important thing which has to be kept in mind is that MDP is not planed as M-Commerce application. No financial transaction will be dealt with in the MDP scenario. The concept was designed for (and limited to) distributing recommendations and notifications to mobile users. There might be a voucher send out in one of these messages to the user.

5.3 The "Chinese Wall" approach

As described earlier in chapter 2.5.2 "Chinese Wall" approach the "Chinese Wall" seems to be an appropriate way to protect the users data. To apply the "Chinese Wall" approach in a recommendation application for the Multi-Dimensional-Personalisation scenario we have to extend the traditional way of the "Chinese Wall" to meet the identified requirements.

As mentioned before personalisation is only possible if the user trusts at least one organisation that they will do no harm to him based on the (private) information disclosed to them. For a personalisation concept which would work with multiple sources for the recommendations a solution is to store the profile of the user anonymously (see way no. 2) with the middleman and pass a representation of this data without a real reference about the user to the participating / requesting servers.

Such a type of middleman approach can act as a Chinese wall, that means it acts as in-between the user and the service provider. By doing so the organisation, which wants to offer such a service or recommendations to the user, will only deal with an anonymous profile. This makes it necessary that the middleman follows the point 3 stated above by Cranor (1999).

This approach would work if there is a trusted relationship between the user and the MDP service provider (a.k.a. as the middleman or the Chinese Wall, see Figure 47). The middleman would handle the storage, collection, maintenance and handling of the profile data of the user. In order to allow other organisations to provide recommendations or services to the users based on their profile (i.e., the combination of the interest of the user, its location and the temporal component, etc.) the middleman would take the request from the information providers and return the number of matching profiles. If the provider orders the delivery the middleman will execute the delivery of the recommendation / service offering to the users with matching profiles.

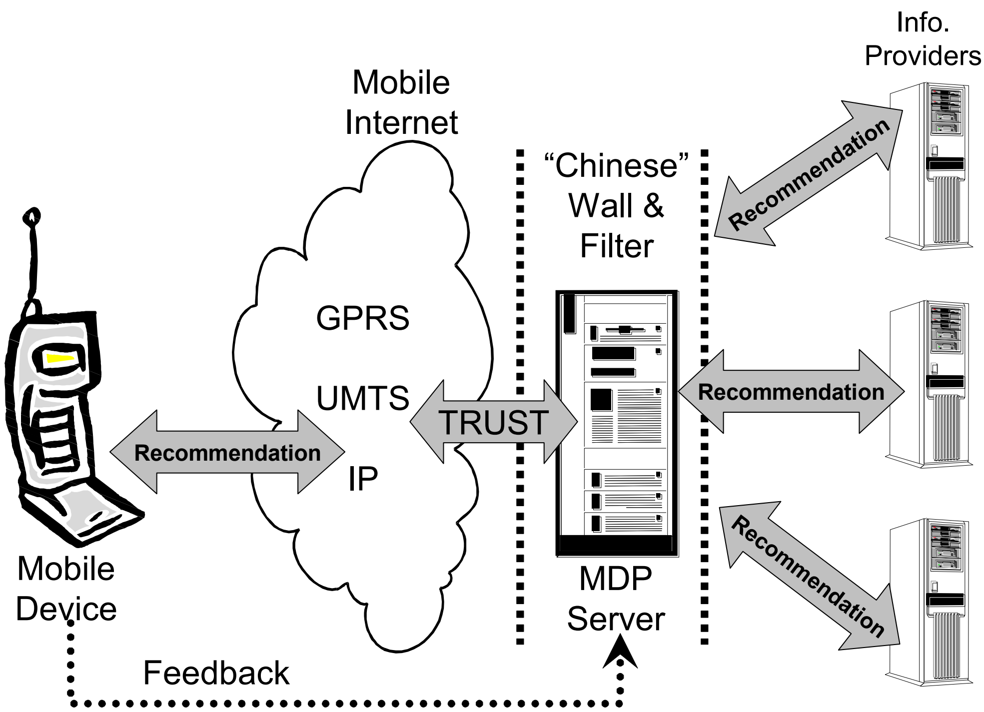


Figure 47 Multi-Tier-Architecture for „"Chinese Wall" based recommendation

The difference between the traditional application of the "Chinese Wall" and the way applied in the MDP scenario is that in the traditional way a consulting company works on data of multiple clients and the teams use the "Chinese Wall" to prevent data from leaking from one team to the other. In the case of a middleman / MDP "Chinese Wall" the middleman protects the profile data of the users from the organisations which want to offer recommendations or services. By the MDP extended "Chinese Wall" the data is separated by the multi-tier architecture and prevents the information provider or advertiser from directly accessing the data in an unwanted way. In addition the data can only be accessed through the MDP information provider client interface which allows on predefined actions on the data. The real user identity is not available on these datasets so even if there would be a breach in security no links to the users could be directly made.

By doing so an organisation which wants to provide recommendations to MDP users would only get the possibility to select profiles which do not contain any information about the user. Kobsa expresses exactly this as a legal requirement in Germany that the use of User profiles is only acceptable if pseudonyms are used. The profiles which can be retrieved under a pseudonym shall not be combined with data related to the bearer of the pseudonym[3]. This requirement can be fulfilled by an extended "Chinese Wall" between the part of the application which works with data from identifiable users, and the component which makes generalizations about pseudonymous users and adapts the information accordingly. The necessary communication between the components should take place only through a trusted component handles the pseudonyms or the pseudonymization procedures to protect the real users data. (Kobsa, 2002). This is one process is the main purpose of the extended "Chinese Wall" proposed by MDP.

When an organisation which wants to provide recommendations or services, it will select anonymous profiles that correspond to their chosen target audience. The

[3] Based on the German Teleservices Data Protection Act (1997) reference by Kobsa (http://www.iuscomp.org/gla/statutes/TDDSG.htm last accessed March 2012)

middleman would take the recommendation / service offer and would pass it on, based on the selected anonymous profiles, to the users. By doing so the organisation which wants to offer recommendations can select a user base entirely based on the interests, their location and the available temporal information of the user without knowing the user personally. This way offers total anonymity to the user but allows recommenders to select a matching target audience. The vital requirement is that the user trusts the middleman (acting as the "Chinese Wall") and that the information provider is able to get his message through to potential clients. One drawback could be the issue of faked identities to receive, for example, discounts even if the person would normally not fit the target audience. In the application of a MDP "Chinese Wall" only the middleman would know if the matching profile represents a matching dog or a matching person.

A user would be, for example, selected by the information in the corresponding anonymous user's profile. The data in the profile would be defined by the user (e.g., the interests of the user) and the users behaviour (i.e., regular movement patterns and the temporal information collected or provided, e.g., from a schedule).

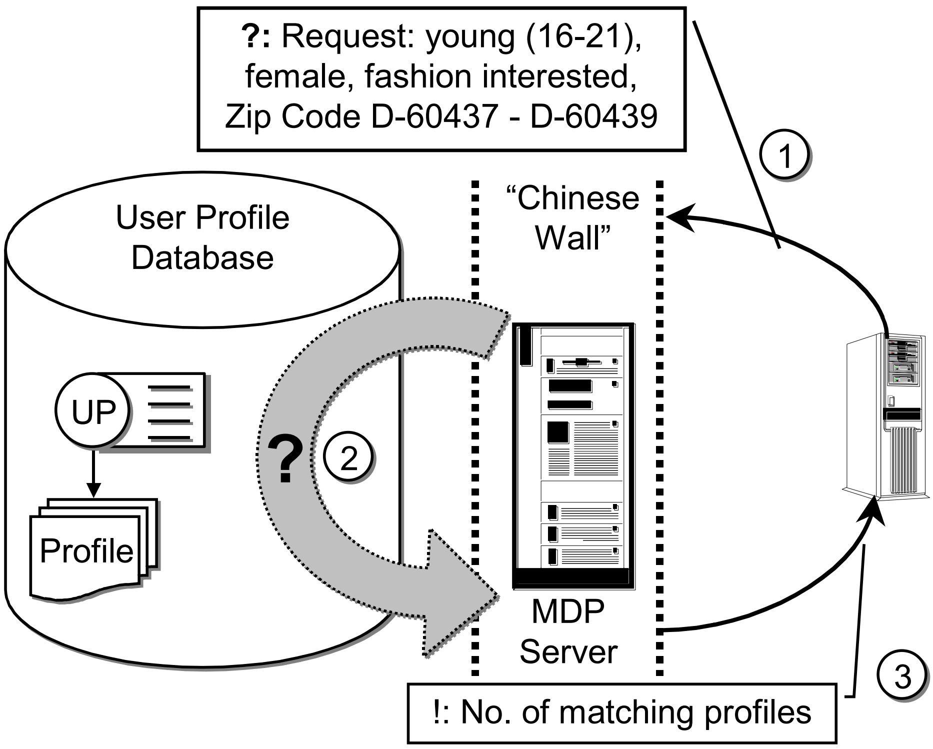


Figure 48 Request for matching profiles

Figure 48 shows that a company which wants to offer a service or recommendation to young females, aged 16 to 21, which are in the area described by the ZIP codes 60437 to 60439 (No. 1). The MDP Service will query its database for users matching the requested profile and which are currently in the area identified by the ZIP code range (No. 2). The service returns the number of matching profiles (No. 3) in order to allow that the requestor can book the service.

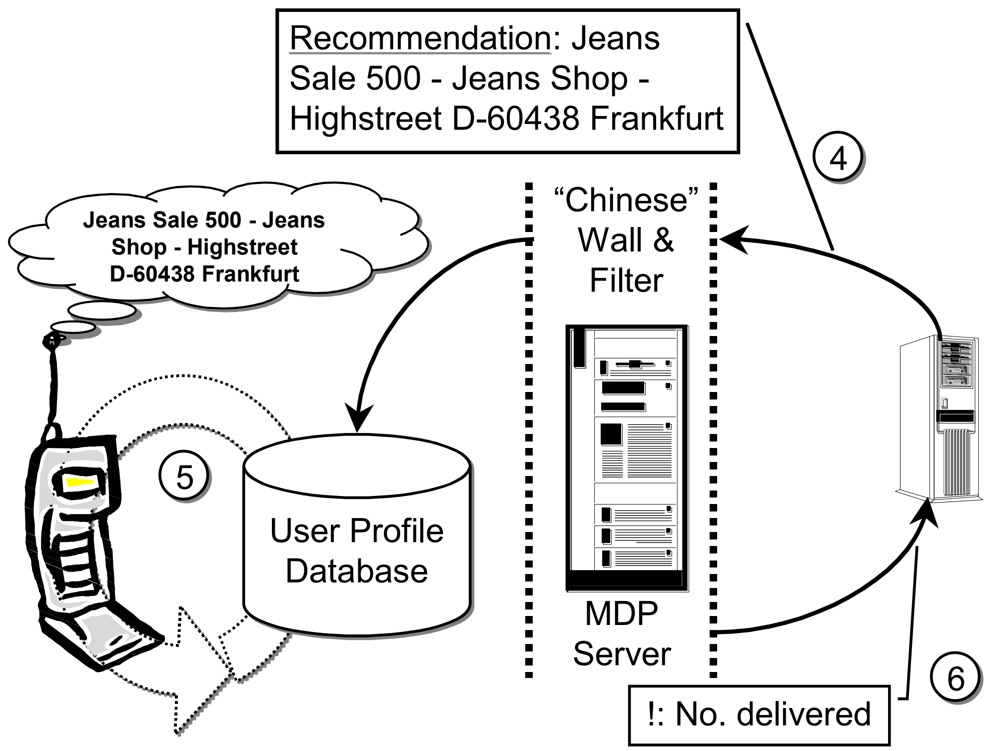


Figure 49 Recommendations are made through the Chinese Wall

After the requestor has booked the recommendation service via his MDP client interface (No. 4) the message is passed on to the users which fit the selection criteria (No. 5). The requestor will be informed of the number of recommendations delivered (No. 6). In this scenario the requestor never gets directly in touch with the user the recommendation gets send to. The user only stays in touch with the MDP provider which protects the privacy of the user by providing access only anonymous profiles to the requestor. Even if the profiles contain information about the user like their interests, their location and other information the requestor never gets "real" information about the user like their user name or phone number.

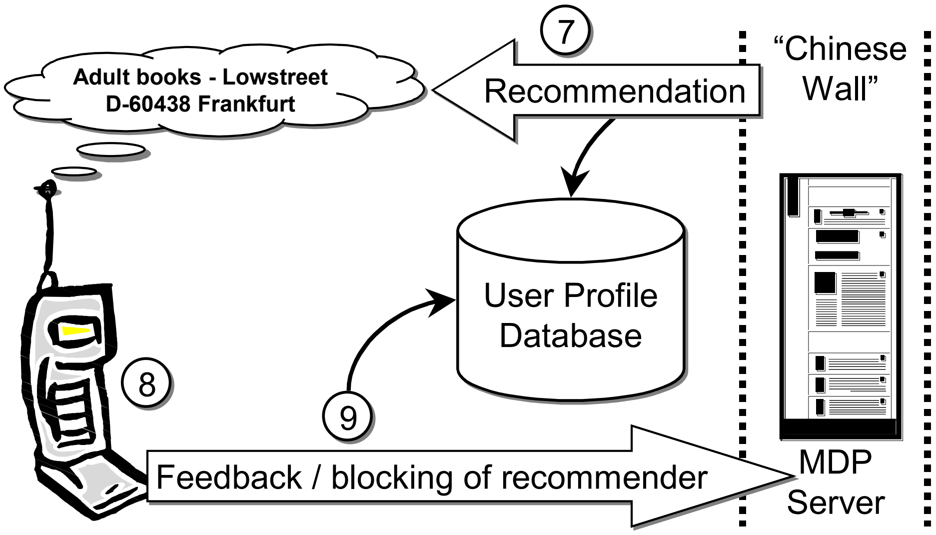


Figure 50 Feedback given for spam recommendation

An optimization for the recommendation, which means a "self-cleaning effect" for such a system can be achieved by giving the user (No., 8; see **Figure 50 Feedback given for spam recommendation**) the opportunity to report unwanted recommendations (No. 7), spam or even directly blocking recommendations of a certain origin (No. 9). This will allow the MDP process to exclude this user in future requests for a such a matching profile (see Figure 45 Extended form of personalisation based on interest, location and time, No. 2) without that this information will be available to requestor of this anonymous profile.

Spam, spim and Phishing are examples for a breach in the privacy protection of e-mail users. When the MDP service will be established this could even reach out from the online to the offline world. A MDP provider which would apply a "Chinese Wall" approach could filter the unwanted recommendations and by doing so would protect the privacy of the user.

5.3.1 Trust, privacy and the "Chinese Wall" approach

Schafer et al. (2001) characterize that anonymizing techniques bad for recommender systems as they make it impossible for the recommender system to identify the user which uses the system and therefore limiting the capability of the system to collect data the necessary data about this user in order to make accurate recommendations for this user. Recommender systems can only be successful when privacy concerned customer can be sure there data will be protected and not misused.

As the most users are very privacy conscious such a service has to take care of providing privacy while delivering a service. Saltzer and Schroeder (2004) define the term "privacy" as a term defined by the social environment / society which is the ability of an individual user is in control of his personal data especially who can access what data and when. Anderson (2001) definition of privacy is that a user can protect whatever he regards as his personal data or secrets and therefore preventes an invasion into his personal (data) space.

The recommender would have the opportunity of actively providing recommendations without knowing the target personally. As written by Warren et al. in 1890 a person can chose to be left alone but in addition the can chose or control when, how, and to what extent personal information about them is communicated to others (Westin, 1970).

Mogenahalli et al. (2008) results of their studies are that:

> "The focus of this study was to determine how the different trust factors influenced the different dimensions of trust. Data gathered from a survey was analyzed for the relationship between trust factors and the different dimensions of trust. User interface design and ubiquitous connectivity were found to influence acceptance trust. Good service description and customer support provided by mobile commerce vendor were found to have a positive effect on

competence trust. Clearly stated privacy policies and incentives were found to play an influential role in developing benevolence trust in mobile commerce vendor and reputation of the mobile commerce vendor to directly influence predictability and integrity trust“.

The case of the proposed extended "Chinese Wall” approach would be such an alternative as the anonymity and privacy of the user would be preserved by using data separation and an anonymising / pseudonymising approach for the user profile data.

This architecture separates the target audience (i.e., the users) from the information providers that want to reach them by using a middleman which represents the "Chinese Wall”. Users already have a "trust” relationship to somebody. Nowadays users trust their bank, mobile phone provider or credit card company. All these organizations possess, that means, have access to sensitive data about the user which are similar to the data needed and used to provide the Multi-Dimensional-Personalization recommendations. Your bank knows how much money you have in your account and what you are spending it for and where you are spending it. The same applies for a credit card company. In the case of the mobile phone provider they also possess data about the location of the user, to whom the user is calling and which toll services (like micro payments, ring tones or images) the user is using.

This is similar to the identity protector approach which work with pseudo-identities to protect the interests of the user by converting the user’s actual identity into a pseudo-identity “ (Senicar et al., 2003). This part is similar to the extended "Chinese Wall“ approach which is not only using anonymisation and pseudonimysation but also separates the data and the access to it . Both approaches protect the users identity and profile so that the can use personalised services and his identity andprivacy is always protected. (Senicar et al., 2003).

In the MDP case the user only stays in touch with the MDP provider which protects the privacy of the user by providing access only anonymous profiles to the requestor. Even if the profiles contain information about the user like their interests, their location and other information the requestor never gets "real" information about the user like their user name or phone number. Again this shows some similarities to the identity broker approach: the identity protector is separating the system into two domains: the identity domain and a pseudo domain. One is the domain in which the user's actual identity is known and accessible to the system and another one in which real identity of the is not accessible. By doing so it is possible to access personal data without revealing the true identity (Senicar et al., 2003). In his survey about location privacy Krumm (2009) lists the research works done in this field. For MDP the common approaches like Anonymity, Spatial and Temporal Degradation or Obfuscation cannot be applied as the MPD system would be rendered useless. The approach of privacy policies between the user and the MDP system, acting as SPOT *(Single Point of Trust, as explained earlier)*, seems to be the best way enabling the system to work and provide benefits to the user.

The main difference is that the "Chinese Wall" is the "Single Point Of Trust" (short SPOT, **Figure 51 SPOT – basic architecture**) for the user and can act as a privacy hub for many applications freeing the user from having to take care of its protection for every single application.

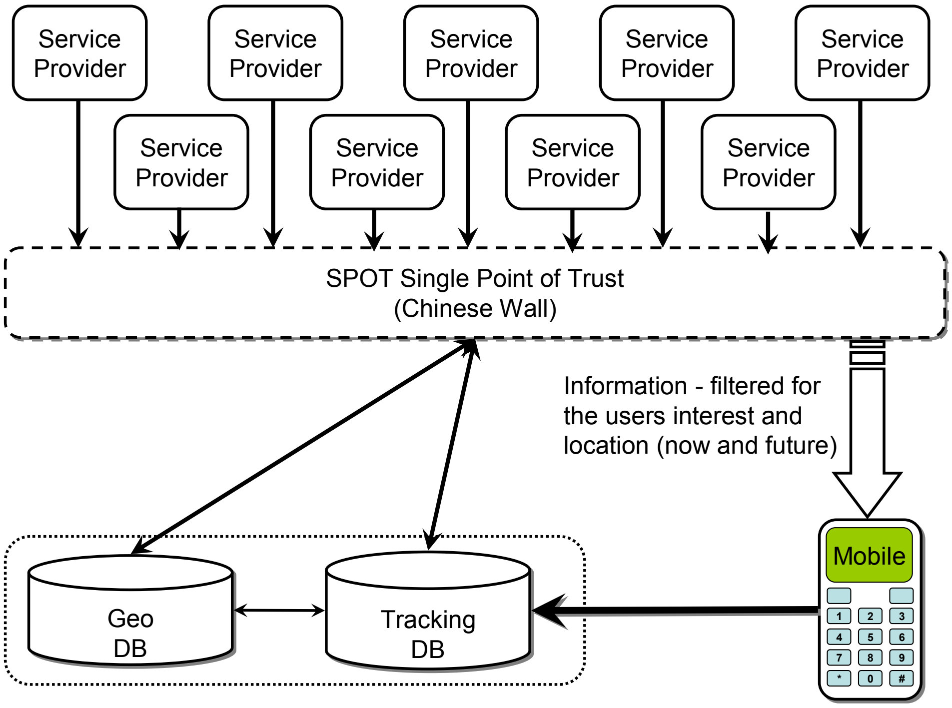


Figure 51 SPOT – basic architecture

In addition this architecture supports the requirement defined by Kaasinen (2003) that "Although the users would benefit from a personalised service, they may not be ready to define a profile separately for each service and each context of use".

Even if this sounds similar to the proposed extended "Chinese Wall" the authors of Senicar et al., (2003) they suggest that the user shall control the identity protector whereas the "Chinese Wall" approach would act as a kind of single point of personalization support which could be used by various applications via a common interface. This could mean that not even anonymous profiles would be made available to the requesting recommendation service, which means that the recommender would not even get access to the pseudo domain of the identity protector approach. This would even enhance the protection of the user.

The MDP provider would work as SPOT *(Single Point of Trust)* for the MDP user. The user would have to trust at least the MDP provider like they, for example, trust their mobile phone service provider. As the MDP is clearly positioned in a mobile environment the mobile phone service provider could be the provider for such a MDP service.

Spam, Spim and Phishing are examples for a breach in the privacy protection of e-mail users. When the MDP service will be established this could even reach out from the online to the offline world. A MDP provider which would apply an extended "Chinese Wall“ approach could filter the unwanted recommendations like a firewall and by doing so would add additional protection to the privacy of the user.

An optimization for the MDP recommendations, in other words, a "self-cleaning effect” for such a system could be achieved by giving the user the opportunity to report unwanted recommendations, spam or even directly blocking recommendations of a certain origin. This will allow the MDP process to exclude this user in future requests for such a matching profile without that this information will be available to requestor of this anonymous profile. Naturally the opposite way, namely a subscription of recommendation from a recommendation service, shall be possible.

The P3P (“Platform for Privacy Preferences Project”) standard (W3c, 2002) could not be directly integrated into the approach as it is mainly a privacy classification system for a web site. The standard is used to inform users on how their personal data will be used on a web site. As the mobile MDP user will only get directly in touch with a web site or services when he follows a recommendation which has a link provided. This would be the only point where the P3P standard would apply. The MDP provider site could use P3P as well for classifying their services. The P3P machine-readable XML can be used to encode privacy policies. This specification can be extended by using EXTENSION to be used it in the MDP scenario.

5.3.2 Movement patterns

The actual movement patterns of the user, their historic movement patterns as well as calendar entries which have a location attached are vital to provide recommendations which extend from the online world to the offline world. As mentioned above the information about the location of the user is nowadays already available to other organisations like a mobile phone provider.

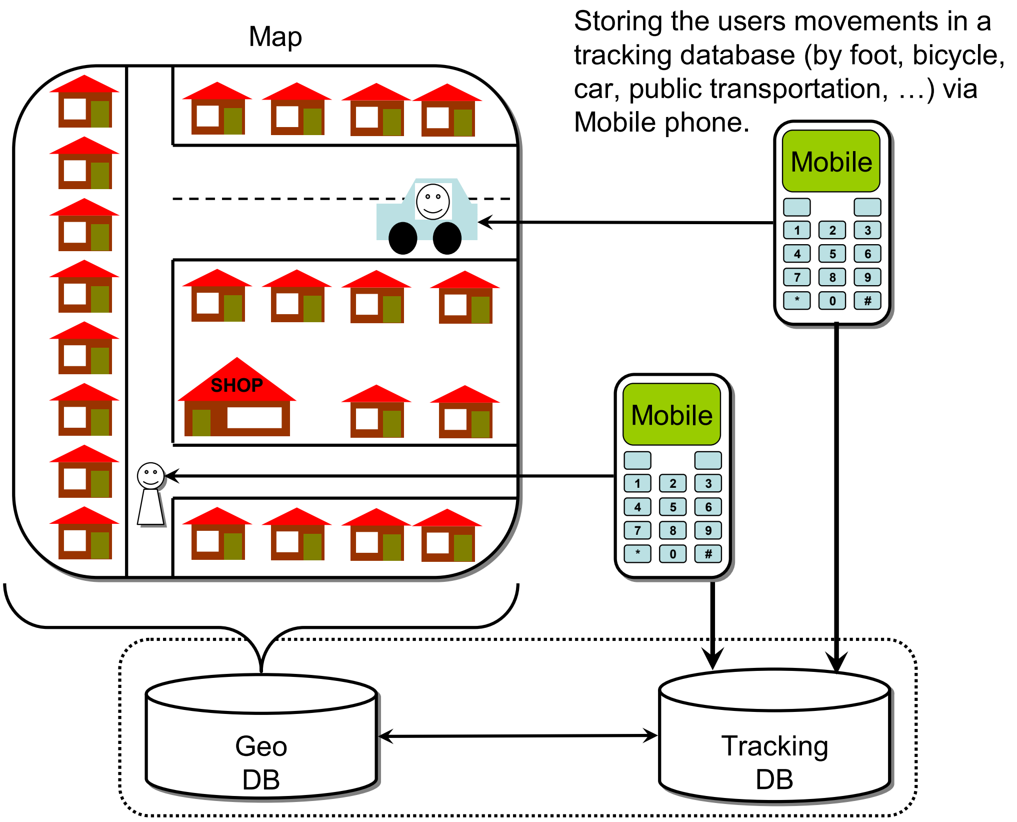


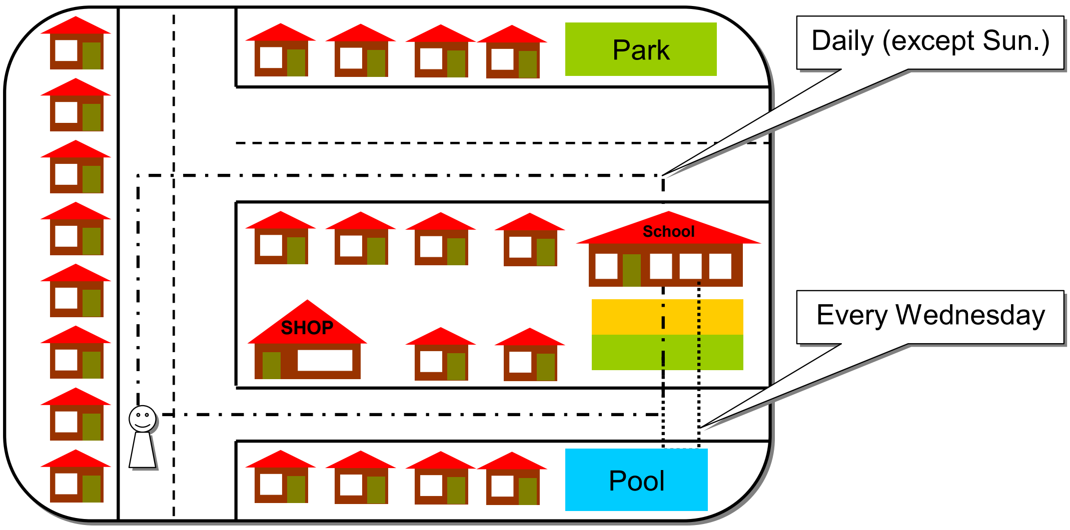
Figure 52 Recording Movement Patterns of Mobile Users

Again the MDP provider will have access to this past, future and present data in order to be able to provide recommendations based on the users movement. For providing accurate recommendation the MDP provider has to analyse the movement pattern for the type of movement (see **Figure 52 Recording Movement Patterns of Mobile Users**). In this case if the user is walking, using a bicycle, public transportation or a car this could be evaluated by the speed, the position of the user (e.g., street, motorway or train tracks – this depends on the accuracy of the device which delivers the position information) or by using a corresponding profile which is set by the user / device.

