



UNIVERSITY OF AGDER

**Recommending Services in Pervasive Environments**

**By**

**Jan Olsen**

**Thesis submitted in Partial Fulfillment of the  
Requirements for the Degree Master of Science in  
Information and Communication Technology**

**Faculty of Engineering and Science  
University of Agder**

**Grimstad**

**May 2010**

## Abstract

The presence of mobile devices with network connectivity continues to increase in all parts of the world, opening up direct channels to mobile users. The threat of information overload is prevalent, and if not subjected to control in terms of legislation and deployment of more intelligent and user-considerate systems it is likely to cause problems. This is particularly important in the case of push-based advertisement systems where information must be of relevance to the mobile user preferences, needs, and interest.

This paper proposes a solution and architecture of a consumer-oriented, push-based, context aware location based advertisement system. The system is designed to operate in compliance with the World Wireless Research Foundation (WWRF) guidelines for the future space of information services: personalization, ambient awareness, and adaptability. The system is intended to operate in pervasive environments.

The proposed system, called AdvertLBS, harvest knowledge about service providers and consumers in terms of preferences, geographical and temporal locations. The system applies knowledge about services, consumers, and learns context information in order to establish a broad service recommendation context.

The AdvertLBS system adopts a hybrid approach to recommendation logic and proposes to use a subset of suitable matching algorithms to produce service recommendations relevant to the consumer's interests and needs.

## Content

Recommending Services in Pervasive Environments .....	1
Abstract .....	2
Content .....	3
PREFACE .....	7
Chapter 1 – Introduction .....	8
1.1 Thesis Goal.....	9
1.2 Traditional Push-Based LBS’s .....	9
1.3 The WWRF Guidelines for I-Centric Communication Services .....	10
1.3.1 Personalization .....	10
1.3.2 Ambient Awareness .....	10
1.3.3 Adaptation .....	10
1.4 Recent Location Based Systems Research.....	11
1.4.1 The DYNAMOS Approach [1] .....	11
1.4.2 CityVoyager [2].....	11
1.4.3 Bluetooth and WAP Push Based Location-Aware Mobile Advertising System [12] .....	11
1.5 Classification of Recommender Systems .....	12
1.5.1 Knowledge-Based Systems .....	12
1.5.2 Content Based Recommender Systems.....	13
1.5.3 Collaborative Filtering Systems .....	13
1.5.4 Hybrid Systems .....	14
1.6 The AdvertLBS System .....	15
Chapter 2 – Research Methodology .....	18
2.1 Analysis of Initial Problem Statement .....	18

2.2 System Vision and Requirements .....	18
2.3 Identification of Research Challenges.....	19
2.4 Solutions and System Architecture .....	19
2.5 Qualitative Evaluation of System Design .....	20
2.6 Contribution to Science .....	20
Chapter 3 – Scenarios and System Requirements .....	23
3.1 System Requirement Guidelines .....	23
3.2 Scenarios and Visions .....	23
3.2.1 Scenario #1 – Registration and First Impressions .....	23
3.2.2 Scenario #2 – Advert LBS Service Profile Registration .....	24
3.2.3 Scenario #3 – Advert LBS Service Recommendation .....	25
3.2.4 Scenario #4 – AdvertLBS Learning Capabilities .....	25
3.3 Requirements and Use Cases .....	25
3.3.1 Use Case Actors .....	26
3.3.2 Service Consumer Use Cases .....	26
3.3.3 Service Provider Use Case Model.....	29
3.3.4 AdvertLBS SystemCore Use Case Model .....	32
Chapter 4 – Research Challenges .....	34
4.1 Knowledge and Context Provisioning.....	34
4.1.1 Static System Knowledge.....	35
4.1.2 Dynamic Context.....	36
4.2 Context Representation .....	39
4.3 Recommender Logic .....	39
4.4 Service Monitoring.....	40
Chapter 5 – Solutions and Design .....	41
5.1 Steel Threads .....	41