As mentioned above this scenario implies privacy issues as well. This means if the user wants to use the MDP service the user has to be aware that at least the MDP provider will know / has to know his position in order to provide the recommendation service. Again the position of the user will be only known to the MDP provider which will select the users (anonymous and matching) profile in order to provide a recommendation to the user.

5.3.3 Gathering data about and for the User

There would be several ways to gather this data. For the location and temporal information this data could be gathered automatically (see **Figure 53 Building a Knowledge base for recommendation**). For the interest dimension it would be possible to work with a controlled vocabulary or hierarchy of interests and let the user chose the matching interests.



Daily routine: School kid walks to school – plays after school at the playground and walks home. Wednesday they go swimming after school and then return home from the pool.

A shop or park close to this way could advertise their services.

Figure 53 Building a Knowledge base for recommendation

Another, more convenient, way would be to analyse the surfing behaviour of the user to gather information about his likes and dislikes (e.g., by a rating function for sites visited or information frequently read or accessed). As Mobasher defines that Personalisation should be executed automatically without interactions by the user but based on the user's actions, the user's profile, and (possibly) the profiles of others with 'similar' profiles (Mobasher et al., 2001).

This is where the new Multi-Dimensional-Personalisation concept can provide significant benefits to the user. The approach can support the user in coping with massive information overflow. The online world as well as the offline world provides a vast array of opportunities, information and services or events the might be relevant to the user. The main problem nowadays is to get the right information at the right time at the right place and in the right format matching the (daily) routine of the user or supporting the user on new ways or unknown ground (an addition to the service could be a pull LBS service which also takes the interests of the user into account, e.g., for spontaneous trips at the weekend)..

As mentioned above a powerful extension of the model is to use a feedback function to the middleman to provide feedback about the recommendations or service offers received (similar to the ratings for eBay™ or Amazon™ sellers/buyers). This could work in multiple ways, for example, to block an organisation because of wrong or bad recommendations or other reasons. This feedback would allow the middleman to fine tune the service provided for the individual user. If the middleman evaluates the user feedback it would be possible to eliminate organisations which provide bad services or recommendations. If an organisation gets many bad ratings the middleman should consider not dealing with them anymore. By doing so the service would get tailored right to the user's wishes so that everybody could receive matching recommendations and not just spam. As positive example of this feedback approach there could be the case that an user expresses his wish to the middleman to pass more personal details to the organisation which provided a recommendation. In this case a closer relationship between the user and an organisation could be established. Naturally this relationship could be revoked if the user wishes to do so.

5.4 Privacy by design

Unlike many other projects the MDP concept was from the beginning designed with the protection of the privacy of the end user in mind. The requirements presented in the section "2.4 Privacy, security and trust" have been tried to be taken into account. As the user will accept such a system only if he trust the system that it will cause no harm to him and he has a benefit from it this privacy awareness is an important USP (Unique Selling Proposition). Earp and Anton (2004) found that it is in the interest of a business to establish a privacy management and a privacy policy as the need consumers which are providing personal information to them so that the business able to undertake their business and customer relationship management. If the user understands the policies, how his data is treated and protected the customer will feel confident to disclose personal data without fearing to risk everything. In addition the customer has to understand what benefits he has doing so.

Earp and Anton (2004) refer to the US FIP Principles consist of the following (The Code of Fair Information Practices; Code, 1973):

- Notice/awareness – Consumers should be given notice of an organization's information practices before any personal information is collected from them
- Choice/consent – Consumers should be given options as to how any personal information collected from them may be used
- Access/participation – Individuals must be given the ability to access data about him or herself and to contest that data's accuracy and completeness
- Integrity/security – Reasonable steps must be taken to ensure data is accurate and secure
- Enforcement/redress – A mechanism must be in place to enforce the four core principles of privacy listed above.

Burgoon et al. (1989) describes the privacy dimension as the empowerment to limit and control access to the users privacy by any means.

By taking Bauer et al. (2005), Barnes and Scornavacca (2004) and Smutkupt et al. (2010) into account (see 2.3 Mobile marketing and advertisement) the MDP approach requires the user to download an app for their smartphone and sign up to the MDP service. The request for permission will be part of the MDP registration process. At the same time the user has the possibility to tailor the privacy settings to reflect his will. The user is made aware that data (location, GPS Trajectories, interests, ...) are collected stored and processed but never revealed to anybody as far as the IT security put in place can prevent this. Especially that no information provider or advertiser will get direct access to the data and the data presented is only an anonymous snapshot in time. The MDP concept is based on the voluntary registration of a user which shows that he is willing to receive matching and personalised recommendation and notifications which should give him an added value. The user can always withdraw from this service by logging of or deleting his account. In addition the user can use a feedback process to black list or report information providers or advertisers for unwanted spam or not matching information (see 2.1.3 Location, Places, Routes, Control and Prediction as well, Do Not Call lists).

The privacy is build using several approaches and a layered concept with each layer is seen and protected as entity. Especially the access for the information provider or advertiser is very restricted by using a specialised application which works only on a set of anonymised / pseudonymised data and does not allow these users to query the data freely but only in a limited way. The result set of a filter for potential targets or customers does not deliver the customer Joe Doe. It’s only delivering that there is a customer which matches the selection criteria. So by modifying the query and running it several times it is not possible to identify and track one specific customer.

The MDP system could be also used as a "just in time” pull LBS which could deliver recommendations and notifications to a user matching the location or area the user is at that moment. The disadvantage would be that none of the advanced features could be used.

5.5 Location related MDP issues

The related research (Song et al. 2004, Zheng et al. 2008, Liao et al. 2007, Sohn et al. 2006; see 2.1 User location and recommendation services) therefore supports that the use of MDP prediction of the user's routes, transportation mode, high level user activities and locations (or places) is possible and can be used for (personalised) LBS services. By using a Markov model Ashbrook & Starner (2002) analysed (or predicted) the probability of the path used from one location to the next based on recorded GPS tracks with high probabilities. MDP extends the approaches taken so far by not only incorporating the past movement patters of a user but also using information about the future trips of the user based on his schedule.

The paper about the survey of Kaasinen (2003) defines further requirements (see 2.1.2 Context- and Location-aware as well) which have to be met in order to make such a system successful:

- "The user should be able to flexibly control the release of private information such as his/her location at a given time. The user should be allowed to remain anonymous when (s)he wants".
- "Personalisation in location-aware services is a good way of improving the usability of the services by providing the most essential information and the most probable options easiest available".
- An important result of the survey is that "Privacy protection in location-aware services is related to the right to locate a person, use the location, store the location and forward the location. Current legislation is the basis for privacy protection but social regulation can also create rules and norms for different situations in which location-aware services are used (see also Ackerman et al., 2001)"

- “Personalisation in location-aware services is a good way of improving the usability of the services by providing the most essential information and the most probable options easiest available”.

These results of the survey support the conceptual ideas laid out for the Multi-Dimensional Personalisation.

The building blocks of the MDP concept have been research and have proven to work as single entities. Combining them together results in the new and unique approach described as MDP concept.

5.6 Summary

The MDP idea was born in 2002 / 2003 and first published in 2003 (Schilke, SW, German) and 2004 (Schilke et. al., 2004, English). The author is not aware of a full implementation of the MDP concept neither in Europe, Asia or the USA. Even if some of the MDP functionalities or components of MDP have gained more exposure over the last couple of years at that time it was not an inevitably obvious idea to combine the defined components to build MDP. Some of the components necessary for MDP have been covered in research projects but have not been implemented in a larger scale. Most research projects known to the author cover one or two components of MDP, but no project has gone as far to implement MDP concepts in full. Some systems offer functionalities to allow developers to enhance their own systems with MDP like functionalities (Xtify, 2012) but only for their own system / app and not as a hub or provider (SPOT) for multiple advertisers or information providers. The MDP / SPOT approach would allow the user by controlling one system to control may information providers at just one place.

Based on the idea which started the research project about how MDP could look like (plus the scenarios describing the envisioned functionality) and the input from the end user survey a concept was formulated. The requirements for personalisation in a location based services scenario, the use of past, actual and future movement patterns in time brackets, the identification of regular visited spots, the interest classification from the user, protection of privacy and gaining the trust of the user have been identified and defined based on own research and the research of other researchers / research projects. It seems feasible to say that based on this the concept would work in a real live scenario if implemented.

In the next chapter the concept is presented as a proposed architecture which covers the requirements and functionalities which have been described.

6 Service design for MDP

The MDP idea was described as scenarios which will be presented in the following sections to explain the components of the concept, that is, systems in terms of the work that users will try to do when they use those systems (activities and interactions), which is roughly based on the Scenario Based A Design approach described by Carroll (1999) and Rosson and Carrol (2002) is based on a description of a system in very early stages of the development by (detailed) descriptions of scenarios of the planned usage (e.g., user stories) in order give the developers a guideline to develop the necessary functionalities. This Scenario-Based Design is moving the the design of a system away from describing system operations (i.e., functional specification) to describing how users will use and work with the proposed system. This relatively lightweight method allows to imagine a future system and its possibilities. The following sections present these scenarios and a proposed architectural concept suitable for a possible real world implementation.

The proposed architecture for Multi-Dimensional-Personalisation (MDP) covers the main points and issues which have been identified during the research phase, the tests with the mock ups and addresses the points identified by the expert interviews as well. A main issue for such architecture is the scalability as a rapid growth of the numbers of users has to be anticipated if the MDP system is successful. Even if this is a problem which will be only faced during a real world implementation it is important to cover these requirements with an architectural proposal which describes the service design of the proposed system. The architecture also influences the business model as the implementation must win the trust of the user that the system provides them and their data with security, privacy and data protection by building this into MDP by design, that is, its (proposed) architecture. As the main focus of this work is the MDP concept and not IT security or software architecture this proposed MDP architecture is used to illustrate the important issues and requirements which have to been taken care of. An additional research project or during an actual implementation phase of the MDP concept this topic has to be defined more in detail.

The components which are used to build the MDP system are the MDP client (native application on, in market share, leading smartphone platforms), the MDP server systems (consisting in this proposed architecture of the MDP server, an MDP Intermediate server and the MDP Ad server for the communication with the information provider or advertiser). The technologies used in the example are all based on existing technologies. As the sever system should be scalable the servers should be seen as black boxes (no hardware sizing etc. is given – the server is described only by its functions). In addition as the MDP system relies on real push messaging for the notification of the mobile user some smartphone platform depended issues have to be taken into account. It would always be possible to fake push notifications by letting the MDP client frequently check (poll) for updates in a pull fashion.

6.1 MDP Client

There is a basic set of functions required to make the MDP concept work for the user which are described here. Before a user can use the MDP client it would be necessary to register an account with the MDP system. This could be done either via the MDP service provider's web site or via the MDP smartphone application. After the first registration the user is asked to provide some additional (some of them optional) data for his user profile (e.g., gender, age, languages understood etc.). Naturally he can always change this information later in the user profile (see Figure 54 Logon / Logoff from MDP Server).

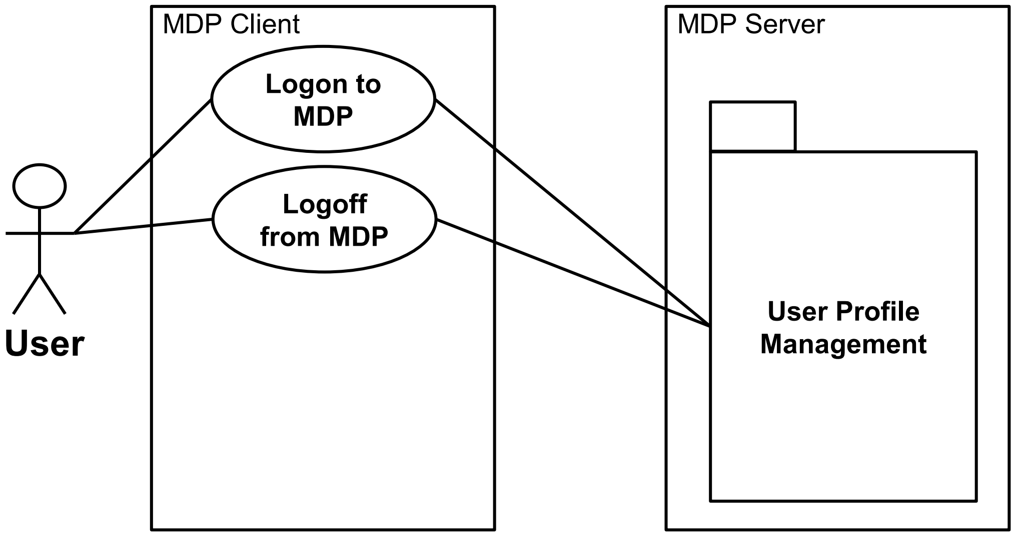


Figure 54 Logon / Logoff from MDP Server

After downloading the MDP application onto the smartphone the application has to be connected to the MDP account of the user. During this time platform dependent information can be passed on to the server (e.g., platform of the smartphone, operating system version, connectivity, bandwidth, etc.). In addition the server provides the client side application with a certificate for authentication purposes during the communication with the MDP server. By doing so the device and the messages sent from the device are tied to the account of the MDP user. In case of a device is used by multiple users (or the user is using several devices) it is possible to logoff the users account, that is, the device, from the MDP service (see Figure 54 Logon / Logoff from MDP Server).

Once the connection between the user, its device and the MDP server has been established, the user can use the device. Once logged on the client can use the user profile which is stored in the MDP server's user profile management.

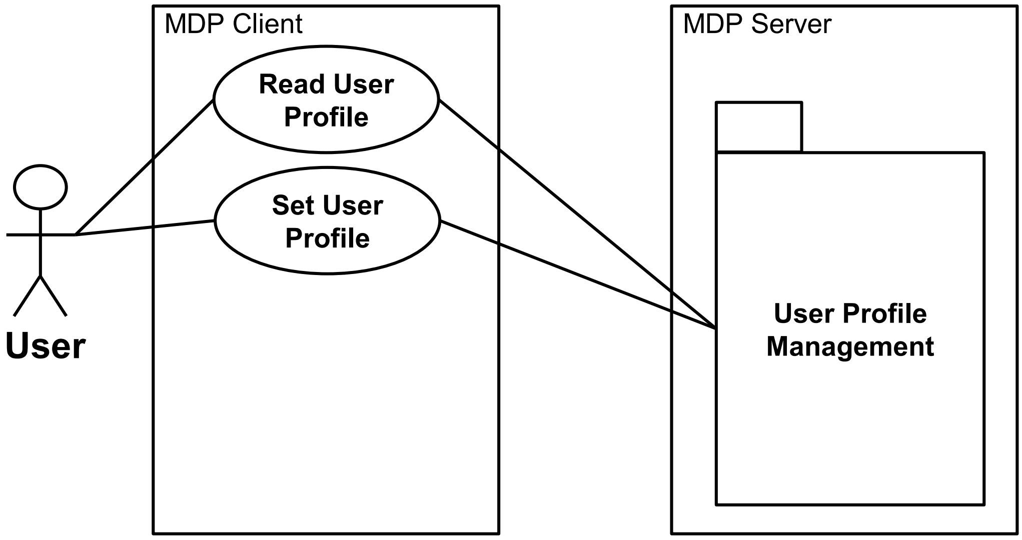


Figure 55 Editing MDP user profile

Editing the user's MDP user profile and configuration of the MDP client can either be done by a web interface of the MDP system or via the MDP client application on the smartphone.

The functionality shall be the same just via a different interface. The following figures always show the MDP client regardless if it is used via web interface or the smartphone application (except for the location functions which mainly would work on a client with GPS even if an IP based or manual location setting would be possible as well). Another important function for the user is to express his interests so that it will be possible to provide him with matching personalised LBS recommendations (see Figure 55 Editing MDP user profile).

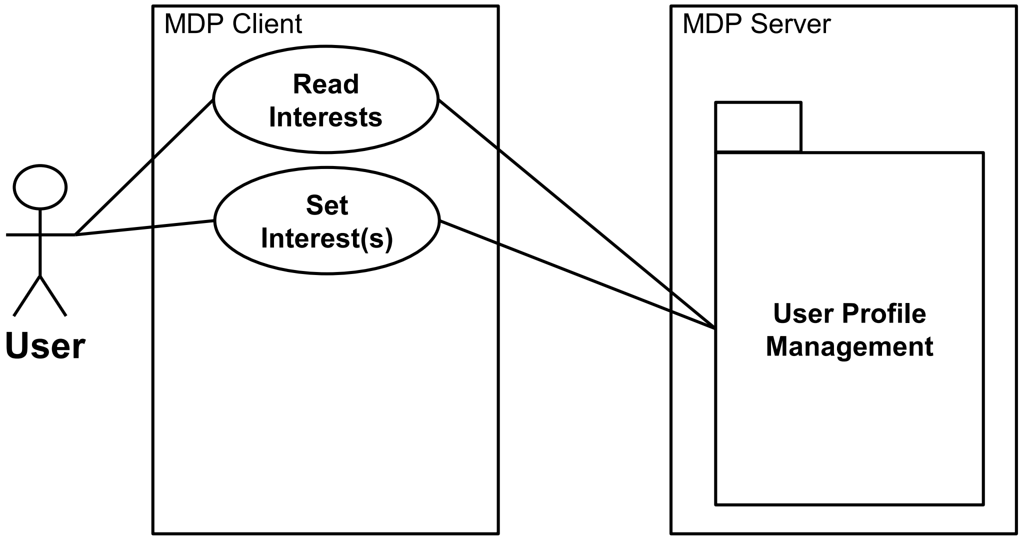


Figure 56 Configuring user interests

This necessary function allows the user to check and edit the interests he has chosen (see Figure 56 Configuring user interests). The changes will be written to his profile on the server. A local copy will be stored on the client device (e.g., for making changes while offline). The MDP Server would provide the MDP client with a tree structure of a controlled hierarchy of terms describing the interests the user has. This ontology can be used by the client to select on every level of the controlled vocabulary. This would automatically include the next level(s) of interests for the user. An example is the structured category hierarchy information of the DMOZ (Directory Mozilla; DMOZ, 2012) ODP (Open Directory Project, RDF dumps of the category hierarchy information). As an example the user could be interested in:

- Cooking: Pizza;
- Cooking: Meat: Poultry: Chicken: Salad
- Cooking: World Cuisines: Asian: Japanese (which would include the sub categories, like miso and sushi)
- Sports: Soccer;
- Recreation: Guns: Competition Shooting: Tactical Action
- Arts: Music: Styles: J: Jazz: Smooth Jazz

In addition a field that allows to user to enter some text describing his interests could be offered. This information could be taken into account when selecting the target audience for the information provider or advertiser.

The next MDP function the user can set and create and edit[4] is the mood.

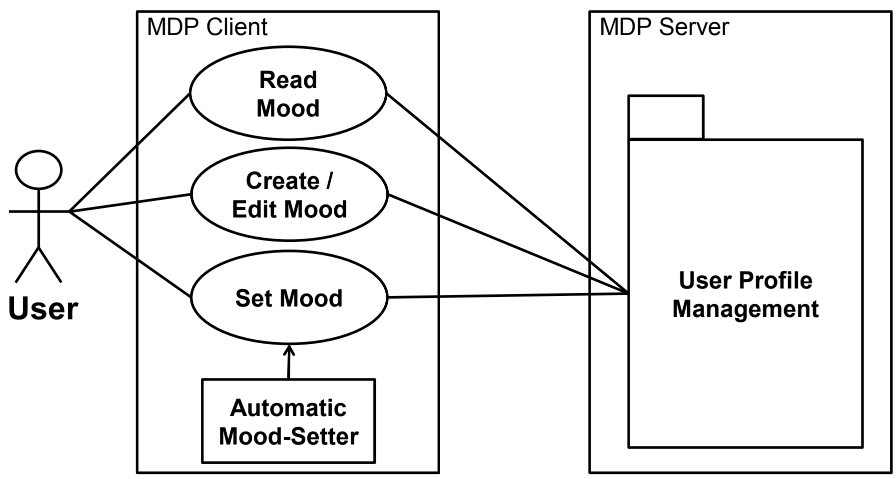


Figure 57 Mood of the MDP user

[4] A part of the edit functionality could be to erase a mood. This applies as well to all other edit functions mentioned.

The Mood setting (see Figure 57 Mood of the MDP **user**) allows the MDP user to tell the system if he is willing to receive personalized recommendations or not (e.g., private, public, party, play, sleep, do not disturb, driving). This can be automatically mapped to the modus set for the smartphone (e.g., "silent", car or based on time brackets (e.g., "sleep" during night between 23:00 and 7:00)) or set by the user. The user can define, which means, create and edit his own moods which then reflect his lifestyle and the reactions he expects from the MDP system (e.g., if recommendations should be delivered and in what fashion). The automatic Mood-Setter of the client would handle the predefined settings which are not set manually by the user (e.g., sleep). The MDP server receives and acknowledges the changes and acts according to them. Regular, that means, automatic, changes (like the sleep mood) would be considered by forward planning for recommendation deliveries in the future. An automatic setting can be overwritten by the user or used at other times as the predefined times, for example, if the user takes a nap in the afternoon he could set the system to sleep even if he is outside the time bracket for this mode.

An additional mood could be introduced: "do not track" – if the user selects this mood the system would stop recording the GPS trajectories and therefore send nothing to the MDP server. It has to be discussed if the client should report to the MDP server that the user has selected the "do not track" mood or if the system just loses sight of the user or if this should be also depending on the user.

The next setting is the mode setting (see Figure 58 MDP mode for transportation). This refers to the transportation mode of the MDP user.

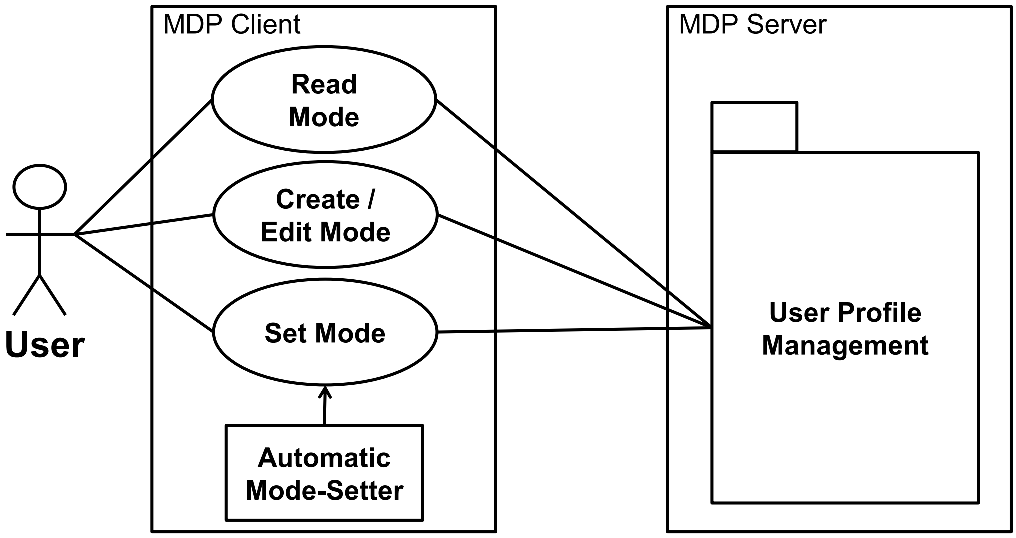


Figure 58 MDP mode for transportation

The MDP mode tells the system how the mobile user is moving, for example, by foot, car, public transportation, bike. This can be set manually by the MDP user or automatically detected by the system (see Figure 58 MDP mode for transportation). The automatic detection would use, for example, the setting of the smartphone if it is plugged into a car phone cradle or connected to the hands-free equipment via Bluetooth. The mode setting can also be set manually by the user, for example, if he is the passenger in a car not using the equipment which would usually changing the mode setting to car as if he would be the driver. The MDP user can create and configure the modes he needs to represent his lifestyle and the transportation modes available to him (e.g., car passenger). The behaviour and parameters of the mode can be edited (and therefore also deleted) by the user.

Depending on the movement mode (i.e., assumed speed of the transportation mode) the notification has to be send well ahead (i.e., time, distance) to allow the mobile user to react if he is interested. All this has to be taken into account from the MDP server system when planning to send out recommendations to this specific MDP user.

Another parameter influencing the behaviour of the MDP system is the location parameter.

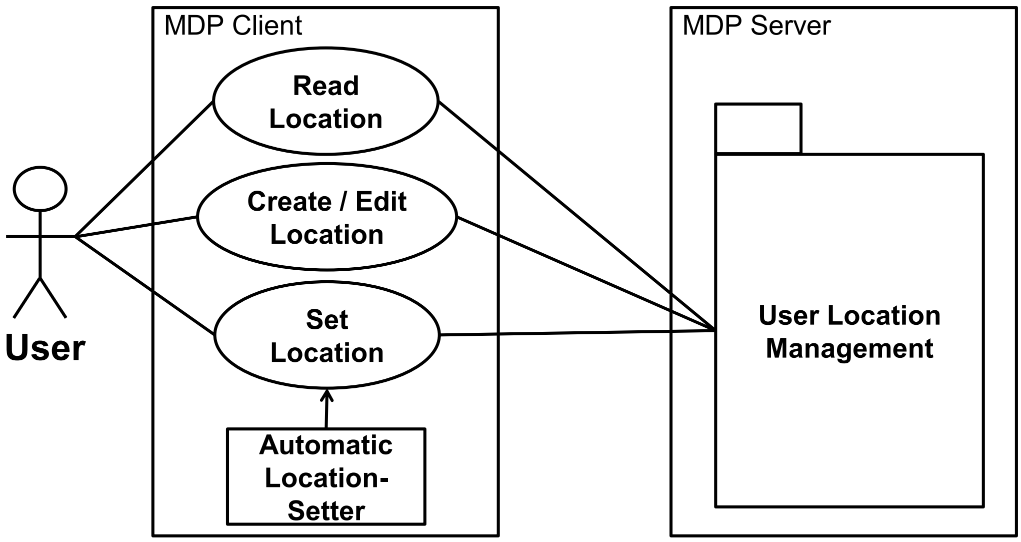


Figure 59 MDP location of the user

In this case it does not mean the actual real time geographical position of the user but rather a steady position where the mobile MDP user is supposed to stay for a longer time period. The mobile user has reached a certain place (e.g., at work, in school, at university, at home) and will set this position in his MDP location profile. This can be set manually by the MDP user or automatically if a certain geographic region is reached (see Figure 59 MDP location of the user, for example for frequently visited places like the home, office or school) or by a time bracket like the office hours. By doing so regular visited places without GPS reception (like an office building) can be identified and therefor considered for sending out LBS push recommendations nearby.

In order to allow the MDP user to have its lifestyle reflected he can create and edit these locations which will be stored on the MDP server as well. Again the MDP user can manually overwrite[5] the automatic setting (e.g., if the user is sick at home and not in the office during office hours). This position will be known only to the MDP server and will only be used to provide the MDP user with matching LBS push recommendations. The location of the user shall never be published or made publically available (except the users want social media integration in order to publish their location on their own will).

The most important function with an automatic update is the position update in order to record the (real time) position, that is, the movement tracks, of the users movement patterns (see Figure 59 MDP location of the user). The smartphone must provide the MDP client application with the possibility to read the users position, for example, by using GPS, A-GPS or other ways to acquire the MDP user's current location.

The automatic position update would be a scheduled service of the MDP client. This schedule has to be based on experiences made or further research to optimize the ratio between the necessary data transfer and the accuracy of the data needed from the MDP prediction or estimation functionality, for example, during the GPS trajectories recording experiments (see chapter "Movement patterns) made a one minute interval was a good compromise between the frequency of the data transferred or stored and the distance a MDP user could travel in that time frame (depending in the transportation mode).

[5] Or even delete the location while editing it.

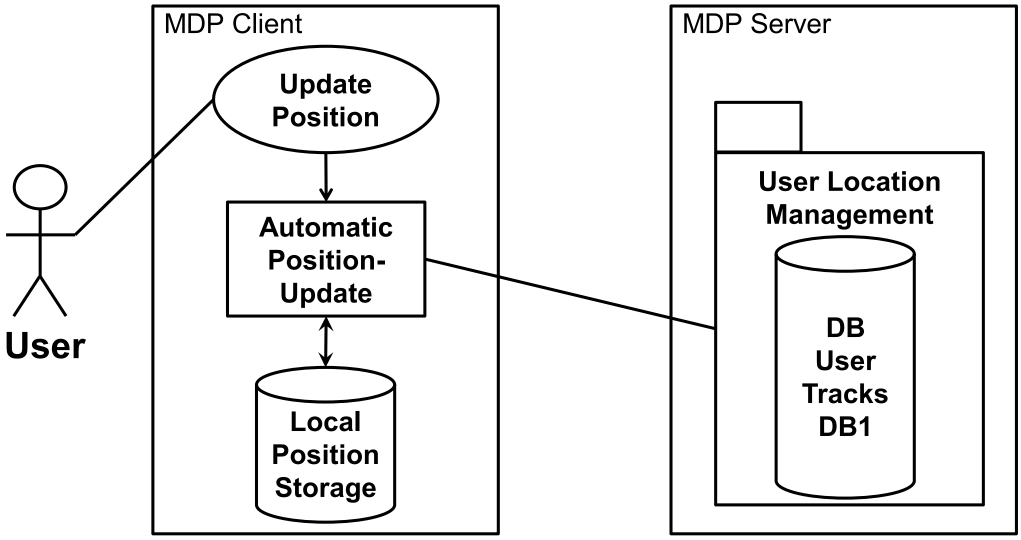
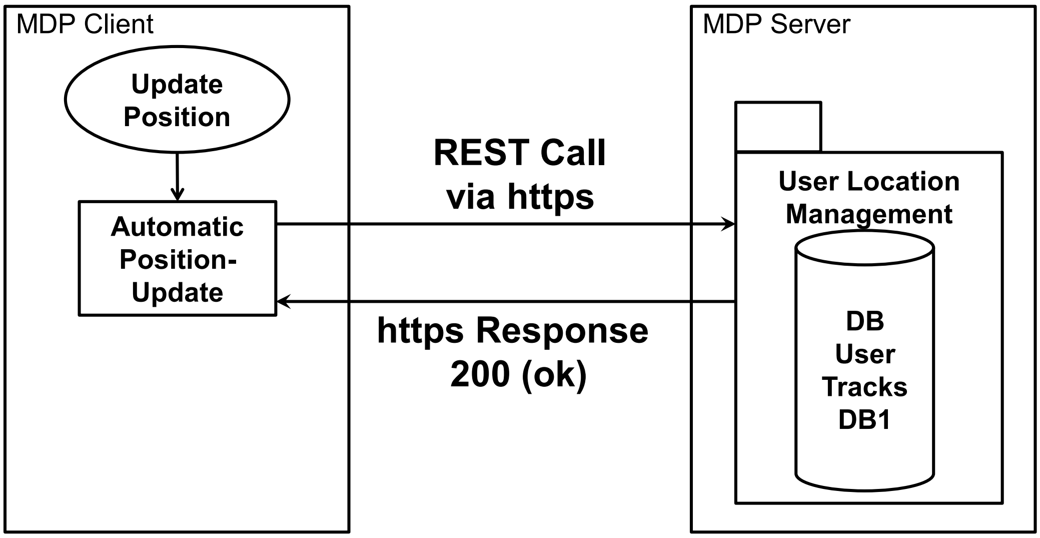


Figure 60 Update of GPS position

The MDP estimation of the users position depends on the recorded past movement patterns during time brackets of the MDP user (see Figure 60 Update of GPS position, i.e., a location where the user stays for a longer period in time).

The use of the regular movement (location) patterns of the mobile MDP user for the personalized recommendations is an important differentiator for MDP from normal pull based Location Based Services (LBS). Nearly everybody has a daily routine, for example, the way to / from work, school, university, training, sports, etc. Research into this field which confirms these regular daily routines and their movement patterns dates back until the 70's (Chapin, 1974, Lewison & Kumar, 1995). By using these historic tracks of the MDP user the system is able to estimate at which point in time (or time bracket) the MDP user probably will be where. By using the (future) schedule of the mobile user it's even possible to recommend something in the future (e.g., for a planned business trip, holiday …). As the (regular, i.e., routine) movement pattern of the mobile users are "know" to the MDP system the possible location of a user at a certain day and time can be predicted and used to schedule notifications ahead in time. The MDP server stores or updates the movement pattern, mode, mood, settings and interests of the user. It acts as Single Point of Trust (SPOT) and protects the data and privacy of the user.. Nobody shall get access to this collected raw data so the protection of this server system is crucial to the success of this concept. This would mean that not even anonymous profiles would be made available to the service requesting service to provide a recommendation, i.e. that the recommender would not get access to the pseudo domain of the identity protector approach. This would enhance the protection of the user (Senicar et al., 2003).

The user needs to develop trust into the system and the measures taken to protect his data by the concept, design and architecture of the system. The SPOT is not supposed to be a single point of failure as it has to be a high available server system. Another security related point is the danger of access to the user data of the administrative personal which shall be prevented by taking specific actions (e.g., dividing administrative access and access to the data in the system). Again this has to be taken into consideration in another research work or a real world implementation.



- **REST Call contains ID of the user / token, timestamp, location (latitude, longitude, altitude, speed, direction, …)**
- **Security for the data transport via https (using TLS/SSL)**

Figure 61 Communication MDP client and server

One of the measures taken to protect the data communication of the MDP user is that all communications between the MDP client and the MDP server (see Figure 61 Communication MDP client and server) via an insecure mobile network (i.e. an Internet connection) are secured by using https and TLS/SSL (RFC 5246 Dierks & Rescorla, 2008; RFC 6101, Freier et al., 2011; RFC 2818, Rescorla, 2000) protocols. In addition, the MDP server and MDP client are validated by their certificates. In addition authentication and strong cipher suites shall be used. This should also prevent eavesdropping and man-in-the-middle attacks. The REST (REpresentational State Transfer; Fielding, 2000) software architecture was chosen because in a mobile internet environment a lightweight, stateless protocol has an advantage over more complex protocols like web services (Pautasso, 2008, as presented in chapter 2.5.1 REST, lightweight protocol, low consumption of memory, CPU, bandwidth and a stateless protocol meeting the needs of mobile clients). As an additional security precaution for the used REST URLs they could be signed to prevent tampering.

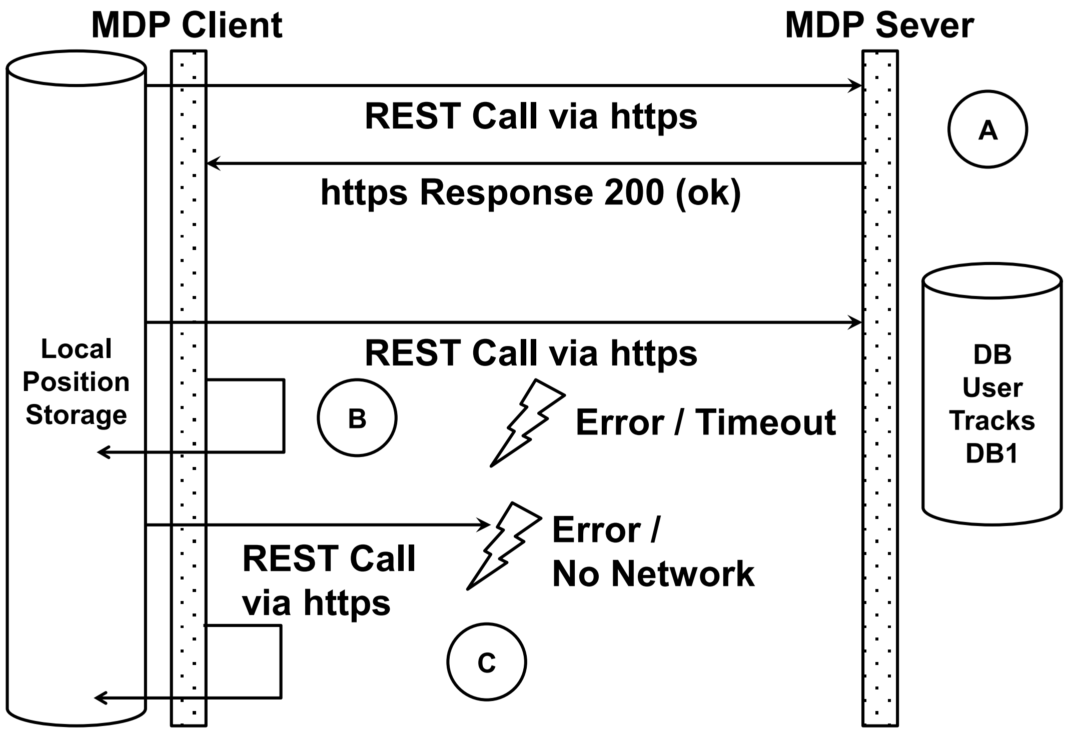


Figure 62 Communication of the MDP client

This figure shows the communication between MDP client and MDP server and the measures taken to prevent data loss. In Figure 62 Communication of the MDP client point (A) shows the normal behaviour if the MDP client contacts the MDP Server. If the REST call goes through to the MDP server the server responds with a positive acknowledgment message. In case of that the request requires more than a positive acknowledgment message is required the response also contains the data payload (depending on the request and the expected response by the server). Case (B) in Figure 62 Communication of the MDP client shows what happens if the MDP client can send the REST call but does not get a timely response from the MDP server. Depending on the function calling the server either an error message is shown on the MDP client side to the user (interactive features) or in case of the position update information (automatic update of the position) is stored in a local database. The automatic position update always checks the local position storage for queued position records before issuing the update of the position data on the MDP server. By doing so it can be made sure that no position data gets lost even if the MDP client device cannot get the acknowledgment message from the MDP server. In case of the data gets through to the server and is not acknowledged a later resend of the data from the MDP client (with a confirmation from the MDP server) would confirm the received data on the MDP server. As the position data contains a timestamp (time of its creation) every unique position record of the MDP user can be identified. A similar approach is taken if the MDP client device does not have a network connection (C, in Figure 62 Communication of the MDP client) and it cannot reach the MDP server by itself. Again the MDP client tries at the next scheduled time to send all the collected position data records from the client's local position storage to the MDP server.

During the research a sample application was developed for an Android smartphone. It was used to test a REST-style call to a REST server (see Figure 63 Screenshot MDP Sample Client app REST call). The call contained the user name, timestamp, longitude, latitude, altitude. The app displayed the result of a reverse-geocoding for the position and showed the suburb, city and country for the position. The REST server which received the REST call stored the information from the client.

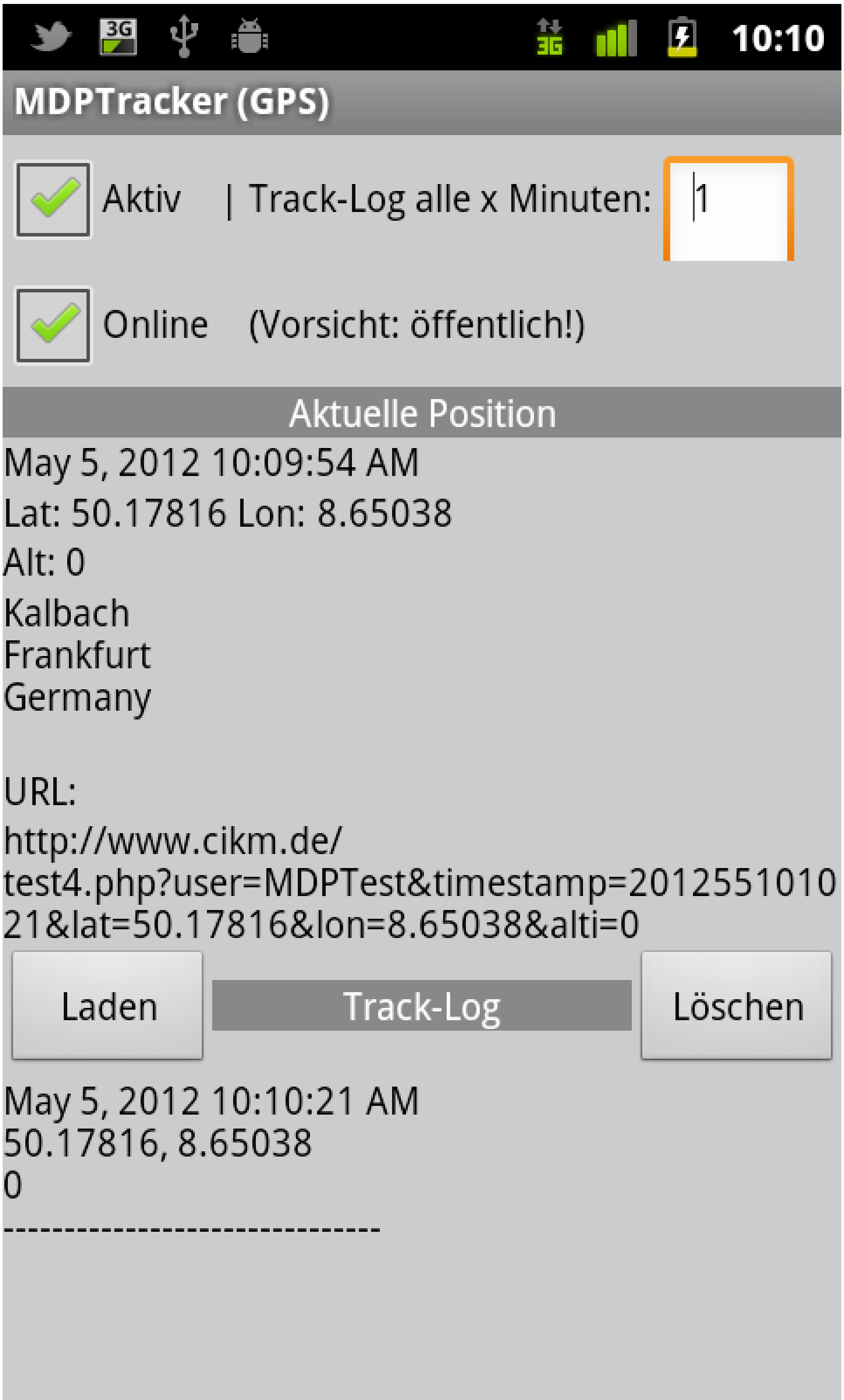


Figure 63 Screenshot MDP Sample Client app REST call

The following lines are from a debug protocol / log of the MDP sample app on the Android client side:

- *05-05 10:10:21.745: INFO/Web(18638): performRequest - connection is org.apache.harmony.luni.internal.net.www.protocol.http.HttpURLConnectionImpl:http://www.cikm.de/test4.php?user=MDPTest&timestamp=201255101021&lat=50.17816&lon=8.65038&alti=0*

  → Making the REST call
- *05-05 10:10:24.395: INFO/Web(18638): performRequest - responseCode is 200*

  → Receiving the http response code from the REST server
- *05-05 10:10:24.405: INFO/Web(18638): performRequest - responseType is text/html*

  → the response delivered by the REST server has the format text/html (depending on the call this response could contain data which has to be consumed by the MDP client app).

The example is not using HTTPs for securing the data transmission or, for example, OAuth, for authentication of the client. The REST server called responds with a http response code 200 signalling the client that the REST call and it's data was submitted successfully. As this is the only response for this call from the server there is no payload in the http(s) response (body). If the server could not process the REST call or if the REST call did not conform to the specification an http response like 303 (See Other), 400 (Bad Request), 404 (Not Found) or 500 (Internal Server Error) could be returned.

An additional security could be provided by protecting the MDP server from attacks via the (mobile) internet by deploying, besides a firewall system, a special application firewall to prevent attacks via manipulated REST calls.

6.2 MDP for Information provider or advertiser

In order to allow information providers or advertisers to use the system and to select their potential target audience based on an anonymised respectively pseudonymised MDP user profiles a MDP Advertiser (web) client application has to be provided. The user has to be register with the MDP Ad server and its services. This allows a clean-up of the Ad server user base if the account was used to send unwanted recommendations (SPAM (e-mail) or SPIM (Instant Messengers)) to MDP users.

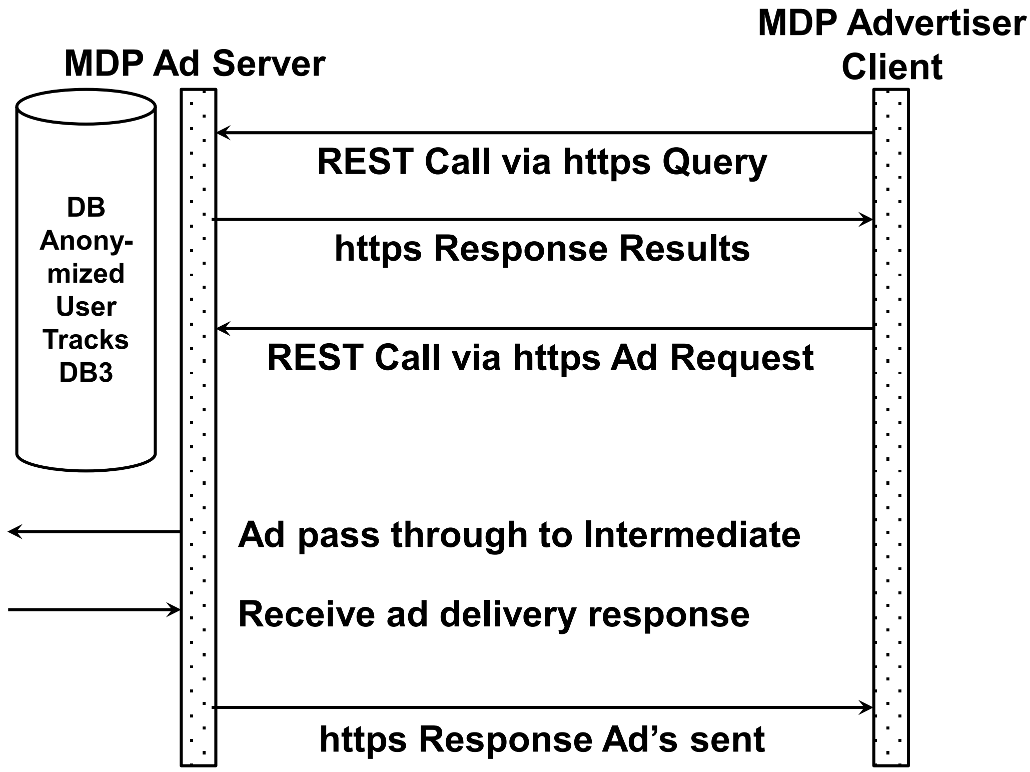


Figure 64 MDP information provider and advertiser access

The registered information provider or advertiser never will get direct access to the anonymised respectively pseudonymised shadow user data set (DB3) which is used to select the potential target audience (see Figure 64 MDP information provider and advertiser access). The selection is based on the anonymised respectively pseudonymised MDP user profiles and can be based, for example, on an area (e.g., 500 meter around the address of a shop), a time bracket (a specific date and time or tomorrow between 12:00 and 13:00), interest (e.g., Italian food) and optional, for example, an age range (20-30 years), gender (male) and other data stored in the MDP user profiles. By creating such a selection filter the requestor will get a response indicating how many MDP users potentially will be available to reach based on the estimation of the MDP Ad server based on the anonymised respectively pseudonymised user tracks. The system would start, based on the selection criteria's, to query the pseudonymised database with the historic tracks and planed whereabouts:

1. Users which are in the selected area with a high probability (estimation or prediction) at the chosen day.
2. Users which are during the selected time (bracket) with a high probability (estimation or prediction) in that area
3. Users which have a matching interested
4. Other filters which have been applied (e.g., gender, age range) if applicable
5. Presenting the results (e.g., a number of users) will be likely a matching target audience for the defined filter

The requestor will never get detailed information about one or more users in the result set. So even by variations of the selection filter it will not be possible to isolate a specific user and track that user down.

Once the selection filter delivers a matching target audience the information provider or advertiser can book the recommendation. For example, this could be an event, some information, a voucher or coupon, a call to, for example, a map application or a link to a web site. The recommendation request will be passed via the MDP Ad server to the MDP Intermediate Server (see Figure 65 Recommendation Request passes through the "Chinese Wall").