5.1.1 Steel Thread #1 – Create Profiles and Service Descriptions.....	41
5.1.2 Steel Thread #2 – Transfer Location Coordinates to System.....	42
5.1.3 Steel Thread #3 – Dynamic Context Provisioning.....	42
5.1.4 Steel Thread #4 – Service and Recommendation Rating.....	43
5.1.5 Steel Thread #5 – Service Hybrid Recommender Logic.....	43
5.1.6 Steel Thread #6 – Service Monitoring .....	44
5.2 Knowledge and Context Provisioning.....	44
5.2.1 Knowledge Provisioning .....	44
5.2.2 Context Provisioning.....	50
5.2.3 Knowledge and Context Representation .....	54
5.2.4 Knowledge and Context Representation - XML Schemas.....	58
5.2.5 Service Profile Description Records .....	64
5.2.6 User Preference Context Representation.....	74
5.2.7 Database Model and Tables .....	80
5.2.8 Hybrid Recommender Algorithm.....	95
5.2.9 Service Monitoring Model .....	105
Chapter 6 – Security and Trust.....	108
6.1 Security.....	108
6.2 Trust .....	109
Chapter 7 – Architecture and Platform.....	111
7.1 System Deployment Diagram .....	112
7.1.1 Front-End Subsystem .....	113
7.1.2 Back-End Subsystem.....	113
7.1.3 Service Consumer .....	113
7.1.4 Service Provider .....	113
7.1.5 External Services.....	114

Chapter 8 – Evaluation of Proposal.....	115
8.1 Evaluation of Requirements .....	115
8.1.1 Recommendation Accuracy .....	115
8.1.2 Registration .....	115
8.1.3 Location Updates.....	116
8.1.4 Knowledge and Context Elicitation .....	117
8.1.5 Service and Recommendation Rating .....	117
8.2 Evaluation of Compliance with WWRF I-Centric Model .....	117
8.2.1 Personalization .....	117
8.2.2 Ambient Awareness .....	118
8.2.3 Adaptation .....	118
8.3 Comparison to Other Location Based Services.....	119
Chapter 9 – Conclusion and Further Work .....	120
References .....	121

## **PREFACE**

This report is submitted in partial fulfillment of the requirements of the Master of Science degree in Information and Communication Technology at the University of Agder, Faculty of Engineering and Science.

The project's supervisors have been Anis Yazidi and Ole-Christoffer Granmo from University of Agder. I'd like to thank them for their feedback throughout the project.

Grimstad, May 25, 2010

Jan Olsen

## Chapter 1 – Introduction

The majority of mobile devices can now be connected to the Internet via Wi-Fi access points or GPRS or UMTS mobile networks. It is now possible to be permanently online with mobile devices. This presents unique possibilities in a wide range of application areas, such as online gaming, information services, social networking, and mobile marketing.

In this paper I focus on the domain of mobile marketing and specifically to the niche of push-based recommendation of advertisements and services in pervasive environments.

The vast majority of research papers on recommender systems focus primarily on building automated systems, focusing in on matching algorithms and doing a quantitative analysis of these algorithms. The systems apply complex and mathematically advanced algorithms in order to infer and provide justified guestimates about what information a user may prefer or not prefer, like movies (MovieLens<sup>1</sup>), books (WhatShouldIReadNext<sup>2</sup>), music (Pandora<sup>3</sup>) and others. These automated systems are working well on the Web, but when information is to be pushed onto a mobile handset, we face the challenge of privacy and realize that other means and methods are required to ensure the necessary quality of service and to protect the welfare of the mobile user.

According to the World Wireless Research Foundation (WWRF) the ambition of future information services is personalization, services which exists around us, present, and constantly aware of our movements, actions, environment, and settings. The services are extensions of the user's cognitive self and her abilities to harvest and analyze information. This is the core of the I-centric paradigm defined by WWRF. In the spirit of this ambition I want to empower the individuals to influence and customize their own service experience. Section 1.2 gives a more detailed description of the WWRF guidelines.

This thesis is not a quantitative mathematical treatise describing complex learning and recommendation algorithms as these algorithms are already well-described and tested extensively in literature. [13]. This paper describes a proposal which captures the necessary requirements related to representation of knowledge and context, data storage, recommendation logic, and other necessary features of a recommender system designed to operate in a pervasive mobile environment, and which complies with the guidelines of the I-centric paradigm provided by WWRF. In other words it takes a broad perspective, investigating a number of issues related to the construction an operation of push-based, context-aware LBS's. The primary design rationale is to provide business with a direct channel to the consumer's private sphere must be permission-based, customer-controlled, trustworthy, and unobtrusive in operation.