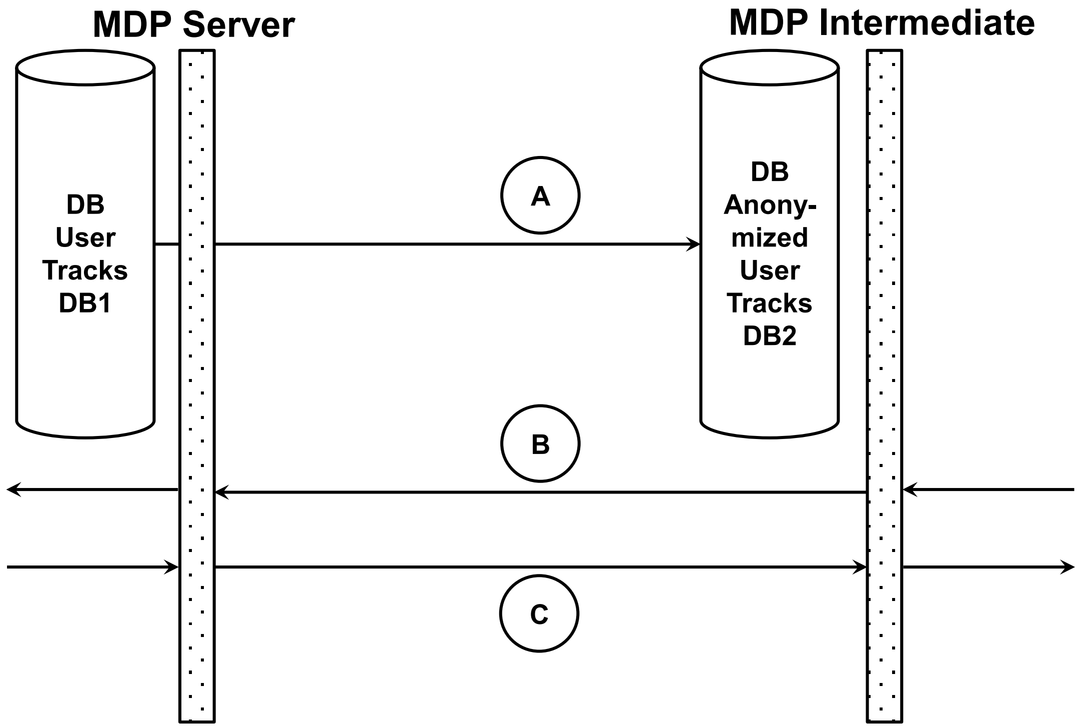


Figure 65 Recommendation Request passes through the "Chinese Wall“

This MDP Intermediate server maps the request from the DB3 anonymised respectively pseudonymised data to its own set of anonymised respectively pseudonymised MDP user data (DB2) and passes it on to the MDP Server (B) (see Figure 65 Recommendation Request passes through the "Chinese Wall“). The MDP Server matches the user id received from the MDP Intermediate to the real users. After sending out the recommendations a response about the delivery of the recommendations to the users (i.e., the number of delivered recommendations (C), see Figure 65 Recommendation Request passes through the "Chinese Wall“) is passed, via the MDP Intermediate Server, to the MDP Ad Server. This feedback allows the information provider or advertiser to evaluate the success rate of the campaign.

The MDP Server selects depending on the device registered for the MDP user the right delivery method and tries to deliver the scheduled recommendation at the right time and at the right location (see Figure 66 MDP recommendation delivery, (A)). If the

MDP user is not in the right area at the time the recommendation should be delivered the delivery is omitted in order not to send not matching recommendations.

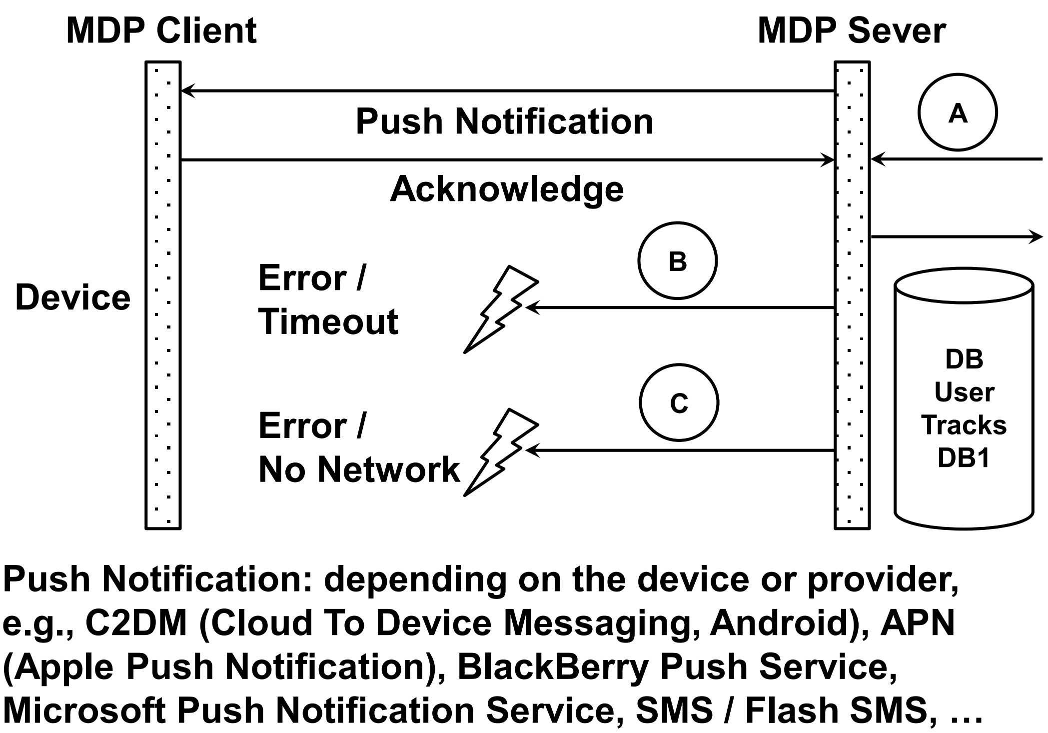


Figure 66 MDP recommendation delivery

In case that delivery is not possible because of technological difficulties (see points B & C in Figure 66 MDP recommendation delivery), the system tries to deliver as long as the recommendation is still valid but it will send a negative response to the information provider or advertiser if it does not succeed to deliver the recommendation to the user.

A regular running service task would create an anonymised respectively pseudonymised shadow dataset of the MDP user profiles by taking these data from the MDP server and updates the data in DB2 (A, see Figure 66 MDP recommendation delivery). The anonymised respectively pseudonymised shadow dataset is provided from the MDP Server based on the data in DB1. This process provides not the real traces of the MDP users but optimized tracks which present a model of the real tracks based on locations, that is, positions, and time brackets. This allows the amount of data to be minimized to the extent that the data contains all necessary data for estimation of the users position with the precision needed to offer the recommendation services. By doing this no real MDP user data is ever exposed to the MDP Intermediate Server.

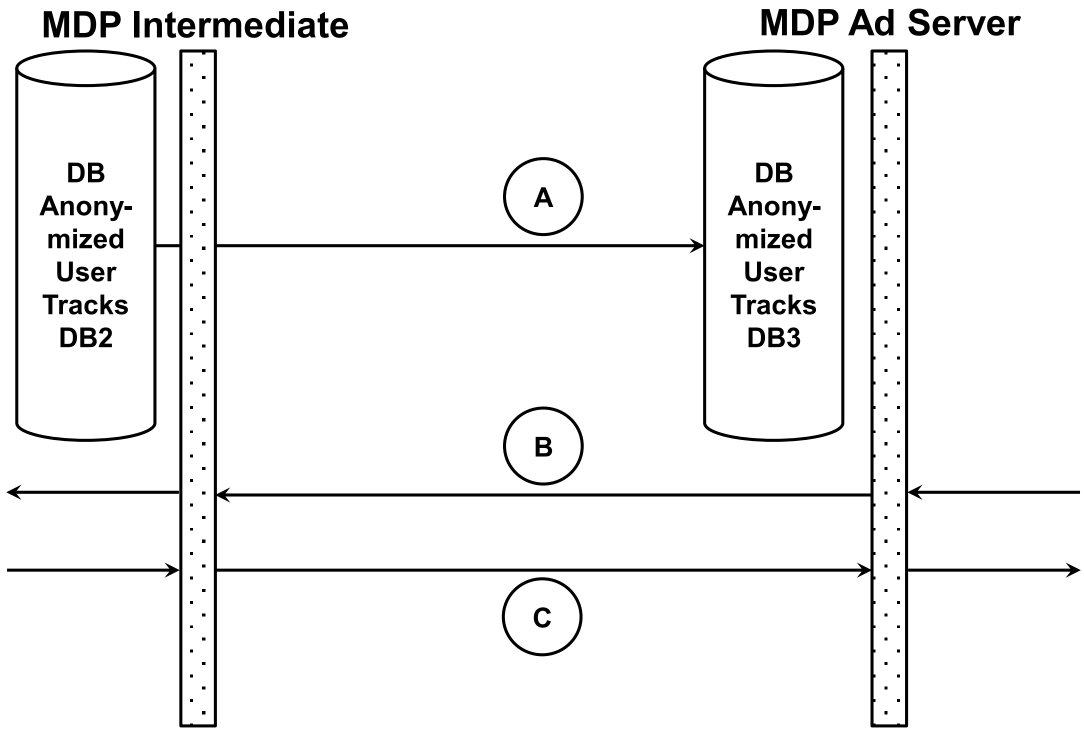


Figure 67 Data transfer between Intermediate and Ad Server

A similar process prepares the anonymised respectively pseudonymised data for the MDP Ad Server. The MDP Ad Server receives its shadow dataset from the MDP Intermediate Server (A, for DB3) (see Figure 67 Data transfer between Intermediate and Ad Server).

The MDP Ad Server only communicates with the MDP Intermediate Server (B & C, see Figure 67 Data transfer between Intermediate and Ad Server) and never communicates directly with the MDP Server. The recommendations which are booked (B) and the feedback how many successful deliveries of the recommendations have taken place (C) are also transported via the MDP Intermediate Server (see Figure 67 Data transfer between Intermediate and Ad Server).

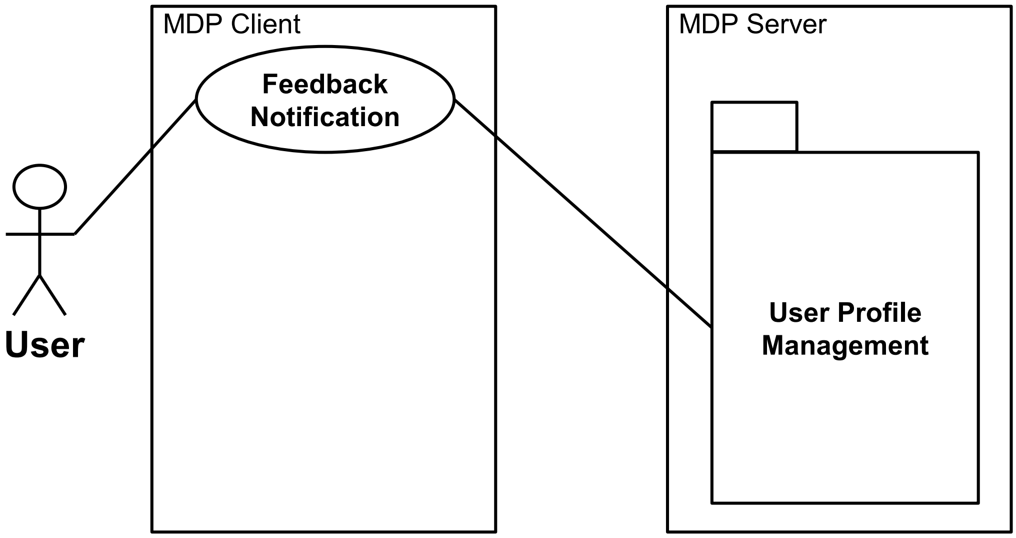


Figure 68 MDP User feedback

If a MDP user gives feedback for the recommendations he received this information will be transported from the MDP Server via the MDP Intermediate Server to the MDP AD Server (see Figure 68 MDP User feedback (C)) to inform the information provider or advertiser. Furthermore the system records the likes and dislikes of the user. For the recommendations the user dislikes he could be removed from future deliveries (based on the sender or type of recommendation). If enough users mark a recommendation as spam the system could send a warning to the MDP information provider or advertiser or even block this account if the problem is resolved.

6.3 MDP Server and "Chinese Wall"

The proposed architecture of the MDP servers will be given as an example which shall present a possible solution to cover the requirements of such a system which is offering functionalities to protect the data and privacy of the MDP users, allows information providers or advertisers to work with the system and is based on a concept and its architecture which designed so that MDP users can gain trust and therefore will use the system.

The main component is the MDP Server which is communicating with the MDP Clients. All the user data is saved on these servers. Camp (1999, p. 249) states that "privacy requires security because without the ability to control access and distribution of information, privacy cannot be protected". Consequently for these servers all possible and state of the art data protection and IT security methodologies have to be applied (e.g., ISO 2700x, Information Security Management System (ISMS) (ISO27000, 2009; ISO27001,2005;ISO27002,2005)).

Another possibility could be using an additional server subsystem as additional protective layer (see Figure 70 MDP server protection of front end (**example)**). The design of a secure IT system and it architecture is not the main scope of this work. The work lists the main requirements for the implementation of MDP. A detailed description or blueprint of such a MDP system is left to further research work or the design for it has to be taken care of during a real world implementation of the MDP system.

The storage of the movement patterns, that is, the GPS trajectories of the users requires a scalable architecture which can handle the storage and querying of such data. A Geographic Information System database or a moving objects database as described by Wolfson et. al.(1998). A special consideration has to be that the MDP Intermediate and the MDP Ad Server will need usable but anonymised respectively pseudonymised data to protect the privacy of the user. If data cannot be traced back to an individual (i.e., if it is un-linkable), the collection and usage of such data poses no threat to the individuals privacy (W3c, 2002).

In addition, the querying functionality of the MDP Ad Server hast to be tailored to reveal only results which can be seen as anonymous snapshots in time showing rather the quantity of user than single users in a defined area of the query matching the location, profile / interests and selected time bracket. So that even if a small number of users or even a single user is the result of the query no user will be revealed. In addition, the prediction functionality needs to be able to have access to the necessary data to estimate which users are at a certain time (bracket)in a certain area.

The main idea, that is the MDP concept, (which was supported by the interviewed experts based on the material provided to them) and extension to the traditional "Chinese Wall" approach is to use an architecture which separates the servers to use a kind of extended "Chinese Wall" in order to protect the user data and the access to it. Introduced by Brewer and Nash (1989), further developed by Sandhu (1992, 1993) the "Chinese Wall" is a very restrictive security policy. The proposed extension to the "Chinese Wall" goes beyond the other approaches of using only access control for partitioning the data in one common database. One proposed approach is to transport anonymised, respectively working with pseudonymised, data from the MDP server (which has contact to the MDP users) to the MDP intermediate server, (presented in Figure 69 MDP Server **communications**). Only the MDP intermediate server shall be allowed to communicate with the MDP server (for example controlled by firewalls).

The separation of the identifiers from the sensitive data (Bettini, 2005) was proposed in the MDP concept - by using algorithms which pseudonymise the data before transferring it to the MDP intermediate server and again before sending it to the MDP AD server shall allow the meaningful use of such data without the risk of exposing sensitive data. Other approaches like the IETF Geopriv Cuellar et al. (2002) or the derived RFC 6280 (2011) are feasible for some LBS / LBA applications but they do not fit the MDP concept completely as they do not work like the MDP concept with a Server which handles all the requests and is the trusted entity which controls the access to the location information of the user. In their definition the presence server is giving location information based on rules directly to other users but also allows them to pass this information on to other users if they have or get the proper permissions (like friend finding or friend location recommendation). MDP does never reveal the location and the identity of a user to advertisers or information provides. Parts of these standards could be adopted for the use in a MDP implementation (for example the access control rules). Similar to the MDP concept Bettini et al. (2005) uses a trusted server as middle man for the communication between the involved parties. They conclude in their paper that even if a trusted server can be seen as risk as it is a single-point, it is a reasonable aproach as mobile devices usually do not have the necessary resources to cope with such a task on themselves.. This architectural concept, in MDP terms SPOT *(Single Point of Trust)*, is also presented by Gruteser et al. (2003), Gedik et al. (2005) and Yee (2005) and so it is safe to say that it is a valid and widely used system architecture based on trusted computing. Bettini et al. (2005) also work with pseudonyms to allow that the user profile is anonymised.

The communication between these MDP servers occurs only inside of the data centre. By this reason the traffic between the servers cannot be listened in to. The only server which communicates directly with the MDP Ad server is the MDP Intermediate server (see
Figure 69 MDP Server **communications**). As described above, this MDP Intermediate server receives an anonymised respectively pseudonymised dataset. By doing so no real MDP user data leaves the MDP Server. The same procedure is used for the transmission of the data to the MDP Ad Server.

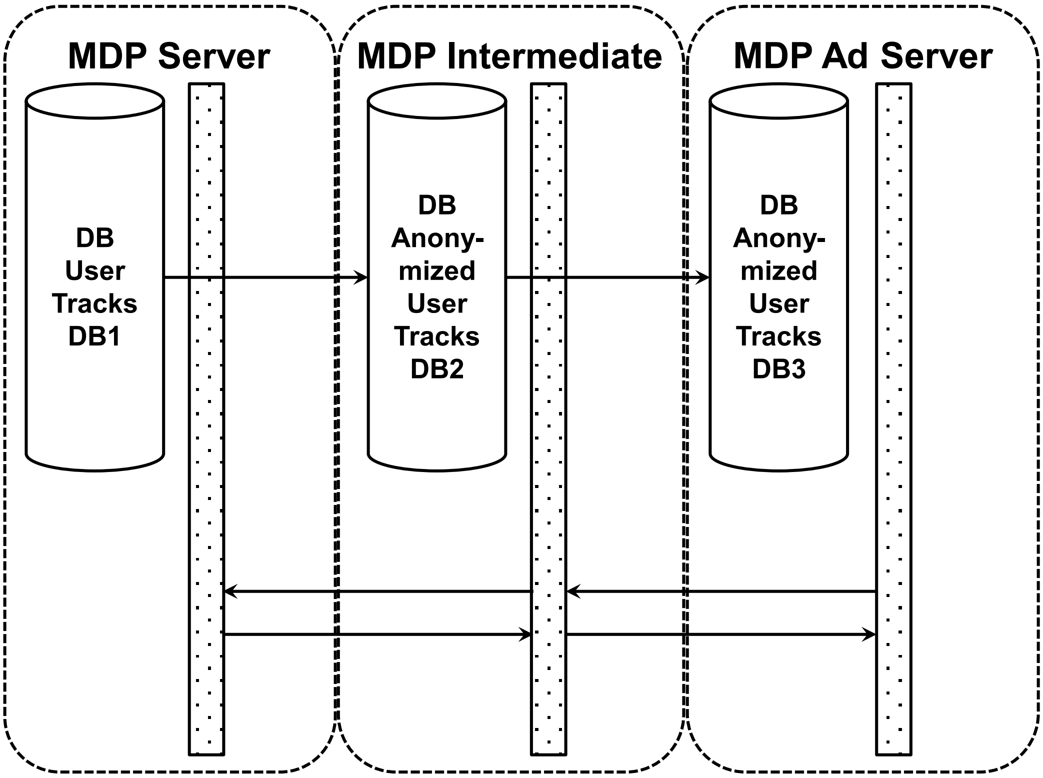


Figure 69 MDP Server communications

These precautions shall represent a possible implementation of the "Chinese Wall" approach by separating the different systems and allowing controlling which data will be accessed by whom. The MDP Intermediate server could be seen as an outer ward with a castle ditch which can be seen as another layer of security commonly known as DMZ ("demilitarized zone“ or perimeter network; for example in Shinder, 2005). Naturally the MDP Ad Server has to be protected from attacks as well. But even if an attack is successful, only the anonymised respectively pseudonymised data from DB3 will be accessible. The attacker would have to drill through via the MDP Intermediate server into the highly protected and secured area which hosts the MDP Server which holds all the data. By implementing all available necessary technologies this could prevented or at least detected so that counter measures could be taken.

As the MDP Server will communicate via https over the (mobile) internet with the MDP clients a layer of protective technologies have to be employed to protect this interface to the server from attacks as well (see Figure 70 MDP server protection of front end (**example)**).

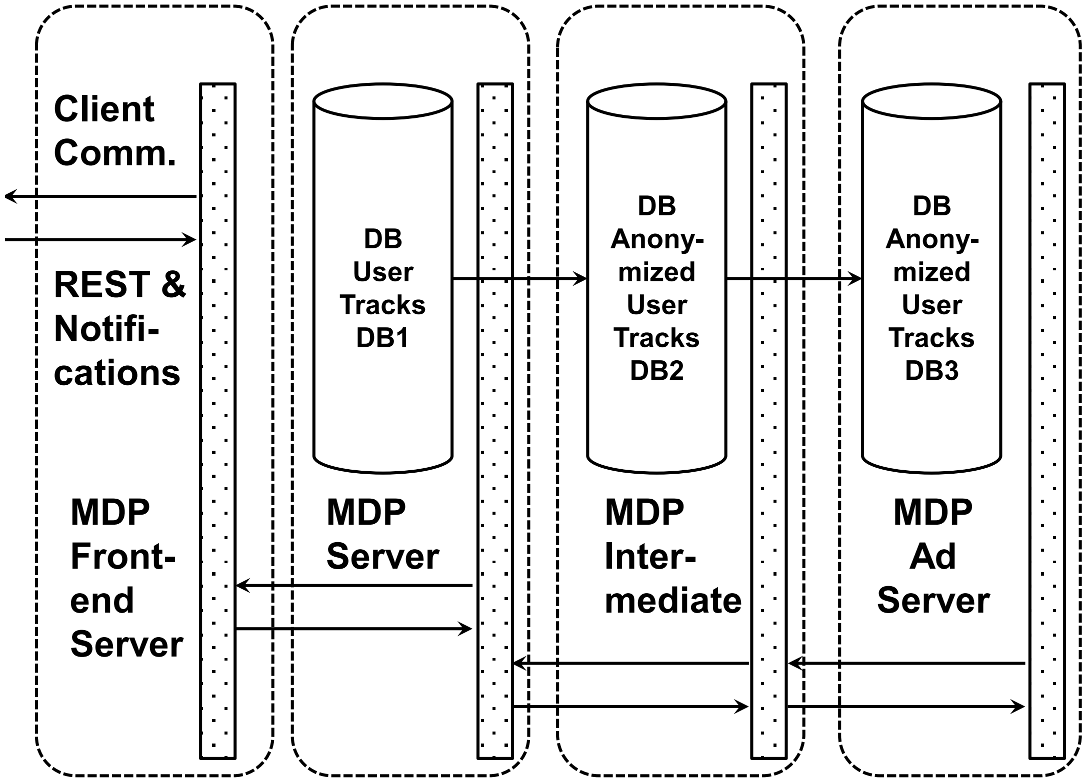


Figure 70 MDP server protection of front end (example)

As the scope of this thesis is to present the MDP concept and a proposed architecture mainly requirements will be presented and the implementation or detailed definition is left to further research or the real world implementation.

These technologies are a proposal which shall illustrate the requirements necessary to describe a MDP system which shall be from the technology side be save to protect the MDP users data from the perspective of data protection, IT security and privacy.

6.4 Summary

In this chapter the proposed architectural components or building blocks for MDP have been described which can be used to implement the described MDP functionalities and requested features of the MDP concept. From the idea of the MDP to the conceptual work especially the privacy issue has been given considerable attention as it is the key and essential issue for gaining the trust of the users. The concept describes the different parts of the platform starting the client for the mobile user. Describing the part of the concept which deals with the privacy and trust enhancing functionalities based around an extended "Chinese Wall" for the separation of the data to provided anonymisation and pseudonymisation of the user data and shows how the potential advertiser or information provider will be able to reach their target audience without exposing the data of the mobile end user. An exemplary blueprint for a scalable architecture based on REST including data encryption on the transport of the user's data was presented as well.

Based on this material the concept will be presented for an evaluation by subject matter experts.

7 Expert Questionnaire

As the scope of the concept and architecture for Multi-Dimensional-Personalisation requires a large degree of implementation for a complete working prototype, this could not be fully realised within the timeframe of a part time research degree, budget, the sheer size of such an implementation and resources of an individual self-funded research project. However, several key parts of this position-aware recommendation and personalisation concept have been implemented and tested in order to enable proof-of-concept (MDP Client for example for data collection and communication via REST to the MDP Server and different test implementations for notification). The experiences from the tests, experiments and the circumstances that a fully working prototype could not be implemented have led to an evaluation via an expert questionnaire in order to gather feedback and get an evaluation based on the opinion of subject matter experts (Hartson et al., 2003) about the concept and the feasibility of Multi-Dimensional-Personalisation. This expert questionnaire was used to gather feedback from experts about specific parts and their overall impression of the presented MDP concept and architecture proposal. Evaluating the concept by using a questionnaire can be seen as a valid method as this technique is an established method in different domains in science (e.g., usability; Lund, 2001; Brinkman et al., 2005, 2009, 2008; Kirakowski, 2007, Chin et al., 1988).

7.1 Expert recruitment

The experts which have been approached have been chosen based on their expertise. The selection was based, factors such as their publications, recommendation from professors or peers, their membership of special interest groups (e.g., Location Based Marketing Association, BCS SIG Geospatial) and industry experts (location based services, mobile phone industry, NGNs …). In addition the experts themselves have been asked for recommendation of other experts which could be approached.

The experts were approached by email with an introduction about the research and the research work, a video screen casting presentation explaining the concept and a presentation in PDF as download (all material is enclosed on the CD / ZIP file / in the appendices A.2.2 Cover Letter and Questionnaire). This method was chosen in order to give all experts the same information about the MDP concept. The PDF presentation was intended as hand-out for their reference. By doing so every expert should have started with the same information before answering the questions (i.e., rating and commenting on the statements regarding the underlying concepts of MDP). The form of a recorded screen cast and a PDF hand-out guaranteed that all the approached experts had been given the same information in the same fashion, which could not have been achieved by doing separate (online) presentations for every expert.

Via email the experts have been asked to self-report, which means to rate the nine questions respectively statements about MDP based on their understanding of the material on a Likert scale (Likert, 1932) with five-level Likert items with the following values:

1 – strong agree

2 – agree

3 – neutral

4 – disagree

5 – strong disagree

In addition to these closed opinion-type questions the experts had been given the possibility to give a comment for each of the statements if they wanted to give some insights from their experience. In total, more than 60 experts were approached, with 14 ultimately responding positively and answering the questionnaire. This sample is considered to provide a suitable basis for analysis given that Virzi (1992), Lewis (1994) and Nielsen & Molich (1990) describe that "The number of usability results found by aggregates of evaluators grows rapidly in the interval from one to five evaluators but reaches the point of diminishing returns around the point of ten evaluators." (Nielsen &

Molich, 1990). The usability results mentioned in the quote referred to usability problems which can be seen similar to the scope of the expert questionnaire targeting the different parts of the concept and its feasibility, usability or acceptance. Based on the research by Virzi, Nielsen & Molich and Lewis with a high level of confidence it can be said that the results would not have changed much even if more experts would have responded to the questionnaire, rated the statements and provided their comments on it (Virzi, 1992; Lewis, 1994; Nielsen & Molich, 1990, page 255). Even if the responses go beyond pure usability issues, the usage of such a system based on the MDP concept is the main context of the questionnaire so that this approach should be valid for this evaluation as the interaction with the user and reaction of or to the user of such a system is the focus of this expert evaluation.

The raw data of the answers are included in a Word file on the enclosed CD / ZIP file (in form of the forwarded email answers (anonymised)). The rating of the expert resulted in one point for the Likert item. If a range or bracket (such as 2-3) was given as an answer then both answers received 0.5 points. In one case two answers have been given and the answer matching the condition respectively intention of the presentation was selected (depending on the explanation of the expert given in the comment). With two exceptions the participants answered all the questions. One expert answered only the first two questions and the second expert answered all questions except question d. The comments, as long as an expert gave a comment, are given without the reference from which expert the comment was given (this was requested by one expert). The short biographies of the experts can be found in the appendix A.2.1Participating experts.

A short description of the fourteen experts:

- A recent PhD graduate working in a Swiss research centre in a similar area
- A Canadian PhD 3rd year student working on a research project about geo tagging information
- Co-founder of a Los Angeles based mobile application development firm working in Singapore, Master Degree
- Lecturer at a Swiss university with research interests in mobile cartography, location-based services, and geographic relevance, PhD
- Founder of the European Chapter of the Location Based Marketing Association, Head of a Consulting Companies Dutch offices, Master Degree
- Professor in Computer Science, University of Applied Sciences, research interests: information and communication infrastructures, device- and manufacturer-independent data exchange, smartphones and tablets as mobile clients for information and communication infrastructures, services based on geographic data, seamless offline-functionality for mobile clients, and mobile usability, PhD
- Project manager for mobile networks, Diplom Informatiker (Master level degree in Computer Science)
- Professor in Computer Science, University of Applied Sciences, Research interests: Networking, Mobile Applications etc., PhD
- Project Manager, Vodafone, Diplom Ingenieur (Master level degree)
- Lecturer at a German University of Applied Sciences, CEO Consulting Company, Diplom Mathematiker (Master level degree in mathematics)
- CEO and co-founder of a search and recommendation company which has a mobile application interest as well, Master degree
- Professor, Internet based mobile telecommunications, Head of Research for Orange, PhD

- Professor of a private university in Japan, specializes in various areas of media informatics, including human interface, communications service, information search, media design and network society, PhD
- Professor with a background in business administration and economics, among other things working on location based handovers in hybrid mobile systems, PhD

The pages that follow present the specific questions that were presented to the experts, with their consequent ratings and all given comments in each case, followed by related discussion and analysis.

7.2 The Expert Questionnaire, Answers, Comments and Discussion

In the following section the expert questionnaire, the original questions, the answers as given by the experts and comments of the experts and a discussion of the findings is presented.

Question / Statement A: *The introduced new and unique model of MDP (Multi-Dimensional Personalisation – a push based personalisation using time, location, i.e. movement patterns, and interest (and other "dimensions" if needed, e.g. age bracket, gender, etc.)) is feasible.*

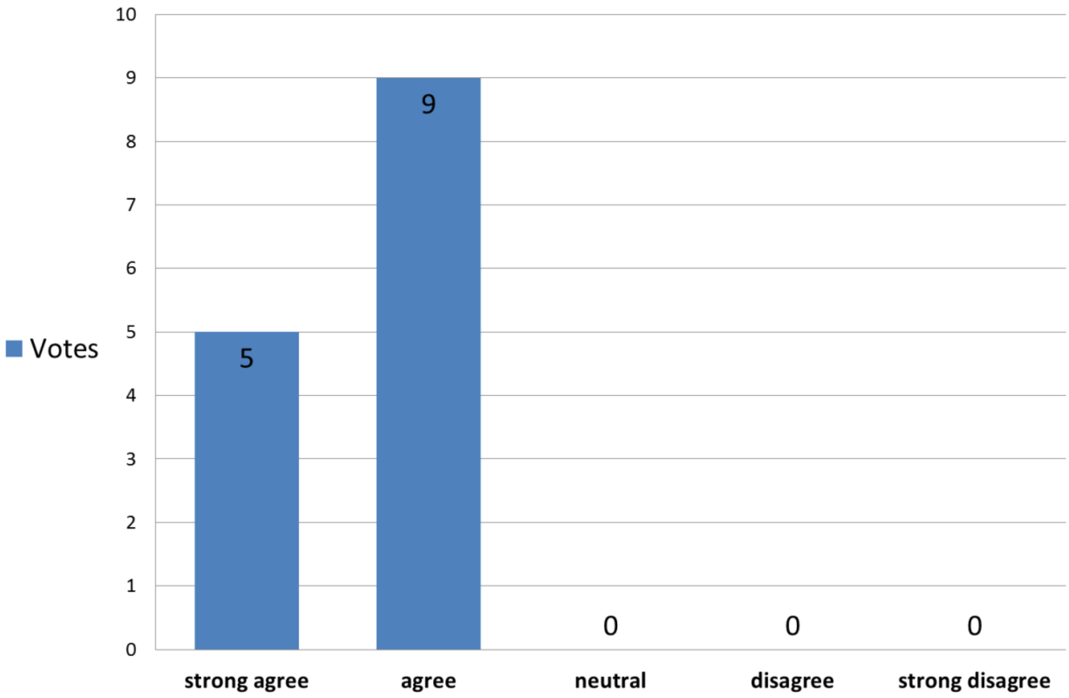


Figure 71 MDP a push based LBS personalization

The associated comments (if given) from the experts for Figure 71 MDP a push based LBS **personalization** was as follows (all comments are given as written by the answering experts (sic)):

- *I believe it is feasible and similar concepts are existing for example Sense Networks.*
- *The main challenge that immediately comes to mind are first how to handle network access issues in problematic areas such as multilevel buildings (e.g. malls) and on subways or underground areas (in Toronto and Montreal there are an extensive underground pedestrian mall & walkways).*
- *Provided you can convince the consumer to volunteer the data you are basing your personalization on, the model itself is viable. However it's a bit of a "Holy Grail"…. Privacy concerns are huge. I certainly wouldn't want my movement's*

tracked continuously even if anonymously. I do understand that you are trying to establish a value to the consumer of delivering valuable information to the consumer… since it is the consumer you have to convince. The merchants/advertisers are an easier group to convince; you just need the broad user base. You have a bootstrapping issue there.

- *certainly there is needed something different from current, pull-oriented LBS*
- *Possible problems, challenges:*

  - Capturing Mood (even good suggestions might be annoying if I am not in a receiving mood)

  - It might be difficult to convince users that the service offers them anonymity. Personalized profiles represent a high market value. On the other hand, it might not be difficult at all, considering current trends (usage of Facebook, willingness to disclose even highly personal data in social networks).

  - Currently, we find a lot of location-based services on the market. A common property is that they are almost all specialized. To be able to bundle several services would be interesting. One of the biggest challenges will be to find not only techniques, but also feasible business models to aggregate existing services.
- *From technical view it's feasible. If it's feasible from business model view, I've doubts.*
- *The model is feasible because it is extents a model implemented in other domains.*

  To my understanding the model adapts a well-known approach to the technological environment of mobile providers (NGMN). Well-known are the business case of selling individual advertisements by social networks like Facebook or other online service, e.g. through tracking individuals by Google-analytics and multiple cross correlations. Somehow these services already include LBS on a wide scale.
- *Needs more details of where the middle tier will be controlled / by whom*

- *There are location based push services available today. I know that Orange offer the service whereby say you are interested in sales in the store Marks and Spencer you would register this fact at an Orange website. Orange then have the network ID codes of all WLAN transceivers in Marks and Spencer stores. The WLAN transceiver is always reporting back to Orange the WiFi network IDs that the registered smartphone detects. If there is a match in Orange database and you (actually your smartphone) is register then a SMS is sent to the phone to say that you are nearby a Marks and Spencer store and a sale is on!*
  The Orange system is crude compared with your proposal. Indeed your proposal seams to exclude the network operator altogether and only involve the user and service provider? No problem but it will predicate a relationship in which the user and service provider will have a formal agreement and that an application resides on the smartphone that is able to tunnel information through the mobile network - This does mean that the exchange of information will be Charged at the operators transport rate - so the end user should be aware that all this messaging of sending GPS updates to the MDP and the MDP messages to the smartphone will incur network charges. If the mobile terminal is moving the location updates could result in a lot of update messages and as a result a lot of charges!
- *But you can refer to the real service provided by Japanese mobile phone Company of Docomo. The servce is called "i-concierge“ you can transefer to English or Deutsch.*
- *This is feasible in the context of ubiquitous computing. As there are many technologies incorporated the heterogeneity of the system may afford a step by step approach. So it has to be designed to stay flexible even for future technologies. Also standardization issues may play a role an data may be provided in different standards and with different timing.*

In general all the experts agree that the concept of Multi-Dimensional-Personalisation is feasible. Some of the comments refer to known issues and recommend existing applications with a similar scope, but not based on multiple dimensions for personalised location based recommendations. Both applications mentioned have rather a couponing approach. The Japanese application could not fully evaluated as the web pages are in Japanese but judging from the pictures and video shown the couponing aspect is coupled with a route finding (public transportation) approach. Issues like being indoors can be handled by using the last know GPS position as an anchor position for further position related recommendation (similar problems arise e.g. in the subway). A big concern seems to be the privacy of the user and location data. The data protection issue is one of the main points which shall be handled by the MDP and its SPOT *(Single Point of Trust)* approach (see also the next question). Besides the privacy issue the user's reception of the service is mentioned as an important factor for user acceptance. All these points also led to the possible problem of a valid and working business model but this is not an issue for this research work.

Question / Statement B: *The introduced concepts of a SPOT (Single Point of Trust) / "Chinese Wall" are a secure way of protecting the privacy of the MDP user and therefor gain the trust of the users in this system.*

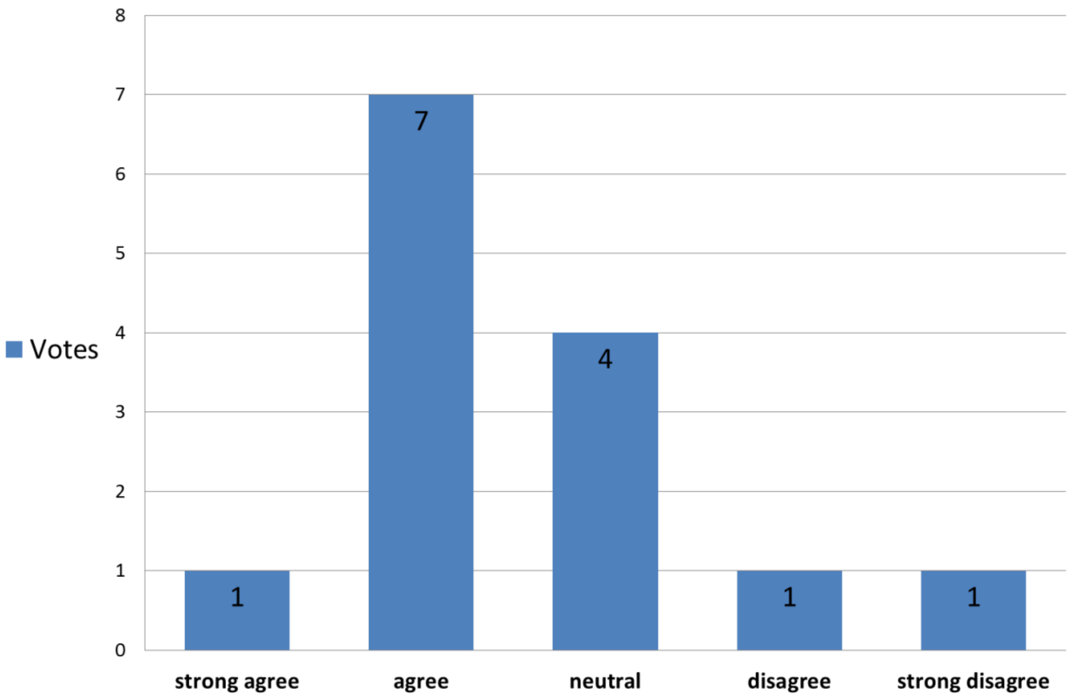


Figure 72 SPOT / "Chinese Wall" for privacy protection

Some of the experts gave the following comments for Figure 72 SPOT / "Chinese Wall" for privacy **protection**:

- *To be able to make any useful recommendations to the user you will need personal information about the user and anonymous data will be difficult to mine for personalized recommendations.*
- *I'm not an expert on security, but is the network transmission of the data secure and/or encrypted? Secondly, user trust has additional factors beyond the security of the backend, for example authentication, reliability, policy statements, jurisdictions, and brand awareness.*
- *I'm not sure. SPOT systems for passwords have only had limited effect in gaining adoption (Facebook Connect, OpenId). The "Chinese Wall" and guarantee of the user remaining anonymous is not the selling feature, it's a requirement in my opinion. While we understand (you and I) that such a*

system does protect the user, and convincing the users of that is a bit harder. Secondly, that database becomes a huge hacking target. It's bad enough that hackers can steal your home address… now they can crack in and find your movements, where you are and when? Even if completely anonymous it would provide excellent "intel" to those who would use the data for illegal or dangerous purposes.

- *I am not an expert in this part, but I am convinced that trust in the system is as important as "good" recommendations.*

  The proposed architecture looks as a feasible approach to privacy issues. Important seems to me, that the user is always aware what happens to his data and has the ultimate control over his/her information. If this can be made clear by your approach, it is very promising.
- *Depends on technical structure. If all the data is located in one server, security will be low. Ideally, the data would be located on different servers with different service providers.*
- *Yes, in case that the different databases are located on different independent companies. But some doubts if this is really feasible from business model view.*
- *Rating 3: Depends on the definition of privacy. You have to trust your provider.I just remember the discussion on US homeland security rules etc. versus the European thought about privacy and legal interception.*

  Rating 1 (matching from the presentation): You may design a secure system which protects your privacy. There are feasible architectures.
- *I trust, what I can manage myself. Add another level - my trust MDP comms.*
- *Chinese walls do not work. There needs to an architectural separation of concerns and perhaps a physical separation of data. One way around the problem is to put the two concerns of the MDP in different entities, part in the network operator - which knows your location anyway - and the other in an application provider?*

- *you can refer to http://www.meti.go.jp/policy/it_policy/daikoukai/igvp/index_en/index.html*
- *We will never be able to design a completely secure system, but this looks very trustworthy, of course depending on the real implementation.*

Again more than half of the experts agree to that the presented concepts would provide a way to protect the user's privacy and therefore allow the user to gain trust for the MDP system. The issue mentioned in the comments that "Chinese Walls" do not work might be a misunderstanding because the intended functionality could not be explained deeply in the short presentation of the concept and the requested architectural separation is an important part of the MDP concept and its proposed architecture as well as the encrypted transmission of the users data over the public mobile internet connection. This would be an issue which has to be taken care of in a real world implementation of such a system and this work can only raise all the issues which have to be taken care so that the concept could be implemented successfully. As the "Chinese Wall" architecture will be implemented transparently into the system the user does not have to take care of this point by themselves but shall be enabled to control most of the data concerning himself via configuration of his profile and the MDP client application. Especially the issue of privacy of the user's data is a key issue for MDP and the MDP design and architecture is aiming to fulfil this protective function but still it cannot succeed if the user does not trust the system, for example, if the user does not understand the concept behind the architecture. "Who" runs the MDP server is an issue addressed by the end user survey explained in another chapter of this dissertation. Naturally the mobile phone provider could offer such services as the access to the needed data is already available but there might be a trust issue. In addition a user might changes his mobile phone provider which would make an independent MDP provider the better choice from the user's perspective. The Japanese web site mentioned seems to be outdated and at the time of accessing it (December 2011 and February 2012) did not contain any information related to this project.

Question / Statement C: *The Support of a feedback / "Spam" indicator is enhancing the user experience and protects the user against unwanted recommendations.*

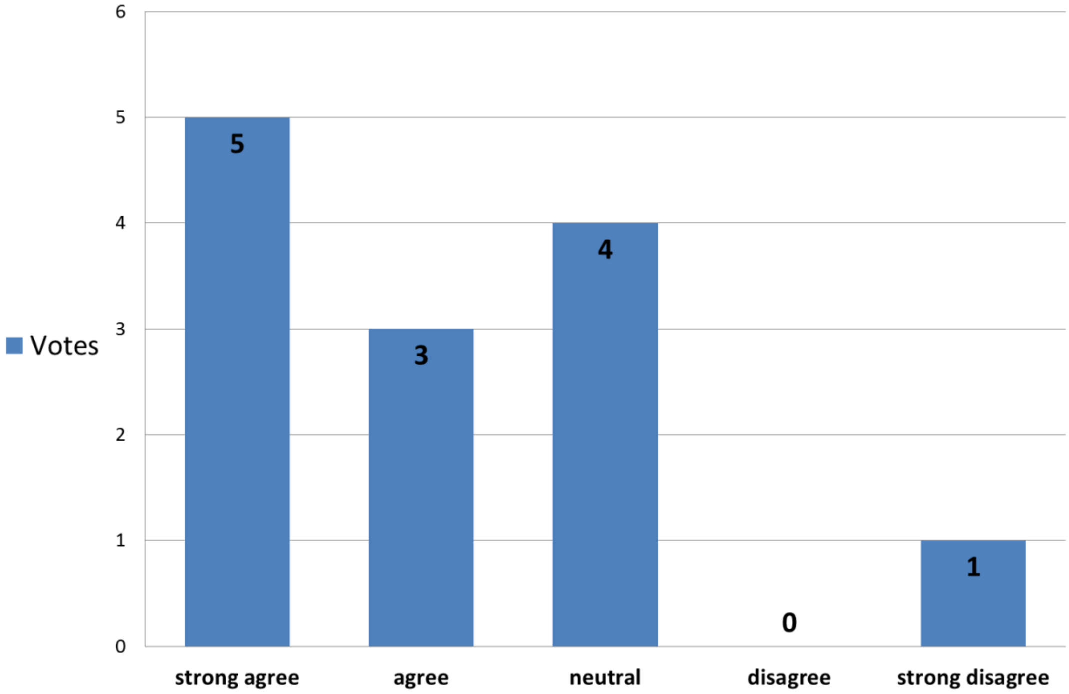


Figure 73 Feedback / Spam indicator increases user experience

Comments given by some of the experts (regarding Figure 73 Feedback / Spam indicator increases user **experience**) :

- *completely depends on the implementation. From my research, users want this type of information but are very concerned about spam. However, how spam is defined by a user is not simple or necessarily consistent.Essential but probably not sufficient. Feedback loop is important. Ask yourself this however: What makes it spam? Technically all messages sent through the system are unsolicited (they are push) …. So it's more a "I like this" and "I don't like this". I guess you can block a sender based on enough feedback, or block that sender from matching to a specific user, but this will be a big area of effort and attention.*
- *This is a crucial point, since too much unwanted information would set most users off.*

- *Idea: Instead offer "I like it", "I don't know" and "I don't like it"-buttons for feedback. That offers a better degree of understanding the user's needs, likes and dislikes.*
- *Same principle as it is today with email boxes.*
- *In principle "yes" but just look at Email. Although there are "intelligent" SPAM filters, some annoying SPAM Emails get through.*
- *why not - that may work*
- *I think you should design the system so that spam cannot be enabled. What I suggest is that the end user can subscribe and unsubscribe to services. If unwanted alerts or messages are sent then the end user has a one-step unsubscribe function within the terminal application.*
- *Users always like to be in control and are more likely to try and accept the new service, if they know how to stop it if needed.*

This time more experts are neutral but still the majority agrees that a feedback loop will enhance the users experience and reception of the service. Although the point is raised that spam filters nowadays are not always working perfectly. In MDP this issue can be solved as the information provider / advertiser has to be registered at the system so that there is a controllable group which allows weeding out the "bad guys" by cancelling their access / accounts. The basic example for user feedback which was used in the presentation naturally can be extended in the form the experts have suggested in a real world implementation. This suggestion is actually a good point which would enrich the possibilities of the MDP user. The aspect that the user needs to be in control is an important point which is built into the MDP concept by design.

Question / Statement D: *The possible aggregation of recommendations based on type / location increases the user acceptance.*

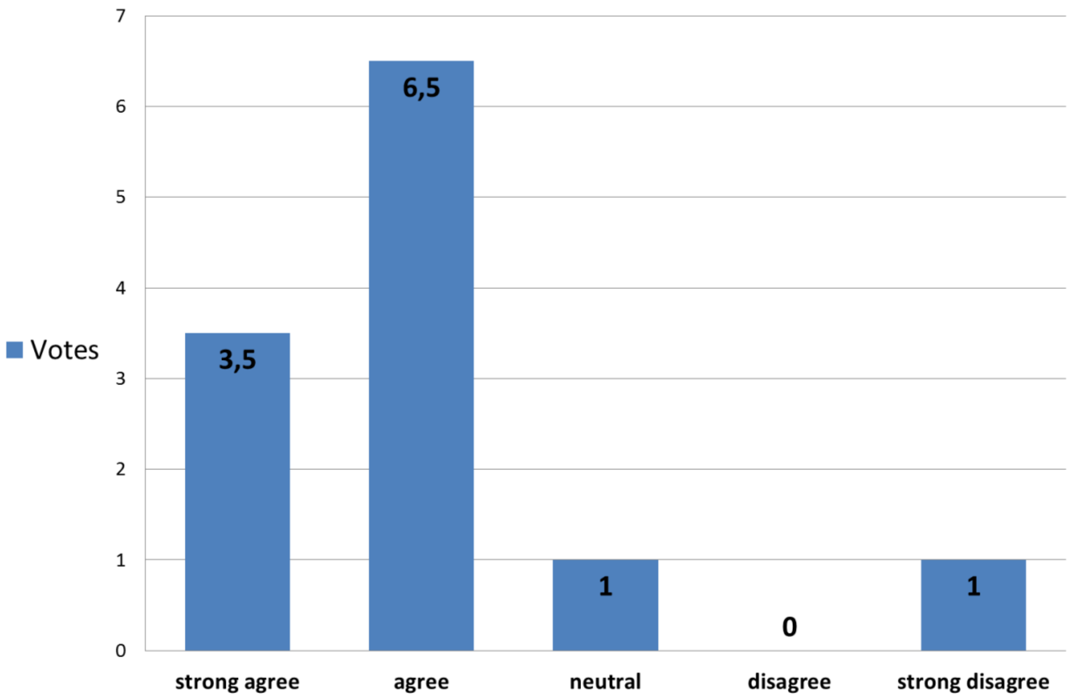


Figure 74 aggregations of recommendations for better user acceptance

Some experts commented on Figure 74 aggregations of recommendations for better user **acceptance**:

- *Yes. Also don't make the notifications modal… If every message requires action people will get annoyed.*
- *foursquare does this*
- *Nothing more annoying than frequent pop-ups. Idea: Instead of pop-ups, use a less intruding technique.*
- *Yes, in case the system db1 is really trustable. In case this system will be hacked and the user data will be misused, the business model is dead !*
- *Depends how users interact with ads.*
- *If I manage my trust MDP level, I would like to provide my "mood" and which informations I like if I'm in a defined mood, eg. hungry, on business trip, don't*

disturb, privacy, ... Full control is needed - than I would like to manage my own surveillance first.

- *This depends on the data base and the way how the aggregation is implemented. This defines the quality and usability of the information for the user. People with a fixed schedule may profit more as predictions into the future are easier in that case. The crucial thing is how to choose suited information. This is not trivial.*

The experts agree on the point that this functionality would increase the user acceptance. Some interesting recommendations regarding the user interface are made and should be considered in a real world implementation. Depending on the user the way and fashion of delivering the notifications needs to be configurable to increase the user acceptance.