<sup>1</sup>MovieLens: <http://movielens.umn.edu/login>, <sup>2</sup>WhatShouldIReadNext: <http://www.whatshouldireadnext.com/>,

<sup>3</sup> Pandora URL: <http://www.pandora.com/restricted>



## 1.1 Thesis Goal

The following statement describes the thesis goal:

*“As a scenario, we are interested in **push based location aware advertisement services**. The main challenge is to design a smart system that notifies the user about relevant points of interest with regards to his current context. Multiple dimensions need to be combined in order to trigger a notification such user context, user preferences, reputation of the service and historical data of the service usage.”*

**From Kompetansetorget, University of Agder**

Based on this description I have researched and investigated solutions and propose a customer –oriented, context aware location based advertisement system which I claim fulfills the goals of the problem description, extends the traditional push-based LBS, and additionally complies with the WWRF guidelines for an I-centric communication service.

I do not include an implementation of the system with this paper, but produces a theoretical basis for an implementation.

## 1.2 Traditional Push-Based LBS's

There is a big difference between a request-oriented and a push-based location based services. Requested-oriented LBS's allow the users to request information about nearby services or objects of interest. The system doesn't need to keep a vast amount of information about the user to perform well. The push-based location service can identify a user by location but will essentially be impotent in terms of providing users with relevant information unless it is in possession of, at least, a modest amount of knowledge about user preferences.

The traditional push-based LBS rely to a large extent on user location. This is not nearly good enough as most recommendations provided by this kind of system is likely to produce a horrendous amount of irrelevant and uninteresting number of recommendations. Also many LBS's work by simple opt-in mechanisms which let users register in a system by sending a keyword to a specific phone number. It will not work in terms of providing relevant services, and it will certainly not work according to the I-centric paradigm.

So, we can conclude that other means and methods are required for push-based LBS's operating in the mobile domain. But, before we dive into the world of I-centric services, knowledge, context, and recommender logic I will briefly present the visions of the WWRF in the next section.

## **1.3 The WWRF Guidelines for I-Centric Communication Services**

There are three dimensions associated with the I-centric paradigm proposed by the WWRF: personalization, ambient awareness, and adaptation. I describe each of these briefly in the following sections. The following descriptions are based on descriptions from the WWRF Briefing WG2-br4 [10].

### **1.3.1 Personalization**

Individuals are different in many respects and this must be accounted for in any system developed to operate in a pervasive communication space. Personalization is defined as the ability of systems to compose and administrate tailored context information related to user preferences.

The service should also be able to evaluate user preferences and provide the user with customized and individual services which meets the users demand. Learning mechanisms in the system should improve knowledge profiles and provide better services.

### **1.3.2 Ambient Awareness**

The ambient awareness component describes the ability of the system to capture and handle situational information. Typical situational information would be user activity, geographical location, mobility, physical circumstances, etc. We understand that the system must continuously sense situational circumstances around the user and dynamically update knowledge and context information.

### **1.3.3 Adaptation**

The system needs to be adaptable in terms of location, time, user needs, network, and end-device capabilities. This adaptability is necessary to allow the system to be present everywhere and to be able to perform and deliver service under changing conditions and circumstances.

## **1.4 Recent Location Based Systems Research**

In this section I will briefly review a few location based recommender systems which have provided me with understanding and motivation for the work with the AdvertLBS recommender.

### **1.4.1 The DYNAMOS Approach [1]**

This approach describes a location based, context-aware recommendation system with social functionalities. The system operates with context harvesting using a separately developed context provisioning middleware called Contory [Riva].

The DYNAMOS approach is primarily a social recommender system in terms of allowing users to tag services, enter recommendations, and leave notes in different geographical areas. It is an informal system where everyone is allowed to participate and contribute with information.

However in order to build a secure, transparent recommender system oriented towards mobile marketing there should be a strict regime concerning control of who is allowed to enter service information into the system. These issues are central topics in the AdvertLBS system.

Please refer to [1] for more information about the Dynamos solution.

### **1.4.2 CityVoyager [2]**

This approach describes a location based shopping assistant which operates on the location history of users, acquired by analysis of GPS coordinates. The system draws up shopping routes and produces a list of frequently visited shops. The system applies a collaborative filtering algorithm to produce recommendations based on this list.

Please refer to [2] for more information about CityVoyager.

### **1.4.3 Bluetooth and WAP Push Based Location-Aware Mobile Advertising System [12]**

This paper presents an approach to deliver advertisements using a Bluetooth positioning. The proposed system is permission-based and sends advertisements to user. The system doesn't implement profiling or personalization mechanisms. Nor does it implement a rating model or a the particular abilities to learn user preferences.

The most interesting portion of this paper is a qualitative analysis of users perception and reception of pushed advertisements. The paper presents a positive attitude to reception of relevant advertisements. Most users complained about too high frequency of recommendations. This is off course a problem if users have not been profiles on preferences, needs and interests. These are issues carefully considered in the system proposed in this paper.

Please refer to [12] for more information about this location based advertisement system.

### **1.5 Classification of Recommender Systems**

With reference to the section 1.4, we see that there is a number of different recommender systems proposed and described in literature. The recommender systems vary in terms of applied algorithms and work domain. It is however possible to classify most of these systems into four basic categories based on which algorithm is used to establish preferences and to produce recommendations.

I do consider it important to spend some time explaining these four categories as they are essential to the understanding of major parts of the proposal described in this paper, the knowledge and context provisioning, and the recommender logic. I will provide a few associations to the AdvertLBS system at the end of each section.

#### **1.5.1 Knowledge-Based Systems**

The knowledge-based approach is based on the system providing and representing knowledge about a user's interests and needs. The knowledge is typically expressed in profiles and in a well-defined and efficient format within a defined context or ontology. The system reasons on the available information and how well an item description matches the user preferences.

The primary advantage of knowledge based systems is that it effectively avoids the so called "cold-start" problem which commonly occurs in recommender system based on learning algorithms. In general learning algorithms requires a training set or a relatively large number of users in order to produce viable predictions. The cold start problem occurs when a recommender is unable to make reasonable inferences concerning items or services to be recommended due to insufficient information.

In knowledge based systems this problem is avoided because there is no need for the preference profile elicitation phase. The AdvertLBS system depends on knowledge about consumer preferences and available services. The problems mentioned above with cold start

and the need of a relatively high number of users to make content-based or collaborative recommender logic work dictate the user of this model.

Other means of constructing, affirming and providing a stronger consumer preference profiles is by analysis of online activity in terms of logging and analyzing the content of user activity on the web. This might indeed provide a lot of preference related context information which can be used to extend or affirm preference profiles. This might prove to be a viable opportunity in online mobile systems.

### **1.5.2 Content Based Recommender Systems**

Content-based recommender systems attempt to provide a correlation between users and items to be recommended. This correlation is primarily established by using item descriptions and user preference profiles.

In “Beyond Recommender Systems: Helping People Help Each Other”, Terveen and Hill provide the following description of a content-based recommender system: “Content-based recommenders build on the intuition of find me things like I have liked in the past. They learn preferences through user feedback.” [4]

According to Burke [5] the definition of a content based recommender is learning user preferences based on feedback provided by the user. Burke explicates on two different forms of feedback, one explicit taste feedback (good or bad) and one implicit feedback like whether the user opened a document and read it and for how long he was involved with the document.

I will not use the content-based algorithm in the AdvertLBS as the primary advantage of this method is captured in the combination of the knowledge-based and the collaborative filtering algorithms.

### **1.5.3 Collaborative Filtering Systems**

A recommender system consists of a number of items or services to be recommended. The system also consists of a large number of users, also called consumers. In such a system it is likely, given a relatively large user base, that there will be user preference profiles which are close to identical, or at least possess a significant degree of similarity. The same similarity applies to the service rating history of the users, as we can be relatively confident that users with a common rating history will have significant preferences in common too.

The collaborative filtering approach attempts to find correlations between users with similar preferences with the intent purpose of creating a collaborative group. This group is usually referred to as nearest neighbors in literature. If we assume the user have been issued a service

recommendation and rated the service favorably. Another user with similar preferences is a likely candidate for the same service recommendation.

The actual collaborative algorithm is divided into two sub-algorithms. One algorithm is used to create the groups and to keep the groups updated. The other algorithm is used to compute recommendations based on what “peers” in the group have preference for or have rated favorably.