Question / Statement E: *The evaluation of past (& future) movement patterns is a feasible way to support the recommendation for location based recommendations / marketing.*

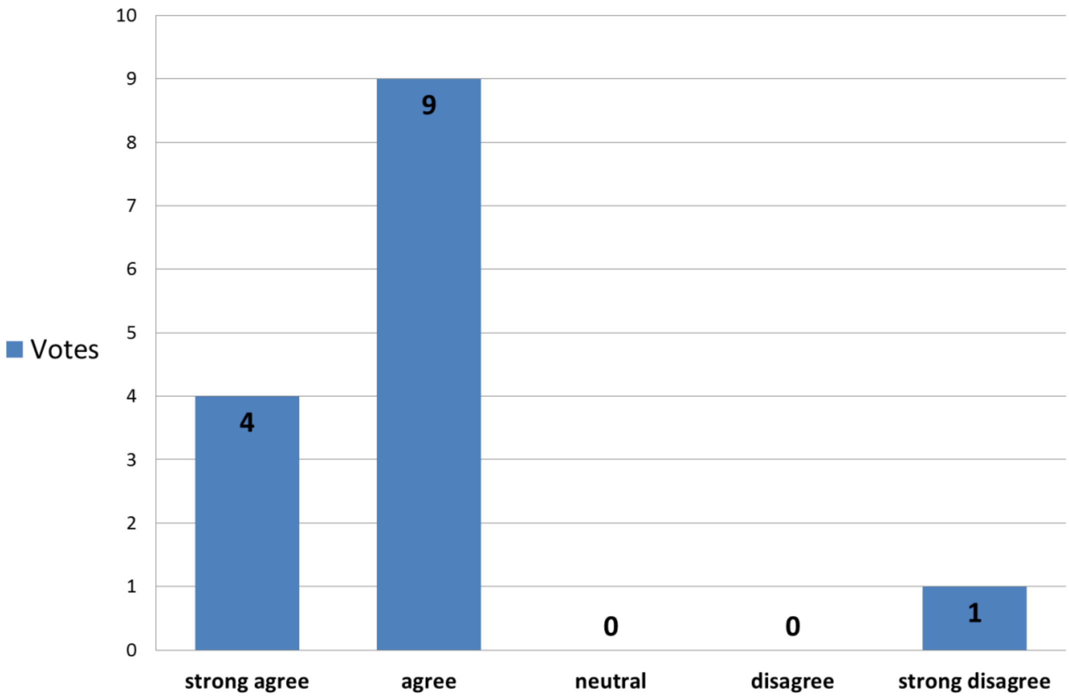


Figure 75 Feasibility of using movement patterns for LBS recommendations

The following comments have been made for Figure 75 Feasibility of using movement patterns for LBS **recommendations**:

- *This is a good idea and I think would work for many users. However, users such as myself have erratic patterns of destinations and travel so I'd be concerned that in these cases the system might have difficulty.*
- *I don't think anyone who knows this space would disagree. Getting accurate information is the hard part. Also need to factor in context. The fact I went to Rome for a month doesn't mean I should be getting advertisements for hotels there in 5 months' time, so you need to be able to separate the noise.*
- *This is certainly a good idea; You may want look into literature from Geography/GI Science on topics like spatial data mining, Geodatamining, Time Geography, Anchor Point Theory.*

  There is also work on recommendation systems (e.g. Schlieder, Uni Bamberg).

It might also be worth to look into activity theory for understanding user needs, motivation, and more complex spatio-temporal behaviour.

- *Feasible, but is it also desirable? Offering a certain degree of "foresight" might make the user perceptive - and thus, apprehensive - of the amount of "knowledge" such a system will aggregate. Against the background of current critical discussions of possibilities for profiling users based on data on the web and esp. capturing movement patterns, this might be a severe problem for the broad acceptance of such a system.*
- *Agree, but it has a very strong dependence to the trust to the system db1.*
- *Feasible way to gather location profiles of users, but to my mind inacceptable. Only supported by G10 Gesetzgebung (legal interception).*
- *fuzzy logic will provide good predictions if there is enough data to combine of an anonymous ID and in comparison to compatible people, ...*
- *I have a serious concern about personal data being misused. Two elements of the architecture concern me. The first is the network storage system referred to in your presentation when the MDP is down and network updates are stored in a distributed HTTP server?! What is this and where in the architecture is it? The second concern is how long is location data stored. Network operators store data for a year to support security services. But application providers should not store such deeply personalised data. I suggest that the location database is purged every 24 hours?*
- *Here also the frequency of the pattern or the consistency of the daily/weekly schedule plays a role. The extraction algorithm is important here. Most likely it will work for a high percentage of users but may fail for more than 10% with irregular movement patterns.*

The experts agree that the method / technology is feasible for recommendation in a location based context. Again issues rose about the concerns of the user (and experts) for the protection of the privacy of the user and data protection of the collected data.

The recommendation to store the data only for 24 hours would make it impossible for the system to estimate the user's whereabouts based on their past movement patterns. The issue raised about getting false recommendations for a trip should be handled by the system as the future recommendations would be based on the (future) schedule of the user an therefor the system would "know" until what time such recommendations should be send. The point made about erratic patterns could be handled by evaluating the planed schedule of the user and using the fix points in the life of that user. Even if besides the home one fix point might be the local airport.

Question / Statement F: *The evaluation of past (& future) movement patterns is an acceptable way to support the recommendation for location based recommendations / marketing.*

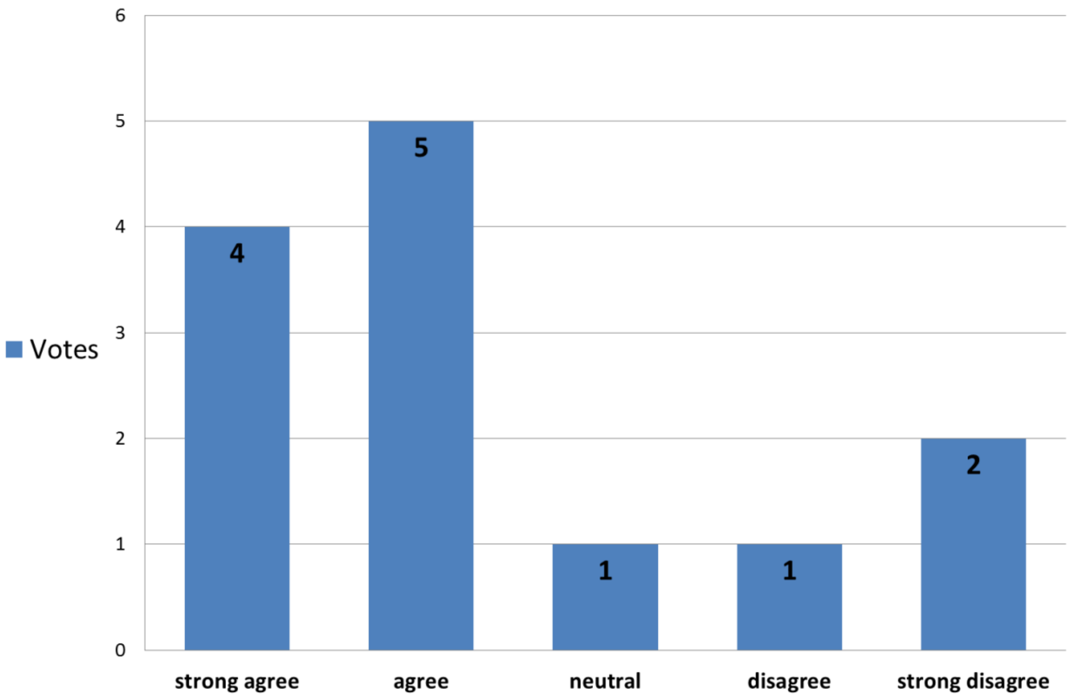


Figure 76 Acceptance using movement patterns for LBS recommendations

Some experts gave the following Comments to Figure 76 Acceptance using movement patterns for LBS **recommendations**:

- *you will need some innovative and well optimized algorithms*
- *It seems like the best approach I've heard of.*
- *This is a massive area of interest for many people in the marketing space and I applaud you for studying it and formulating models for addressing it. Whether it can be marketed in a way that won't push the privacy button of everyone who uses it is yet to be seen, so I can't say whether it would be accepted.*
- *(See comment above) → question e*
- *Agree, but functionality should be able to switch off by user, easily. Like marker "No advertisement" on the post box.*
- *Yes in case the users agreed to be tracked. Otherwise it is illegal.*

- *SaaS principle for mobiles connected to Information Services. If you go for Disco, for a Club vacation with singles only - would you like to know in advance whom you meet? No surprises anymore?*
- *I am concerned that you will used personal data to aggregate to a position that the MCP will make NEW recommendation to which the end user has not subscribed the so called 'you didn't know you wanted these but her they are!' service. As above I believe for privacy reasons ones personal location data should be purged every 24 hours.*
- *See above. → question e*

Even if most of the experts are positive about the usage of past (& future) movement for location based recommendation based on the user’s interests but some experts show a stronger level of disagreement regarding acceptability when compared to feasibility. It can be assumed that the main issue is the fear that the location data of the user is misused. This issue depends on how much the experts trust a system which is operated by someone out of their control. Even if the movement pattern data is nowadays already available to their mobile phone provider or their spending patterns are known to their bank and / or Credit Card Company. The latter one is actually analysing the spending patterns of their customers in order to identify and prevent fraud. This was experienced and verified with the Credit Card Company by the author and a friend. The issue of the data protection is clearly the key issue for the experts.

Question / Statement G: *The use of ontologies (e.g., controlled vocabulary / catalogues, hierarchies) to allow the user to express his interests is realistic.*

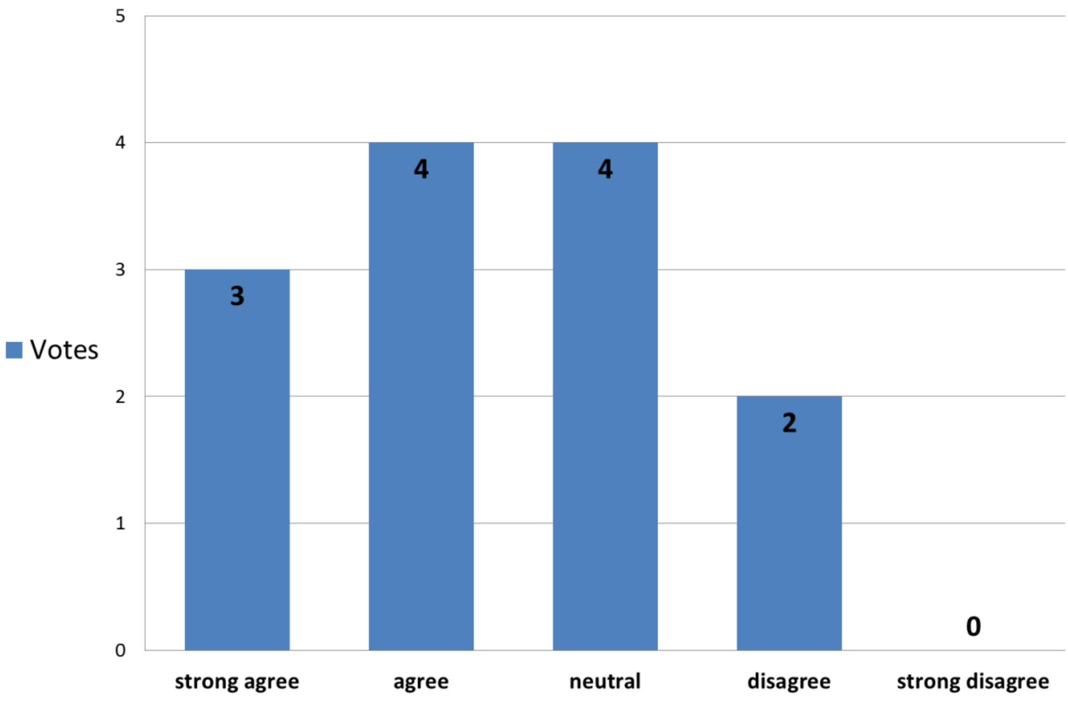


Figure 77 Ontologies for specifying user interests

Comments from some of the experts for Figure 77 Ontologies for specifying user **interests** are:

- *this is a vague overview for a complex task, i would need to know the details to believe it is realistic.*
- *Yes, but there is a usability challenge here. If there are too many categories & hierarchies users may be overwhelmed. If there are not enough then the recommendation engine may not have sufficient means to provide desirable recommendations (and avoid being conceived of as spam).*
- *I have to give it some thought. If the answer is no the problem becomes completely unscalable, so it better by yes.*
- *Probably worth to try; you might check other ways of expressing user interests. Some users might feel restricted by a fixed vocabulary.*

- *Currently, we are working on creating ontologies for data exchange in agriculture. In that context, that is definitely non-trivial. Here, however, it should be easier, as information (advertisement) providers will have to use a given service. It should be much easier to introduce ontologies and get the players in the field to use them.*
- *Not sure what ontology means, but usage of thesaurus db will lead to comparable results.*
- *To my experience, the management of ontologies or lists of interests is often to extensive. Lists are often not actual.*
- *categories should match his mood, e.g. if you provide a matrix with his interests (yes /no by checking) and allow people to help define "moods“, then you will generate a self-learning meta-level - I would like to define my moods, control the information collected and then provide those as an anonymous dataset, as I have been able to review myself, what would happen with it.*
- *Absolutely, especially when supported by a user-friendly smartphone application.*
- *It depends on the open mindedness of the user and the defined ontologies. The definition has to be very precise and un-doubtful and biunique. Most likely some cases will not be contained. Here a fall-back mechanism has to be implemented.*

This statement is received slightly less positive and more with neutral ratings. On one side it is accepted that there has to be something like a "controlled vocabulary” to allow the user to express their interest but at the same time there are some objections that the system is difficult to handle for the users and might not be capable to describe the user accordingly. In addition the maintenance of these ontologies is mentioned as a cost intensive point. Naturally it is easier if the user and the information provider can use the same ontology for describing their interests but there might be another way this functionality could be achieved. This might be a good topic for further research. The handling of the description of the interests of the user and the selection of a target audience is a critical function for the overall system and has to be implemented in a way that it works for all involved parties (MDP provide, information provider / advertiser, MDP user) in an acceptable way.

Question / Statement H: *Such a system gives the end user an added value.*

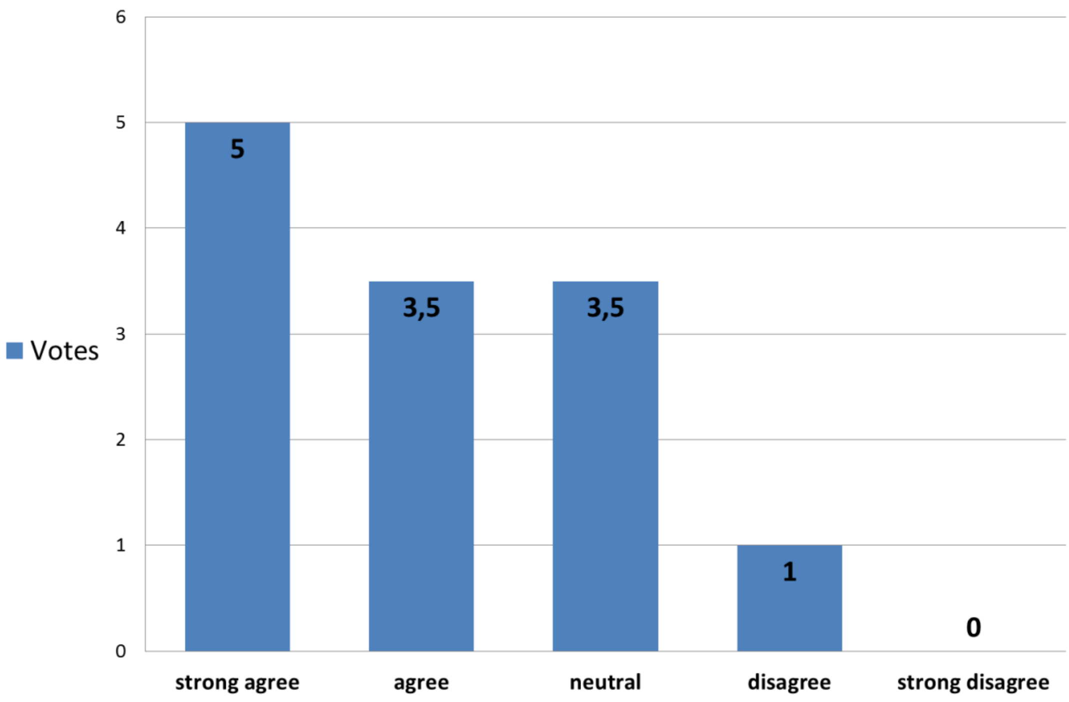


Figure 78 Added values for the user?

The experts who gave comments for Figure 78 Added values for the **user?** wrote:

- *I have found users want this functionality.*
- *I believe it would add value provided that the users wanted to receive awareness of events and promotions. There some variations on this that I think would be extremely valuable, but the core concept is a good start.*
- *The system would have to*

  - bundle popular existing services

  - offer users the possibility to select/deselect areas of interest.
- *Agree, as long the user will not be overwhelmed with advertisement. Otherwise the user will switch off this functionality.*
- *Depends on the business model: in paid services little added value; in free services maybe the base for a business case.*
- *good communication and control - a perfect world.*

- *Yes otherwise they would not subscribe!*
- *Strongly depends on the needs of the user, but is likely for many of them.*

For this statement the experts again give more positive ratings then for the last statement. It seems clear that the user will experience an added value but again the issue user experience, control and the value delivered to the user is the key.

The delivered recommendations do not have to be only coupons or discounts but it can be also more than that. This method could be used in many ways like recommendations for cultural or entertainment events or in a training and education environment. Depending on how good the offers are and how good the service tailors the recommendation to the user the added value for the user will be evident.

Question / Statement I: *You would personally use such a MDP service.*

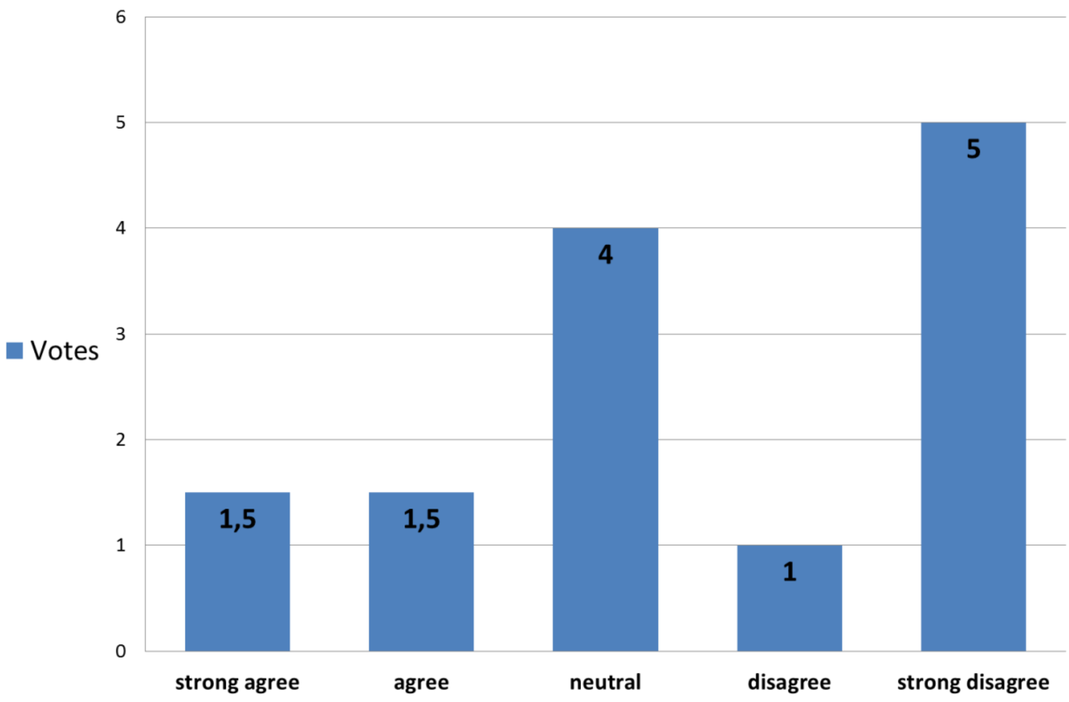


Figure 79 Expert would use MDP

About using MDP some experts wrote as comment (referring to Figure 79 Expert would use **MDP**). For this question as an answer a range or bracket (such as 2-3) was given as an answer so both answers received 0.5 points:

- *I would give it a test try, it would take an impressive service to make me personally use it*
- *I still do not own a smartphone...*
- *I don't want anyone to know where I am. I don't even like Mall's sending me adverts when they know I am in the mall, and I work in the retail software sector.*
- *Yes, for testing purpose. I'm curious. For day-to-day usage, depends on the results from test phase.*
- *Assuming it would work on my 2-year old BlackBerry (as almost nothing seems to anymore) my main concern would be the quality of the content. I would probably experiment for a few days and if the quality is not sufficient I would*

probably not continue using it. Also, I am not a big "shopper" or one that is concerned with getting the best deals on products or services. So the application would have to have content that goes beyond shopping purposes to have regularly value for me and thus ensure my continued usage. If this functionality was embedded with another app (for example, geo-social networking such as on Foursquare, or way finding) then I'd be more apt to use it.

- *Only in few situations. Most of the time ads would nerve me.*
- *I like the idea. BUT I know I would be able to find out who an anonymous person is in reality. So I cannot see how you would make that "anonymous" - good computers get down to the truth in seconds - just imagine Watson (IBM) would get all information of your system, of xing, linkedin and facebook.*
  Then you would get the information: by 99.99% you are Mr. Schilke and you have a girlfriend in lower Manhattan, which your wife is aware off, as they met first time last week after your 2 hours date ;))
  I'm not sure, if that is a proper outcome. How would you secure against our Bundes Trojaner, agains officials from FBI, ... No!! We don't need another surveillance like Facebook, Google, Skype, ... Where you have no right's to delete your anonymous data or your provided personal data.
  If you would need to pay personally for advertisement - by your proposoal you have to
  - as you need the system, the electricity, the time to look at it as you drive, walk, talk, ...
  I see a good chance that people like to try out and afterwards have no idea how to get rid of it , as they have to ... like emails, sms, viruses, trojans, bundestrojaner, ...
  I can think of one good application:
  As I drive, provide a proposal based on
  - target (by Navi)

- rest of fuel

- locations to by fuel

- time / money optimization for taking a fuel stop or extra ride

Because they analyse my behaviour yet and change pricing three times a day, so let's make them getting annoyed by fighting the battle who is faster making the proper decision.

Collect pricing by people who travel and provide suggestions by people who benefit. By this small approach you might have a single application that will benefit nearly every adult person. If that works out, you get a payoff and might implement the infrastructure for more of such ideas.

- *NEVER - my location is private I am currently against the mobile operator storing my location for 1 year, but can't get around that. I am against the surveillance society. I am law-abiding BUT I cherish my privacy.*
- *I would at least give it a try.*

The result for this statement (see Figure 79 Expert would use **MDP**) was rather negative compared to the other results. It could be safe to assume that with the expert knowledge the precautions and the awareness of possible privacy and data protection issues are higher than the knowledge and these issues an everyday end user, which exposes his life freely on Facebook / Gowalla, Foursquare, Google Latitude or other social media websites with location information, has (and if the user might get some immaterial or material or monetary benefit from it). The possibility that "something bad" or a misuse happens to their data is the key concern. Some would try it out but expect a stellar service or product before they would become everyday users of this service. The service described by one expert could be build using the proposed system. One other expert wrote that he would use the system in very rare occasions which would degrade the system to a "normal" pull type of location based service which would have the only advantage that the system knows the user better and could even work better than a pure pull based LBS system (where you have to identify your interest at the given point in time to get a location based recommendation at the point in time of the request).

7.3 Summary of the results and comments for Multi-Dimensional-Personalisation

The overall responses of the experts are clearly positive and support that the building blocks of the MDP concept are usable and feasible. The awareness of privacy and data protection is a key issue mentioned by the subject matter experts who might be influenced by their experience in this field (i.e., knowing what is possible). The sensitivity of the data collected about the user is made very clear. Even if potential MDP users might not share this concern as strongly like the subject matter experts (Barkuus & Day, 2003). The user has to form a trust relationship to a system which should protect his private data (here location, interest, etc.) by any means which are technological possible but for a user centric and interest push based location based services recommendation as proposed with MDP an anonymity of the position of the user as proposed, for example via cloaking (Gruteser, & Grunwald; 2003; Gedik & Liu, 2008; Shokri et al., 2010), is not possible as the system would not be able to function. The anonymity of the user shall be protected by the concept and architecture of the MDP system and will not be revealed to the information provider / advertised. In important factor for the success of such a MDP system is to gain the trust of the users that the measures taken in the design and architecture of the system are protecting them.

Furthermore the ratio of the added value for the user who is using the system on his own will versus the danger of annoying this user with (unwanted) recommendations is an (expected) important result. Especially if such a service makes it worth for a user to allow such a system to track his movements in return for the value of recommendations matching his interests (Danezis et al., 2005). The described feedback loop allows the user to help the system to tailor the recommendations he receives based on his interests. If recommendation send to the user are reported as spam the information provider / advertiser can be blocked as they belong to a closed, which means, a registered and known group. This is clearly an advantage over, e.g., an email system, which allows everybody knowing your email address to send you (unwanted) email. The control about the MDP client side and the information collected about the user is clearly an important factor as stated by experts.

Possible occurring technological problems (like receptions problems in buildings, etc.) mentioned are a useful input even and the have to be considered and taken care of in a real world implementation.