The AdvertLBS system includes a collaborative filtering module in the recommender logic. The main purpose of this is to complement preference profiles. It is also intended to provide the basis for some unexpected recommendations which may lead the consumer into a different path of recommendations. An example of this would be the scenario where a consumer with a preference for Indian restaurants is given a recommendation for a Thai restaurant based on a collaborative group vote and the fact that there are no Indian restaurants available at location.

### 1.5.4 Hybrid Systems

A hybrid recommender system combines several algorithms to produce a recommendation. There are advantages and drawbacks with each algorithm the hybrid solution attempts to reduce the drawbacks of using just a single algorithm. Some systems have a repository of different algorithms which may be applied based on different contextual situations.

Burke surveys a number of hybrid solutions in “Hybrid Recommender Systems: Survey and Experiments” [9]. In this paper he classifies hybrid recommenders into a number of categories is proposed. I have extracted four of these methods as being relevant to the AdvertLBS system. These methods are given in table 1.5.4 below together with a brief description for easy overview. Please refer to [9] for an in-depth description of all categories.

Hybridization Method	Description
Weighted	The scores of several recommendation techniques are combined to produce a single recommendation.
Switching	The system switches between recommendation techniques depending on the current situation.
Cascade	One recommender refines the recommendations given by another.
Feature Augmentation	Output from one technique is used as input feature to another.

Table 1.5.4 Hybridization Methods (From Burke. Ref [9])

In the weighted method the recommender logic uses several algorithms. Each algorithm produces a weight or a score. The weights are combined and averaged and the item or service with the highest weight is recommended. This appears to be a viable method as all involved algorithms, operating on different information, have a say in the final recommendation. The major problem is that some algorithms may have quantitatively and qualitatively good information and other have little information causing in imbalance.

The switching method seems to be a good solution as it requires the system to perform an analysis of the available information and the general context around the service and user before applying an algorithm. Although clever, it will also introduce a higher complexity level as the reasoning about which algorithm to use must also be performed by the system.

The cascading method is basically a process of refinement. The recommendation process is divided into stages where the first stage provides a set of rankings or weight correlating user and items. The next stage refines the recommendation provided by the previous stage and the second stage only cares with items which are not discriminated by the previous stage. This method appears to be particularly nice in terms of efficiency and in the ability to provide a stage-wise elimination of services.

Feature augmentation is based on the principle of stringing together the algorithms together by connecting output to input gates. Each algorithm produces output which another algorithms uses as input.

Burke continues to state that the most common recommender system uses a collaborative filtering algorithm combined with some other technique in order to cope with the ramp-up problem.

With this rather brief overview of the recommendation algorithms we have the necessary background to understand the design rationale behind the AdvertLBS system.

## 1.6 The AdvertLBS System

A design rationale and ambition behind the AdvertLBS system is that it shall provide a professional and concrete solution within the mobile marketing domain with the sole purpose of providing advertisement and service recommendations to users who have willingly and purposefully requested that this kind of information be pushed onto their mobile handsets.

I consider this to be a critical point which differentiates this system from many other proposed systems which uncritically provide single-minded focus on learning algorithms and employing mathematical considerations and techniques for improving the recommendation accuracy. We need to administrate two dimensions in our mind at the same time – the human dimension and the system dimension. We must also keep our priorities right and focus on the

human interaction with the system. The system should be considered an extension of the self, giving more processing brainpower and ability to purposefully navigate in a confusing landscape of information, products, and services. The system must be controlled by the user, but must provide intelligence to relieve the user from the everyday chore of administration.

The initial motivation was that AdvertLBS should be transparent in use. The motivation behind this was that most recommender systems on web work in this transparent, undercover way, by observing and analyzing user browsing habits and behavior in terms of frequency of visited items, items bought, etc. This kind of information harvesting, analysis, and inference operation result in recommendation of other items and products.

This is not the way to go with a recommender system designed to operate on the mobile platform. There are two reasons for this, first the mobile handset is in a completely different privacy zone than the web which implies that sensitivity and design must take great care to respect this privacy. Second, the system will not be allowed to spend a lot of time learning user preferences and for sure the system cannot suggest products and services out of the blue sky, hoping, in the best case, they will be interesting, and in the worst case that it will at least receive bad rating so that it can adjust its preference assumptions. People are easily annoyed, especially about unwanted events on the mobile handset.

Transparency in this context means that the system and associated applications shall operate in the background. This ambition does not imply that the user should forever be protected from having to interact with the system, but rather that it should not be necessary once the system is set up with initial registration and simple preference profiles. This is where the principle of best effort comes into play. It is in this context that the concept of “estimated recommendation accuracy” enters the picture. This simple, quantitative entity tells the user what to expect from the system in terms of the system's perceived ability to recommend relevant services. This is best effort represented as a quantity, clearly visible to the user and acting as motivational factor to improve it by actively providing more information, context, ratings, etc. to the system.

The required initial preference profile registration solves the cold start problem, briefly described in section 1.5.1. The problem with many recommender systems is that there is not necessarily personal information available and the system only learns from direct or indirect ratings provided by the user or other users. Examples of indirect rating may be the actual purchase of a product or simply a recurring pattern of interest represented by particular navigation patterns and item reviews.

As this might be a viable solution on the web it is not considered ideal in a location based mobile recommender system as there is important privacy issues involved. The privacy issues require the system to get explicit permission to retrieve and process location information as well as to provide recommendation messages. There is a lot more sensitivity related to invasion of privacy on a mobile handset than when a user is browsing the web or receiving e-



mails. The AdvertLBS system acknowledges this need for privacy and control, and requires users and service providers to register a minimal amount of personal and service information.

The AdvertLBS requires an initial registration and provisioning of initial user preferences. The level of preference information given by the user is considered to be optional. Once the initial registration and preferences are done and the application is installed on the handset, the consumer will not be required to interfere with the recommender system in terms of preference provisioning. The system will provide recommendations according to the best effort principle and will improve recommendation accuracy as the recommender logic gain momentum.

Based upon these considerations and the presented design criteria I have chosen to base the AdvertLBS recommender on a hybrid approach. The hybrid approach will use a number of recommender algorithms. Each algorithm will produce a rating level or score. There is some flexibility in terms of which algorithms may be used. This depends on how much context information is available for a given user.

## Chapter 2 – Research Methodology

In this chapter I will discuss the methodology I adopted to provide direction and focus in the work with the system.

### 2.1 Analysis of Initial Problem Statement

The initial thesis problem was given in section 1.1. The problem statement does present itself as a typical engineering research problem. The suggestion presented in the thesis description suggested a research approach which involved design and prototyping of a comprehensive solution for test and analysis.

As the scope of the project is quite broad, and based on considerations of resources available and time constraints, I have opted for a more qualitative approach and put focus on researching and discriminating solutions to challenges, and also providing the architecture and design to the system based on the stated requirements. A complete qualitative analysis which related the solutions and design decisions to the requirements are presented at the end of the thesis.

The problem statement is an invitation into an overwhelming amount of research work in the area of location based services and recommender systems. The majority of this research is focused on solutions applied to the commercial side of the World Wide Web (WWW). There are numerous recommender systems working behind the scenes in major commercial web portals, such as for example Amazon. However, when we change the setting and applicability of these recommenders to the mobile platform, most of them will fail remarkably and we need to think in another way. This paper is an attempt based on previous research, existing systems, and a few of my own ideas of how the service provider should meet the right service consumer.

### 2.2 System Vision and Requirements

As the initial problem statement is quite clear on the objectives it was necessary to elaborate and expand the concept of a context aware location based service and envisages scenarios, creates visions, and ultimately provides a set of requirements which was considered to be necessary in order to design the system.

It was indeed necessary to spend time on producing system visions. Visions provide the basis for requirements. Based on the problem statement I tried to produce visions of how a context aware location based service should work. By investigating the literature about recommender system and context-awareness I realized what kind of features and characteristics was common to these kinds of systems.

The visions and requirements were established according to the principle of “mile wide, inch deep” principle. This principle implies that I tried to identify all requirements that would be necessary to complete the established visions, but on a very high level in order to get an overview.

I present the visions and requirements in chapter 3.

### **2.3 Identification of Research Challenges**

Once the visions and requirements were established the next step was to identify and separate the standard implementation problems from the real challenges which would required a careful study of research literature.