The MDP concept is presenting a new and unique technological concept which could be implemented for real world use and this work is not meant to be business case or business model which is depending on user acceptance and monetary success.

The last chapter of this work (No. 8 Conclusions and further works) summarises the work, shows the achievements and the limitations of the research and gives some suggestions for further research projects deriving from this research project.

8 Conclusions and further works

8.1 Introduction

This chapter concludes this thesis by considering the achievements of this research and follows with consideration of the limitations. The chapter proceeds with a discussion on future work and ends with the conclusions.

8.2 Achievements

The MDP research project has shown that the different building blocks of the proposed MDP concept and architecture work as separate entities. The MDP concept was validated by an expert questionnaire which delivered promising results but also raised some issues about the about security and privacy issues. The end user survey also returned positive results and showed that there is an interest in such novel services among smartphone users. The awareness for potential problems in the area of security and privacy have been understood and tried to address within the MDP concept and architecture have been listed in the future works section.

An interesting discovery was that today’s users prefer personalised pull LBS services over proactive push services. It can be assumed that this is caused by a lack of exposure to push LBS systems and the fear of been overrun with notifications and recommendations. A market entry strategy could be to start with pull services and moving the user towards push services by providing a good user experience which would increase the user acceptance over time.

The following research questions had been raised (see 1.1 Objectives and aims of the Research):

1. *Describing a concept which allows the personalised interest and location based proactive delivery of information (at the right place and time).*

The MDP concept extends traditional push based location based services (LBS) to a new level which takes the users past and future movement patterns into account for the delivery of personalised recommendations and notifications which match the interest of the user. As there is usually a regular behaviour of the users the daily location fix points (like home, work place or university), routes between them and the transportation used this information can be incorporated as well in the personalised recommendation selection.

2. *Depict a system architecture which takes security and privacy requirements into account for the communication between the involved parties user, mobile client device, server system and information provider / advertiser.*

The MDP concept and the proposed architecture have been designed with the requirement privacy in mind. As the user acceptance is very important for the success of such a system it has to win the trust of the user therefore it has to do everything to prove that it is worth for the user to allow the system to track very personal data: the whereabouts of the user. The user is only interested in such a system if it causes no harm to him but also offers him a benefit without spoiling this relationship by sending spam messages. The user will be always in control of his data and can use a feedback loop to tailor the information he receives from the system. Another approach would be to allow users to use the MDP system with pseudonyms instead of their real name. By doing so the user would be only identifiable by his routes and locations he is using or if he uses the system as pull service he would not reveal any data at all (but this would degrade the MDP approach to a "normal" LBS pull service without any of the unique and advanced features).

As MDP is a closed system it is not so vulnerable for spam or spim as it has a controllable group of participants as information providers or advertiser. All the communication between the client and the servers will be secured by encryption (e.g., SSL) and the communication will only happen between authorised systems.

3. *Evaluate the concept and its components by using mock ups / sample application and experiments to be able collect the necessary data and experience to form an opinion of the system could be used in a real world implementation.*

   Some experiments have been conducted (collecting GPS Trajectories with a GPS logger device and evaluating them for regular (daily) movement patterns and frequently visited places, building a MDP client sample app and server mock up to collect GPS coordinates and testing the REST communication to transport this data to a receiving sample server, evaluating push notification with a platform independent transport method). In addition an end user survey and an expert questionnaire have been used to evaluate the MDP concept and its proposed architecture. The collected information plus the knowledge gained by the literature and related research works leads to the reasoned impression that all components for MDP can be implemented in a fashion that they would deliver the expected results.

4. *Defining a model for MDP which shall provide data protection / security and privacy by design to win the trust of the users.*

   As mentioned above a lot of care has to be taken from the start to design the system so that the necessary requirements are met. For a proactive location based push service the user has to provide the system with his location data and needs to allow the system to store and evaluate it or the system is defunct. By winning the trust of the user with its new approach of anonymising and pseudonymising the data between the different servers of the system it protects the privacy but still allows performing the desired services.

5. *Evaluation of the MDP concept with end users and experts for get feedback about the proposed solution.*

    The concept, the underlying principals and the proposed architecture have been presented at PhD seminars, conferences, in publications and feedback was gathered and incorporated. An end user survey has been conducted via the internet and the results have been evaluated. After adjusting the concept, some testing and experiments with mock ups an expert questionnaire was done to evaluate to concept, the proposed architecture, its feasibility and the acceptance. As mentioned by the literature and other research works the acceptance for push based systems is or was still in its infancy. The possible solution for MDP to increase the acceptance would be to allow the use of MDP also as pull services and then guiding or educating the users about the positive benefits the push service would deliver to the user.

In the work has been presented:

- A comprehensive investigation of the current state of the art in relation to personalisation of Information services in location based scenarios.
- Experimentation to confirm the validity of daily routine movement patterns of the users as a basis for service personalisation in location based scenarios.
- A conceptual framework was presented for a unique and novel multi-dimensional personalisation approach, taking account the privacy requirements of the user and the integration of both online and offline activities.
- An architectural design was proposed for implementing the MDP approach in a practical context, accounting for real-world challenges such as scalability, multiple mobile platforms to support, security and privacy.

- The validity of the MDP concept was evaluated via detailed feedback from qualified experts.

8.3 Limitations

For the research work there have been some obstacles:

- The full scope of the MDP concept is rather large as the necessary technology for a full system requires the convergence of various technologies. The project has been fully self-funded which did not allow a budget for larger implementations of the MDP concept and technologies. The described MDP concept could not be implemented as a full working system. Instead some of the building blocks (like GPS trajectories recordings experiments, a REST Server which works with an Android app delivering the GPS data to the server, a push demonstration based platform independent flash SMS service, sample showing the areas / ranges for recommendations around a location of a mobile user on a map, …) have been implemented and tested. From the results of the separately tested elements the full functionality of the system has been derived.

- The participation of a significant number of volunteers in the surveys conducted has been difficult to achieve. The results might have been more representative if more end user volunteers would have answered the questionnaires of the survey. As nowadays no real push based LBS services are available the response of the participants of the survey could not been based on actual experiences. This can lead to the impression that the already available pull services are favourable.

- Similar problems have occurred when recruiting experts for the expert questionnaire. A larger number of experts have been identified and approached and the response rate was rather low. Even if some experts had a mobile marketing and advertisement background the information provider and advertiser target audience had been not represented well. Several experts had been approached but did not provide their feedback over a timeframe of about 10 weeks.

- The experiment which was used to collect GPS trajectories to analyse the user movement patterns suffered from a lack of volunteers even if a call for help hast been published via Internet (e.g., in different bulletin systems, forums and news groups). In order to get some results for the evaluation friends, family, colleagues, fellow students and acquaintances have been recruited between 12 and 66+ years. In the last couple of years other research projects could rely on larger groups of participants by recruiting employees, students or researchers of their company or university or by simply offering some monetary compensation.

Despite the different limitations of the research project it has been possible to demonstrate through the researched MDP concept a valid, novel and not obvious contribution to knowledge by providing a sufficient proof-of-concept for the proposed ideas, in other words, the MDP concept and architecture, posited in the earlier sections of this thesis.

8.4 Suggestions and Scope for further Work

During the research for the MDP concept areas where further research work is possible or preferable have been identified, which could be conducted to build upon and enhance that undertaken within the project. These areas, together with new ones, are summarized below.

- Optimization of the storing of the historic movements patterns (trajectories) of a user (longitude / latitude, Time (brackets), etc.) but still useable for prediction of the users whereabouts based on the historic movements.

- Extending the use of MDP platform with other applications beyond mobile marketing and mobile advertisement, which means, recommendations / notifications (for example: Friend Finder, Social Location Application, tourist guidance, traffic optimization)
- Development of an architectural concept for massive parallel usage of the MDP server system in a real world mobile environment with thousands or millions of subscribers
- Design of a system architecture which is not only scalable but also supports the protection of the MDP server system against malicious attacks
- A platform independent real push services towards mobile devices
- Development of a specialised hybrid recommendation engine for recommendations based on interest and location
- Design of a specialised anonymisation respectively pseudonymisation system and algorithm which fulfils the requirements of the MDP concept for providing personalised Location Based Service without revealing the identity of the user
- Definition of possible business models for MDP as a service which supports all stakeholders (users, information providers / advertiser and the service provider)
- Trust building provisions for users to increase subscriber numbers and the acceptance of the service including an educational concept to educate the users about trust, privacy and how to control their data in the MDP system
- Building an advanced location based social network with user generated content based on the MDP platform and using the privacy protecting features.
- Development of an algorithm which senses the needs of the user depending on the location, need/demand and time (bracket), e.g., a lunch recommendation.

8.5 Conclusions

The last slide of the expert interview slide deck characterised MDP as your digital friend:

> *Imagine MDP as a good friend knowing you, your interests, your likes and dislikes, your daily routine, your favourite spots, home and place of work or studying. You might even tell your friend in advance when you travel to which places.*
>
> *This friend makes recommendations, makes you aware of things you might be interested in but would have missed without the friendly recommendation / notification (MDP) without annoying you with unwanted information.*

This gives a good summary of the positive intention MDP has and the results which could be achieved by implementing and using MDP in a responsible manner. The project has a rather large scope so because of time, resources and budget restrictions a full working prototype could not be implemented. As different components of the MDP concept and architecture have been evaluated and show that they are working as expected it can be safely assumed that a working implementation of MDP should work as described in the MDP concept. Requirements from end users and experts have been evaluated and either confirmed the assumptions made or delivered new issues which have been incorporated into the description of the MDP concept and its proposed architecture model.

There is definitely more research work outstanding and a real world implementation should be tested before opening such a MDP service to the public.

9 References

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A. Appendices

In these sections the appendices for this work can be found. Some material is provided as digital copy on a CD / ZIP file or online.

A.1 'Location-Based' Services in a mobile environment survey

The survey questions can be found here. The raw collected data is available on the CD or online.

'Location-Based' Services in a mobile environment survey

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully.

A few words about the research:

The aim of this research is to investigate the extent to which users are aware of 'location-based' recommendation services and their perception of such services. The research will ultimately proceed to propose new methods that overcome (or at least reduce) identified problems.

What are participants required to do?

Participants (end-users of varying technical abilities) will be asked answer questions in an online questionnaire.

How long will it take? What will happen to me if I take part?

If you decide to take part you will be asked to answer a few brief questions regarding 'location-based' recommendation services. A few demographic questions will precede the actual 'location-based' recommendation services questions. It is envisaged that each trial session will last no more than 10-15 minutes for a typical end-user.

Each survey will be followed by an opportunity for the participants to offer their opinions about the survey (Web form). However, they will not be required to divulge any sensitive or private information.

The survey is completely anonymous. No one is grading you on your answers, nor is anyone going to know who filled out the questionnaire. On the analysis of survey results, all participants will be referred to as User1, User2 etc.

What will the results of the study be used for?

The survey is part of a research project leading to the degree of Doctor of Philosophy at the University of Plymouth, (School of Computing and Mathematics, Faculty of Science and Technology). The aim of this phase is to investigate the extent to which users are aware of 'location-based' recommendation services and their perception of such services. The research will ultimately proceed to propose new methods that overcome (or at least reduce) identified problems.

Participants will be given the opportunity to find out the results of the study. To access a copy of the results the participants will find a link to a web page where the results will be posted after they finish the survey. By copying this link they can later anonymously visit this page to get their copy of the results.

Contact for Further Information

If you want any further information about this study you can contact me via e-mail at: steffen.schilke@plymouth.ac.uk

In case you have any concerns about the way in which the study has been conducted, you can contact the Faculty of Science and Technology Business Manager, who is secretary of the Faculty of Science and Technology Research Ethics Committee. The contact details are:

Faculty of Science and Technology Business Manager

University of Plymouth

Drake Circus

Plymouth

PL4 8AA

Phone: 01752 233311

Thank you for taking the time to read this information.

Please answer the following questions:

General Questions about the participant

Please give us some information about yourself.

1 How old are you?
Please choose the appropriate answer

2 Please indicate your gender.
Please click on the appropriate answer

- Male
- Female

3 What is your occupation?
Please click on the appropriate answer

- None
- Student
- Self employed
- Employed
- Retired

4 From which area are you from?
Please choose the appropriate answer

5 Do you own a mobile phone?
Please click on the appropriate answer

- No
- Yes, but mostly switched off
- Yes, only to be reachable
- Yes, normal usage (less then 10 hours airtime a week)
- Yes, heavy user (more the 3 hours airtime a day)

6 How do you go to work, university, ... ?
Please click on the appropriate answer

- Home, usually stay at / around my home
- Usually go there by foot
- By using a bicycle
- Public transportation (bus, train or subway)
- Motorcycle
- Car (or taxi)
- Various transportation systems

7 Which of the following features does your phone have?
Please click on all appropriate

- GSM Multi-band mobile phone
- UMTS mobile phone

answers

- [ ] Camera
- [ ] PDA
- [ ] GPS
- [ ] Wifi / WLAN

Technologies

In this section we want to determine your knowledge of mobile phone technologies and services. We will ask you about the technologies that are available to you, the technologies you are actually using, and the technologies that you plan or want to use in the future.

8 What mobile phone technologies are available to you?
Please click on all appropriate answers

- [ ] SMS Short Message Service (texting)
- [ ] MMS Multimedia Message Services
- [ ] Video messaging
- [ ] Mobile blogging (text, picture or video)
- [ ] (Mobile) Internet usage (web, eMail, instant messaging)
- [ ] 'Location-Based' Services (LBS)
- [ ] Mobile phone (for voice calls)

9 What mobile phone technologies are you using?
Please click on all appropriate answers

- [ ] SMS Short Message Service (texting)
- [ ] MMS Multimedia Message Services
- [ ] Video messaging
- [ ] Mobile blogging (text, picture or video)
- [ ] (Mobile) Internet usage (web, eMail, instant messaging)
- [ ] 'Location-Based' Services (LBS)
- [ ] Mobile phone (for voice calls)

10 What mobile phone technologies are you planing

- [ ] SMS Short Message Service

to use or want to use?
Please click on all appropriate answers

(texting)

- [ ] MMS Multimedia Message Services
- [ ] Video messaging
- [ ] Mobile blogging (text, picture or video)
- [ ] (Mobile) Internet usage (web, eMail, instant messaging)
- [ ] 'Location-Based' Services (LBS)
- [ ] Mobile phone (for voice calls)

How is your trust relationship to ...

Please identify your trust relationship to various business partners. We use the following scale:

++ is a strong trust relationship
+ you have some trust
0 is neutral
- you have some doubts
- - no trust

11 How much do you trust your bank / credit card company?
Please click on the appropriate answer

- ( ) + +
- ( ) +
- ( ) 0
- ( ) -
- ( ) - -

12 How much do you trust your ISP Internet Service Provider?
Please click on the appropriate answer

- ( ) + +
- ( ) +
- ( ) 0
- ( ) -
- ( ) - -

13 How much do you trust web sites / ecommerce shops / portal?
Please click on the appropriate answer

- ( ) + +
- ( ) +
- ( ) 0

- -
- - -

14 **How much do you trust your email provider?**
Please click on the appropriate answer

- + +
- +
- 0
- -
- - -

15 **How much do you trust your phone company (fixed / land line)?**
Please click on the appropriate answer

- + +
- +
- 0
- -
- - -

16 **How much do you trust your mobile phone company?**
Please click on the appropriate answer

- + +
- +
- 0
- -
- - -

17 **How much do you trust your search engine?**
Please click on the appropriate answer

- + +
- +
- 0
- -
- - -

18 **How much do you trust your 'Location-Based' Service provider?**
Please click on the appropriate answer

- + +
- +
- 0
- -
- - -

19 **How much do you trust public services or government organisations?**
Please click on the appropriate answer

- + +
- +
- 0
- -

- -

20 Which "world" do you trust more?
Please click on the appropriate answer

- Neither
- "Offline" - real life
- "Online" - Internet
- Both the same level of trust

How is your privacy preserved at ...

Please identify how you think privacy is preserved from various business partners. We use the following scale:

++ strong protection of you privacy
+ you privacy is protected
0 is neutral
- you have some doubts about the protection of your privacy
- - no protection of you privacy

21 How is your privacy protected by your bank / credit card company?
Please click on the appropriate answer

- + +
- +
- 0
- -
- - -

22 How is your privacy protected by your ISP Internet Service Provider?
Please click on the appropriate answer

- + +
- +
- 0
- -
- - -

23 How is your privacy protected by your web sites / ecommerce shops / portal?
Please click on the appropriate answer

- + +
- +
- 0
- -
- - -

24 **How is your privacy protected by your email provider?**
Please click on the appropriate answer

- ++
- +
- 0
- -
- - -

25 **How is your privacy protected by your phone company (fixed / land line)?**
Please click on the appropriate answer

- ++
- +
- 0
- -
- - -

26 **How is your privacy protected by your mobile phone company?**
Please click on the appropriate answer

- ++
- +
- 0
- -
- - -

27 **How is your privacy protected by your search engine?**
Please click on the appropriate answer

- ++
- +
- 0
- -
- - -

28 **How is your privacy protected by your 'Location-Based' Service provider?**
Please click on the appropriate answer

- ++
- +
- 0
- -
- - -

29 **How is your privacy protected by public services or government organisations??**
Please click on the appropriate answer

- ++
- +
- 0
- -
- - -

30 **In which "world" is your**

- Neither

privacy better protected?
Please click on the appropriate answer

- "Offline" - real life
- "Online" - Internet
- Both the same level of protection for privacy

'Location-Based' Service (LBS) awareness and interest

In this section we want to find out about your awareness about 'Location-Based' services and your potential interest in these services. We will ask you three questions based upon the same set of services. These will consider the services you are aware of, those you are currently using, and those that you plan or want to use in the future. The other questions have explanations when they are asked. You can give multiple answers, i.e., selected multiple services.

31 Which 'Location-Based' Services are you aware of?
Please click on all appropriate answers

- 'Location-based' or 'location-aware' advertisment, mobile Coupons (discount) or messages
- Navigtion support (car and non car)
- Recommendation of the closest / nearest point of interest (restaurant, hotel, shop, histroic site, ...)
- 'Location-aware' recommendation services (based on interests, e.g. sales, movies, food, ATM, ...)
- 'Location-aware' personalisation (filtered information based on interests)
- Locating missing or stolen mobile phone, car, goods, animals, ...
- Locating or tracking (mobile) people (e.g., kids or friends)
- Emergency support services / Emergency 'Location- Based' Services (ELBS), i.e., panic button / emergency message (e.g., e911 or e112 support)
- Integration with your schedule and location of events (pro active LBS personalisation / recommendation)

32 Which 'Location-Based'

- 'Location-based' or 'location-

Services are you using?
Please click on all appropriate answers

aware' advertisment, mobile Coupons (discount) or messages

- [ ] Navigtion support (car and non car)
- [ ] Recommendation of the closest / nearest point of interest (restaurant, hotel, shop, histroic site, ...)
- [ ] 'Location-aware' recommendation services (based on interests, e.g. sales, movies, food, ATM, ...)
- [ ] 'Location-aware' personalisation (filtered information based on interests)
- [ ] Locating missing or stolen mobile phone, car, goods, animals, ...
- [ ] Locating or tracking (mobile) people (e.g., kids or friends)
- [ ] Emergency support services / Emergency 'Location-Based' Services (ELBS), i.e., panic button / emergency message (e.g., e911 or e112 support)
- [ ] Integration with your schedule and location of events (pro active LBS personalisation / recommendation)

33 **Which 'Location-Based' Services are you planing to use or want to use?**
Please click on all appropriate answers

- [ ] 'Location-based' or 'location-aware' advertisment, mobile Coupons (discount) or messages
- [ ] Navigtion support (car and non car)
- [ ] Recommendation of the closest / nearest point of interest (restaurant, hotel, shop, histroic site, ...)
- [ ] 'Location-aware' recommendation services (based on interests, e.g. sales, movies, food, ATM, ...)
- [ ] 'Location-aware' personalisation (filtered information based on interests)
- [ ] Locating missing or stolen mobile phone, car, goods, animals, ...
- [ ] Locating or tracking (mobile) people (e.g., kids or friends)
- [ ] Emergency support services / Emergency 'Location- Based' Services (ELBS), i.e., panic button / emergency message (e.g., e911 or e112 support)

	☐ Integration with your schedule and location of events (pro active LBS personalisation / recommendation)
34 Which payment model would you prefer for using Location Based Services (LBS)? *Please click on all appropriate answers*	☐ Free ☐ LBS service covered by monthly fee plus cost for usage / per service ☐ LBS service covered by monthly fee (flat rate) ☐ Only pay by use / per service (pre-paid) ☐ Advertisement supported / payed / sponsored
35 What technique or method or delivery for 'location-based' services would you prefer? A push mechanism pushes the information to you / your device whereas by using a pull technique the user has to request the information when needed. Please mark all which would apply to you. Explanation of Push vs. Pull: The other questions in this section are concerned with the push and pull of information. An information pull is that an user has to request an information activley, i.e., "What time is it“. The information push is pushing information to the user without that the user has to request the information (e.g., the Blackberry email push services). *Please click on all appropriate answers*	☐ 'Location-based' services pull ☐ 'Location-based' services push ☐ Mobile personalisation services pull ☐ Mobile personalisation services push ☐ Services based on information from your schedule pull ☐ Services based on information from your schedule push ☐ Mobile personalisation services based on location - pull ☐ Mobile personalisation services based on location - push ☐ Mobile personalisation services based on location and your schedule pull ☐ Mobile personalisation services based on location and your schedule push
36 Do you think Emergency 'Location-Based' Services (ELBS, e.g., e911 or e112) would be helpfull to save lives? Should this service be mandatory and who shall pay for this service? Please check all statements which apply. *Please click on all appropriate*	☐ Don't know ☐ No ☐ Yes ☐ The ELBS service shall be financed by service fee ☐ The ELBS service shall be financed by taxes

answers

☐ The mobile phone provider shall be forced to provide ELBS by law

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Closing Statements

Thank you for participating in this survey. If you want a summary of the results or wish to contact the author please go to http://www.schilke.net/R35ULT5/ . Please copy or save a bookmark of this link for your future reference.

Please push this Button to submit your results.

A.2 Expert Interview and Questionnaire

The presentation provided can be found here. The video and the raw collected data are available on the CD / ZIP file or online.

A.2.1. **Participating experts**

The list of the experts which have participated:

1. Prof. Dr.-Ing. Kira Kastell, Professor of electrical engineering also with background in business administration and economics, among other things working on location based handovers in hybrid mobile systems (lower 3 layers), female in the mid thirties from Fachhochschule Frankfurt am Main, University of Applied Sciences, Fachbereich 2, Informatik und Ingenieurwissenschaften, Studiengangsleiterin Elektrotechnik
2. Professor Ogawa (Keio University, Japan) specializes in various areas of media informatics, including human interface, communications service, information search, media design and network society. In 2009 he received a Best Paper Award in the thematic area of Human Interface and the Management of Information.
3. Paul Reynolds is a Professor of Communication Engineering at Plymouth University. He is a technical specialist in Internet based mobile telecommunications. Until recently he was Head of Research for Orange and currently is the CTO of a small software start-up company "Conetivita”. This company aims at providing communities with a set of ‘knowledge discovery’ and the ‘stake-holder identification’ web based tools that transparently use information (static, dynamic, structured, unstructured, extrapolated…) that exists within an organisation. He is also a ‘Technical Auditor’ for the European Commission. He is active in innovation and recently added a 15th patent to his catalogue that includes fundamental technology inventions such as Seamless Mobility Management and Policy Mobility Control upon which the current mobile services rely. He currently supervises 2 PhDs at Plymouth. In the past he has

directed all Orange's research and innovation activities and the European Union's funded research into distributed computing for mobile telecommunications. He has designed mobile networks for eight countries; chaired sessions at two European Union Mobile Communication Summits; been the technical leader of the industrial Mobile Wireless Internet Forum and of two major European Union research projects; been the chairman of EU's Group responsible for leadership of Europe wide 3G mobile telecommunication trials; and, has successful supervised over 13 PhDs to completion. He is a Fellow of the Institution of Engineering and Technology and is responsible for interviewing, and making recommendations on, senior engineers whom have applied for Fellowship of the institution. On behalf of the Engineering Council, he conducts interviews, and making recommendations on, candidates whom have applied for Chartered Engineering status. He has a PhD in Telecommunications.

4. MARK WATKINS is CEO and co-founder of goby. Mark's inspiration to start goby is rooted in his passion for creating interesting ways for people to find and explore information about how to spend their free time. Prior to starting goby, Mark led Engineering & Professional Services for Endeca, a provider of search and information access solutions for the online arms of companies such as Borders, IBM and American Express. Before that, Mark held various executive leadership positions for technology companies such as Parametric Technology, a leader in engineering collaboration, data management and 3D design, and Evans & Sutherland, an early computer graphics pioneer. Mark has a Master's degree in Mathematics from the University of Utah, is the co-holder of a patent, and has published a number of articles in peer-reviewed technical journals. Mark also sits on the board of Styleta (www.styleta.org), an online nonprofit boutique run by a network of college students that collects designer fashion donations, sells them online, and donates the proceeds to charity partners who focus on women's initiatives. During his free time, Mark is

an avid outdoorsman, tennis player, music fan and culture buff who uses goby to find new backpacking trails and historic sites to tour, and to feed his eclectic (ok, "odd“) music addictions.