I identified five different areas of research opportunity of both primary and secondary nature: context provisioning mechanisms, context representation models, efficient location tracking models, recommendation and matching logic, service monitoring, and service rating models. I explicate on each of these research area in many of the chapters in this paper.

The identification of research challenges enabled me to also identify the critical requirements in the system. By identifying the critical requirements I could isolate and defined steel threads which would give direction and momentum in producing the architecture.

Research challenges and solutions are described in chapter 4.

### **2.4 Solutions and System Architecture**

At this stage in the research process I had already established the research challenges areas and concrete problems which had to be solved, and identified and described the critical requirements in the system.

It is a very basic criterion in any development or research process characterized by a certain amount of uncertainty to attack the most critical issues first in order to mitigate the risks

involved. I attempted to this by focusing on the non-trivial, research related issues first to see if I could establish a solid architectural and design foundation for the system.

I reviewed and read available literature in the research areas of interest and identified a number of proposals which I aligned and measured the proposals with the requirements and disposed of most, considered adoption or adaption of others.

The final system design is realize a solution based on existing research knowledge and proposals and adaption to the specific mobile marketing system described in this thesis.

### **2.5 Qualitative Evaluation of System Design**

With a system architecture and design in place based on research, adaptation, and improvements of existing proposals, together with solutions specific to the AdvertLBS system, I did a qualitative evaluation of the system. The qualitative evaluation is concerned with showing that the requirements of the system is covered by the system design and that the system, compared to other systems in the working domain, provides solutions to problems which is either not considered or badly solved in other systems in the working domain of the application.

### **2.6 Contribution to Science**

From a scientific viewpoint is it quite clear that there have been and is currently being performed a huge amount of research on the topic of recommender systems and how location based systems can be improved and fitted into a service space consisting of users already suffering from information overload. In this respect it is of critical importance to focus on quality and not quantity. It is critical to personalize services and put the individual in control of the services he chooses to use.

Personalization is the trend in what we see in every aspect of service provisioning these days, whether it comes to personalization of TV channels or personal trainers at the gym, everything is turning slowly into personalization, a sphere of ambient and omni-present services rotating around the user. This is also the design rationale behind the AdvertLBS system.

The main purpose with this thesis, from a scientific perspective, is to take a broad perspective to describe and provide a design and architecture of a location based advertisement system which takes user knowledge and learned context into account.

There is a huge amount of quantitative research on context and recommender logic, and algorithms in academic literature. If I decided to do another implementation and test of a collaborative filtering or a content-based filtering algorithm it would probably just be another one among a million others. I did not feel it was necessary to apply pressure on that side of things. The algorithms used in these systems are more or less established, they work, and some are slowly becoming de facto tools applied to produce recommendation. It's more or less matter of customizing them to fit the purpose and domain.

I did however experience great confusion when reviewing research literature as the amount of it is quite overwhelming and rich. I was also puzzled to see that relatively few systems seem to have emerged from the computers in the lab into the actual business domain. I believe the reason for this is confusion and that research is isolated to very narrow and specific topics. This makes it difficult to comprehend system in a holistic perspective.

So, instead of spending my time implementing another collaborative-filtering algorithm and testing it, I decided concentrate my research on providing the solution of a complete push-based, context-aware location based advertisement system to provide a theoretical foundation for this kind of system.

By doing this research I quickly discovered a highly mathematical and automated trend which made me question what role the actual user should be playing in these complex and automated systems. The user seemed to be wiped of the field, like something completely irrelevant and outside the system. The system and the algorithms seemed to be the primary objects and the user the secondary, placed almost accidentally into the picture. I do consider these fully automated recommender systems viable on the Web, but they are not immediately applicable in the mobile environment.

Currently most location based services operate on thin layer of user knowledge. They are light-weight solutions. Most system takes only the consumer location into account and is primarily request-based as I described in section 1.1 about the nature of the traditional location based service. The consequence of adopting a light-weight approach to a mobile marketing system is ill-behavior in terms of intrusiveness and provisioning of irrelevant and uninteresting information to the consumer. This is ultimately harmful to both the service providers and the consumer.