5. Manfred Sielhorst - Diplom in Mathematics with a minor in Computer Science from TU Hannover, several years worked for international software companies (Actis, CA, DataMirror, adept consult, basyskom) in the area of Tools for AS/400, ERP, HA and RT Integration, Information logistics, mobile Databases and reporting with BIRT. Member of Dante e.V. (TeX user group in Germany), COMMON Deutschland e.V. (IBM user group), IBM CEAC member for Germany and visiting lecturer at Hochschule Darmstadt.
6. Ingo Willimowski, Dipl.-Ing., Project Manager, Vodafone D2 GmbH, Project Manager Intelligent Networks Projects & Platforms, Head of SIG VDE/ITG-Fachausschusses 5.2 "Kommunikationsnetze und –systeme“, Author of various books, patents and articles, visiting lecturer
7. Prof. Dr.-Ing. Andreas Grebe, Fachhochschule Köln, Fakultät für Informations-, Medien- und Elektrotechnik, Institut für Nachrichtentechnik, Forschungsgruppe Datennetze, Cologne University of Applied Sciences (CUAS), Institute of Communications Engineering, main area of expertise: networks, protocols and NGN
8. Wilfried Evers, Male, age 52, project manager for mobile networks, Diplom Informatiker
9. Prof. Dr. H.-Chr. Rodrian is professor of Computer Science at the University of Applied Sciences in Bingen, Germany. His research interests are in information and communication infrastructures, particularly in the area of agriculture. Some research topics are device- and manufacturer-independent data exchange, smartphones and tablets as mobile clients for information and communication infrastructures, services based on geographic data, seamless offline-functionality for mobile clients, and mobile usability.

10. PJ Verhoef, technology marketeer, entrepreneur, runner, husband, father in reversed order of importance. Through various companies and teams, he has built businesses around the marketing of technology as well as the technologies of marketing, co-founded the Location Based Marketing Association, European Chapter.
11. Tumasch Reichenbacher holds a MSc degree in Geography from University of Zurich with a specialisation in Geographic Information Systems and Cartography. After a position as GIS developer for cartographic production in the Industry he was a research assistant at Technical University Munich where he received his PhD in 2004. From 2007 to 2011 he was a lecturer at University of Zurich. Dr. Senior Research Associate. Geographic Information Visualization & Analysis (GIVA) Department of Geography University of Zurich. His main research interests are mobile cartography, location-based services, and geographic relevance.
12. Stephen Brown, Director of Technology, TURNKEY BUSINESS SOLUTIONS (Pte) Limited, Undergraduate Degree in Computer Science from UCLA, Masters in Electronic Engineering from UCLA, 16+ years commercial Software Development / SDLC Management experience, Co-Founder (and active board member) of Perceptive Development (www.perceptdev.com) a mobile applications/hardware development house based in Los Angeles, Currently leading a development team based in Singapore with offices in Hong Kong, Philippines and Singapore
13. Glen Farrelly, third year PhD student at the University of Toronto's Faculty of Information. Prior to this I was a web producer (entailing both web development and design) for over ten years. I'm currently also an Online User Experience consultant. My current PhD research is examining the role of geotargetted information delivered via mobile location based services.

14. Dr. Katayoun Farrahi, Universitätsassistent (Postdoctoral research fellow), Institut für Pervasive Computing, Johannes Kepler Universität Linz, Thesis: A Probabilistic Approach to Socio-Geographic Reality Mining

A.2.2. **Cover Letter and Questionnaire**

In addition to some introductory words the email cover letter for the experts which have volunteered to participate in the interview and questionnaire look like this:

Please give me some feedback about my academic project "Multi-Dimensional-Personalization in online and offline[6] contexts“.

A short video presentation explaining the concept can be found:

http://cikm.de/MDP4expert/MDP4expert.html

A direct link to the video: http://cikm.de/MDP4expert/MDP4expert.mp4

A longer presentation can be found as PDF at

http://cikm.de/MDP4expert/mdp4expert_long.pdf

If you could kindly rate on a 1 - 5 scale (1 (strong agree), 2 (agree), 3 (neutral), 4 (disagree), 5 (strong disagree)) and comment against each of the following statements:

a. The introduced new and unique model of MDP (Multi-Dimensional Personalisation – a push based personalisation using time, location, i.e. movement patterns, and interest (and other "dimensions” if needed, e.g. age bracket, gender, etc.)) is feasible.

Rating:

Comment:

[6] After the questionaire was send out the project / dissertation name change in the Viva Voce

b. The introduced concepts of a SPOT (Single Point of Trust) / "Chinese Wall" are a secure way of protecting the privacy of the MDP user and therefor gain the trust of the users in this system.

Rating:

Comment:

c. The Support of a feedback / "Spam" indicator is enhancing the user experience and protect s the user against unwanted recommendations.

Rating:

Comment:

d. The possible aggregation of recommendations based on type / location increases the user acceptance.

Rating:

Comment:

e. The evaluation of past (& future) movement patterns is a feasible way to support the recommendation for location based recommendations / marketing.

Rating:

Comment:

f. The evaluation of past (& future) movement patterns is an acceptable way to support the recommendation for location based recommendations / marketing.

Rating:

Comment:

g. The use of ontologies (e.g., controlled vocabulary / catalogues,hierarchies) to allow the user to express his interests is realistic.

Rating:

Comment:

h. Such a system gives the end user an added value.

Rating:

Comment:

i. You would personally use such a MDP service.

Rating:

Comment:

Please provide me as well with a short biographical description of your person as reference.

If you have any additional question about the concept please let me know and I will try to answer it or give you a phone / skype call when it fits your schedule.

Thank you very much and kind regards

Vielen Dank

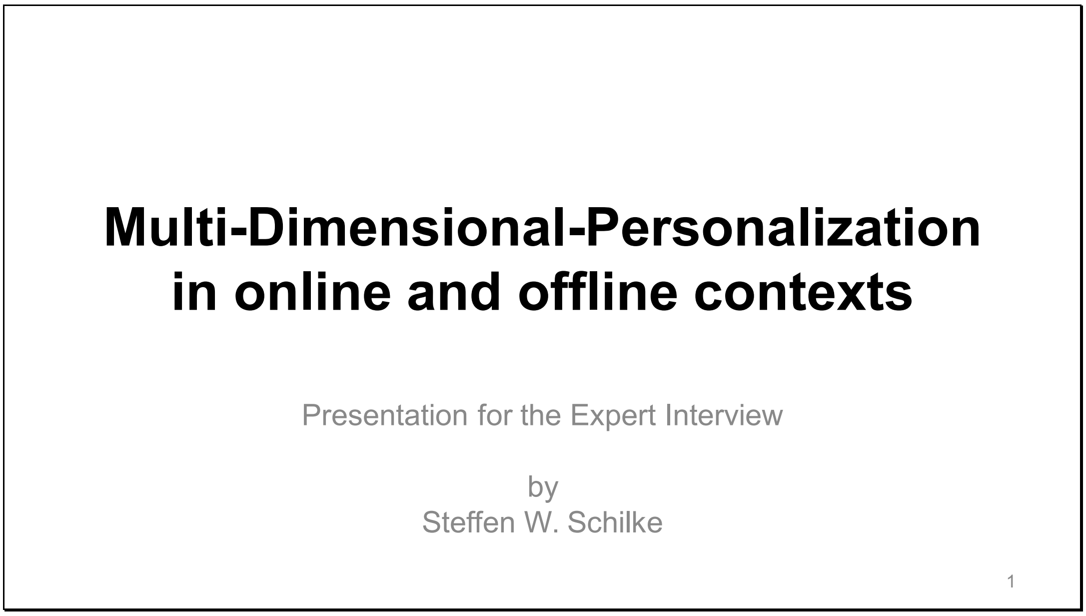
Mit freundlichen Grüßen

Steffen W. Schilke

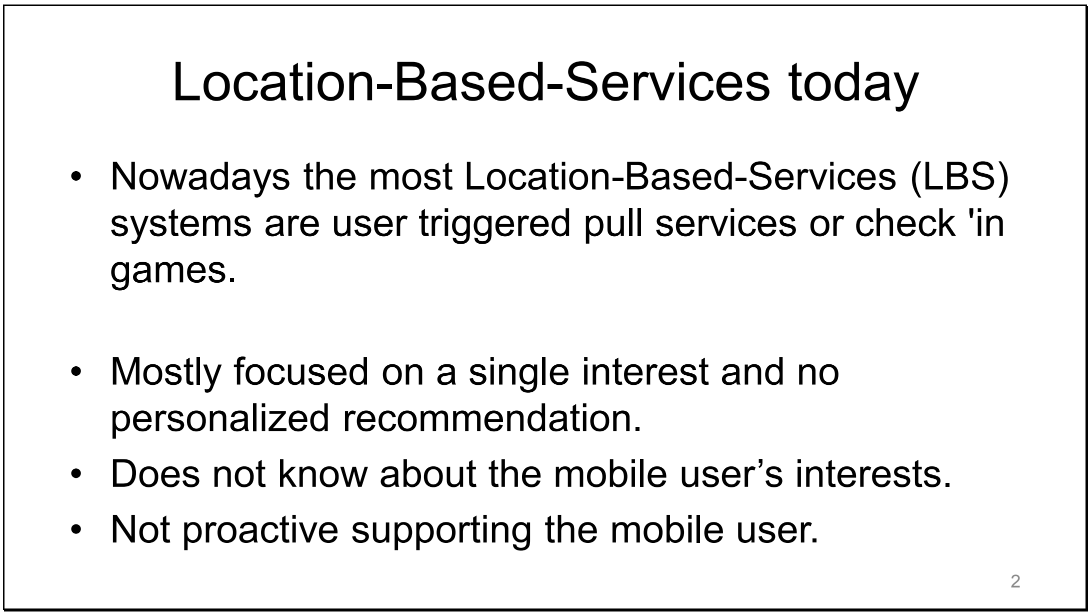
http://www.cscan.org/default.asp?page=showprofile&type=student&id=9

A.2.3. **Slides used in the video presentation**

Slide 1



Slide 2



Slide 3

The stakeholders

- **Mobile user** – wants privacy, needs to trust the LBS, want's useful information and an added value by using the service, no spam.

- **Information provider** (e.g., Advertisement / Information source) – want's to reach a specific target audience, does not want to waste money / efforts, wants attention for his message hence generating a value for both sides.

3

Slide 4

Multi-Dimensional-Personalization

- A new and unique proactive push service model to support mobile users with personalized LBS recommendations. Knows the (mobile) user and his interests, his behavior / movement patterns and future schedule (and location).

- Protects the privacy of the mobile user but offers advertisers the opportunity to reach their target audience.

4

Slide 5

Dimensions, e.g.:

- **Time** – a bracket of time which characterizes a time slot.
- **Location** – during a time slot the user is at a certain places (e.g., home, workplace, university, shopping, sports or on the way between these places).
- **Interest** – what the user is really interested in. Specified by the user and based on a hierarchical controlled vocabulary.

5

Slide 6

Historic & Future Movement Pattern I

- An important differentiator for MDP is the use of the regular movement (location) pattern of the mobile user for the personalized recommendations. Nearly everybody has a daily routine, e.g., the way to / from work, school, university, training, sports, etc.

6

Slide 7

Historic & Future Movement Pattern II

- Using / storing the GPS trajectories in a protected MDP system it's possible to predict / estimate the whereabouts of the mobile user in order to present matching recommendations.

- Using the schedule of the mobile user it's even possible to recommend something in the future (e.g., for a planed business trip, holiday, …).

7

Slide 8

MDP: Mode

- **Mode** – how the mobile user is moving, e.g., by foot, car, public transportation, bike, etc. This can be set manually by the user or automatically detected by the system.

  Depending on the movement mode (i.e., speed) the notification has to be send well ahead (i.e., time, distance) to allow the mobile user to react if he is interested.

8

Slide 9

MDP: Mood

- **Mood** – this allows the mobile user to tell the system if he is willing to get personalized recommendations or not (e.g., private, public, party, play, sleep, do not disturb, driving, …).

  Can be mapped to the mode set for the phone (e.g., "silent", car, based on time brackets) or set by the user.

9

Slide 10

MDP: Location

- **Location** – if the mobile user has reached a certain place where he stays for a certain time (e.g., at work, in school / university, at home).

  This can be set by the user or automatically set if a certain geographic region is reached.

10

Slide 11

MDP: Notifications

- **Notification** – the mode the notifications are presented like one-by-one or aggregated.

  The user can give feedback on the notifications received by the MDP system in order to weed out unwanted or not matching information or spam.

11

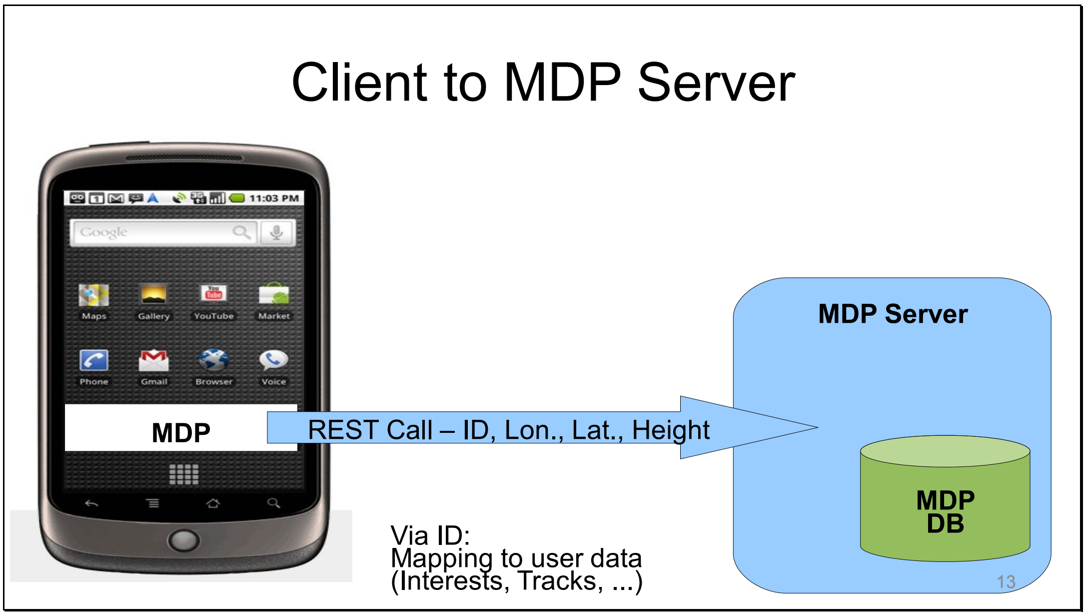
Slide 12

The MDP architecture I

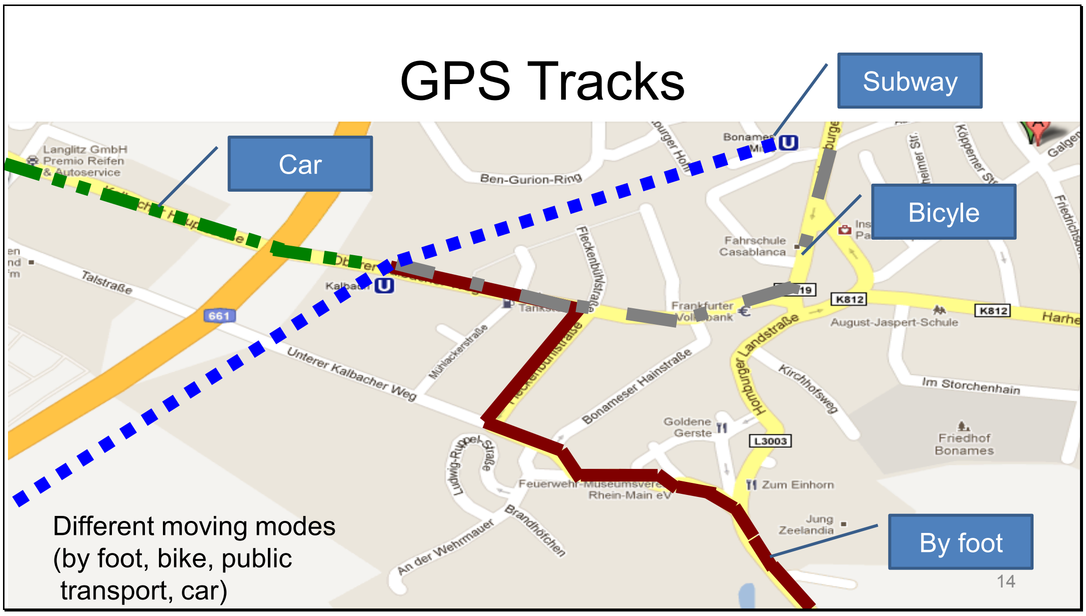
- The mobile user has a MDP application on the smartphone which communicates with the MDP Server.
- The MDP server stores the movement pattern, mode, mood, settings and interests of the user. It acts as Single Point of Trust (SPOT) and protects the data and privacy of the user.

12

Slide 13

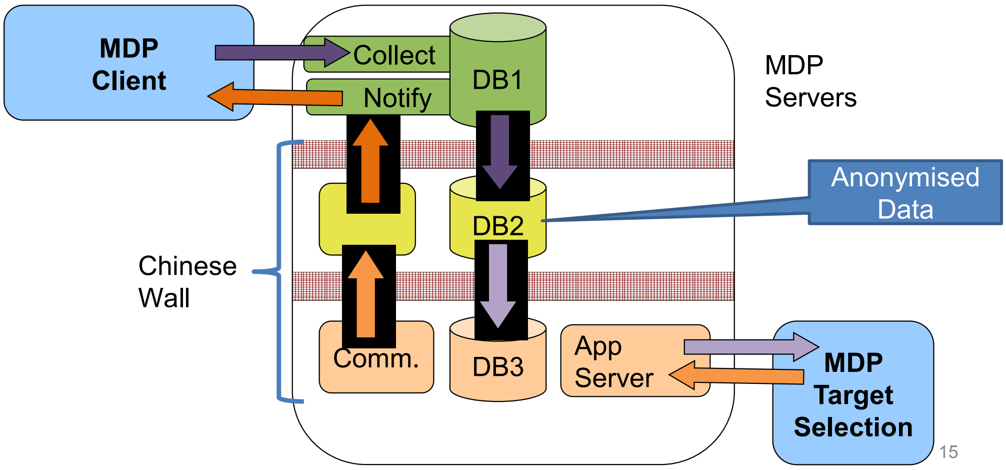


Slide 14



Slide 15

Proposed MDP Architecture



15

Slide 16

The MDP architecture II

- An anonymised shadow dataset will be generated to allow the selection of matching anonym mobile user profiles by the information source / advertiser for information / content delivery.

  This "Chinese Wall" protects the access to the "real" mobile users data.

16

Slide 17

The MDP architecture III

- The information provider (e.g., advertiser) will only get access to selection results from the anonymised shadow dataset.
- The selection results will never unveil the identity of mobile users. Even if there would by an attack to identify a specific mobile user this would not be possible because only anonymised user profiles would be returned and no access to the mobile user profile information would be possible.

17

Slide 18

Selection Results (Sample)

18

Slide 19

Receiving Notifications

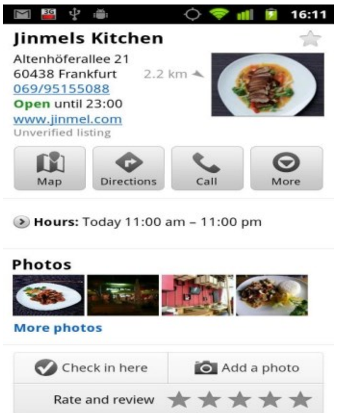
- For the push of the notification the user receives, e.g., a pop-up, will be used – this could be, e.g. a voucher, links, app calls or information.
- Depending on the device an appropriate technology will be used. As long as no generic notification method for all platforms is available (e.g., Flash SMS).

19

Slide 20

Notifications

- The notifications can be integrated with web sites or applications on the device.



20

Slide 21

The MDP architecture III

- As the (regular / routine) movement pattern of the mobile users are “know” to the system the possible location of a user at a certain day and time can be predicted and used to schedule notifications ahead in time.
- The other selection criteria's will be applied as well in order to define the result set for the notification.

21

Slide 22

MDP – your digital friend

Imagine MDP as a good friend knowing you, your interests, your likes and dislikes, your daily routine, your favourite spots, home and place of work or studying. You might even tell your friend in advanced when you travel to which places.

This friend makes recommendations, makes you aware of things you might be interested in but would have missed without the friendly recommendation / notification of this friend (MDP) without annoying you with unwanted information.

22

A.3 Movement Pattern

Materials from the GPS trajectories recordings as KML files are available in digital form on the CD / ZIP file or online. The volunteer's names have been removed from the filename.

A.4 Conferences attended and Publications

The following sections list the publications which have been published and the conferences attended during the PhD research project.

Copies of the publications can be downloaded or requested from the Centre for Security, Communications and Network Research (CSCAN) of the Plymouth University CSCAN web site:

http://www.cscan.org/default.asp?page=showprofile&type=student&id=9

A.4.1. Conferences attended

This is a list of some of the conferences which have been attended during the PhD research work.

1. Fourth International Network Conference (INC 2004), Plymouth, UK, 2004
2. Tag der Forschung, Fachhochschule Darmstadt, Germany, 2005
3. Sixth International Network Conference (INC2006), Plymouth, UK, 2006
4. 5th Security Conference, Las Vegas, USA (2006, Work was presented by the Director of Studies), 2006
5. Tag der Forschung, Fachhochschule Darmstadt, Germany, 2006
6. Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007), Plymouth, UK, 2007
7. Fourth Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2008), Wrexham, UK, 2008
8. Informatik 2008 - GI Jahrestagung, Munich, Germany, 2008
9. Medienmittwoch: Mobile Internet – Auf der Überholspur oder nur zu hohe Drehzahlen im ersten Gang?, Frankfurt, Germany, 2008
10. Google Developer Day München 2008, Munich, Germany, 2008
11. m2d2 - MobileMonday Developer Day for Android, Düsseldorf, Germany, 2010
12. TechTalk #15 "RESTful HTTP: The Architecture of the Web", Darmstadt, Germany, 2010

13. Eight International Network Conference (INC2010), Heidelberg, Germany (Organizing Co-Chair)
14. Google Developer Day 2010, Munich, Germany, 2010
15. Seventh Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2011), Furtwangen, Germany, 2011

A.4.2. Journal papers

1. **Multi-Dimensional-Personalisation for the online & offline world**
   Schilke SW, Bleimann U, Furnell SM, Phippen AD
   Internet Research, vol. 14, no. 5 pp379-385, 2004

A.4.3. Conference papers

2. **Fitting Extended Blended Learning and Multi-Dimensional-Personalization into Learning Management Systems**
   Schilke SW, Bleimann U, Stengel I, Phippen AD
   Proceedings of the Sixth International Network Conference (INC2006), Plymouth, UK, 11-14 July, pp393-400, 2006
3. **Enhancing Privacy Through Anonymous Recommendation for Multi-Dimensional-Personalisation**
   Schilke SW, Furnell SM, Bleimann U, Phippen AD
   Proceedings of the 5th Security Conference, April 19-20, Las Vegas, USA, ISBN: 0-9772107-2-3, 2006
4. **A "Chinese Wall“ Approach for Anonymous Recommendation in a Multi-Dimensional-Personalisation Scenario**

Schilke SW, Bleimann U, Furnell SM, Phippen AD Proceedings of Sciences Electroniques, Technologies de l'Information et des Telecommunications (SETIT) 2005, 27-31 March 2005, p155 (abstract), ISBN: 9973-51-546-3, 2005

5. **Multi-Dimensional-Personalisation for the online and offline world** Schilke SW, Bleimann U, Furnell SM, Phippen AD Proceedings of the Fourth International Network Conference (INC 2004), Plymouth, UK, 6-9 July 2004, pp545-552, 2004

A.4.4. Internal publications

6. **Multi Dimensional Personalisation Architecture Proposal for a Prototype** Schilke SW, Bleimann U, Furnell SM, Phippen AD Proceedings of the Fourth Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2008), Wrexham, UK, ISBN: 978-1-84102-196-6, pp121-133, 2008

7. **Multi-dimensional-personalisation - in "whom" we trust? Perception of trust & privacy** Schilke SW, Bleimann U, Furnell SM, Phippen AD Proceedings of the Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007), Plymouth, UK, ISBN: 978-1-8410-2173-7, pp11-22, 2007

A.4.5. Posters

8. **A new breed of learning Management Systems: working with Extended Blended Learning and Multi-Dimensional Personalisation**
Schilke SW, Bleimann U, Phippen AD, Stengel
Poster presentation at Tag der Forschung, Fachhochschule Darmstadt, Germany, 17. October, 2006
9. **Extending Meta Data of Learning Management Systems for Extended Blended Learning and Multi-Dimensional Personalisation**
Schilke SW, Bleimann U, Phippen AD, Stengel
Poster presentation at the Sixth International Network Conference (INC2006), Plymouth, UK, 11-14 July, 2006
10. **Using a "Chinese Wall“ for Anonymous Recommendation and the Protection of Privacy**
Schilke SW, Bleimann U, Furnell SM, Phippen AD
Poster presentation at Tag der Forschung, Fachhochschule Darmstadt, Germany, 25th October, 2005
11. **Multi-Dimensional-Personalisation**
Schilke SW, Bleimann U, Furnell SM, Phippen AD
Poster presentation at Tag der Forschung, Fachhochschule Darmstadt, Germany, 19th October, 2004

A.4.6. Other publications

12. **Personalisierung - das vergessene Thema? (in German)**
Schilke SW, bdvb aktuell 83, Mitglieder-Magazin des Bundesverbandes Deutscher ISSN 1611-678X, p18, 2003