Another important issue is to consider is user consent in terms of location tracking and the necessity of obtaining permission to push commercial and other kinds of information on a mobile user handset. The system proposed in this paper focus on this aspect of this kind of system.

As I've already mentioned before, but repeat because the intention must always be kept in mind, the World Wireless Research Forum states clearly the ambitions of the next generation of service provider systems in their I-Centric communication service architecture, where the

## Chapter 3 – Scenarios and System Requirements

key goals expected of future location based services is: personalization, ambience, adaptation to user and environment.

## Chapter 3 – Scenarios and System Requirements

This section describes the system visions and requirements to the AdvertLBS system.

### 3.1 System Requirement Guidelines

The AdvertLBS must be implemented according to three guidelines:

#### 1. The system shall abide to the WWRF I-centric Guidelines

The system shall be personalized, meaning it shall be an extension of the user and revolve around the user. It shall be highly customizable by the user and present, but at the same time offer a transparency mode. Which mode is prevalent is the choice of the user. The system shall improve its recommendation accuracy automatically by learning mechanisms.

#### 2. The system shall be unobtrusive in operation

Thresholds of uncertainty shall be established. These threshold levels will prevent the system from sending recommendations without a good enough recommendation accuracy estimate.

#### 3. The system shall work according to the principle of “best effort”.

The concept of “best effort” is a central term in the AdvertLBS. Best effort is understood in terms of providing recommendations which is perceived by the consumers as relevant in three dimensions: time, space, and preferences.

The user is informed about the systems perceived ability to produce sensible recommendation via the “estimated recommendation accuracy” value. This value is the concrete manifestation of best effort in the system.

### 3.2 Scenarios and Visions

In this section I present four scenarios In the next section I will identify and describe critical use cases related to the scenarios. The following scenarios describe the registration, location tracking, and recommendation process.

#### 3.2.1 Scenario #1 – Registration and First Impressions

A user (service consumer) has created a profile on the AdvertLBS web portal. She has registered a short preference profile which describes the major service categories covering her

interests or needs. She has further downloaded the AdvertLBS mobile application to her handset and is now installing it. The application installs successfully.

She starts the AdvertLBS mobile application enters username and password and is let in to the mobile application dashboard. The dashboard is a simple user interface with a recommendation message inbox, simple profile update functionality, and settings. On the dashboard there is also a status message indicating no recommendations in inbox. There is also a clearly visible recommendation accuracy estimate, expressed in percent, on the screen. The recommendation accuracy estimate tells her about the likelihood of receiving relevant service recommendation messages based on the system knowledge and context information in the system. If this estimate is below a defined threshold level the system will advice her to improve her preference profile. If the estimate is too below a minimum threshold the system will refuse to recommend services and inform the user about this. This will typically occur if the user is new and have not provided sufficient preference profile information for the system to reason about.

### **3.2.2 Scenario #2 – Advert LBS Service Profile Registration**

A clothing shop (service provider) register on the AdvertLBS recommender system. The shop adds an advertisement for the shop. It's a shop selling clothes for teenagers.

The shop register a service profile in service business area *Shopping* and service domain *Clothes*. A description of the shop, opening times, address (location) is added. The service profile is extended with a target consumer profile. The target consumer profile describes in detail the target group of the advertisement, in this case the teenagers between 16 and 20 years old. The target consumer profile is an extension which provides the service provider with a possibility to target a specific consumer group.

Eighteen year old Jill has registered in the system. Clothes are in her preference profile. Her age and the, gender, and general preference profile match with the service description and the target user profile. The match triggers the system to send a recommendation message which contains the shop advertisement and map with a route showing how to find the shop.

The shop later decides that they want to create another advertisement in the system, but this time the advertisement should include information about jeans, price, size, and brand. They use the service description template editor to create a service description template which will describe the particulars of this service. The final service profile description will be specific and will rendezvous with consumers having registered preferences which coincide with the service.



### 3.2.3 Scenario #3 – Advert LBS Service Recommendation

As a traveler John would like to know about interesting and exotic restaurants offering a cheap quality meal in areas he's currently visiting. This applies only when he's abroad and only in some isolated geographical areas. He is not interested in recommendations in his home town or places he knows well. Further he's only interested in these recommendations between 4 pm and 8 pm as this is the time he might consider eating dinner.

John creates a preference record in the AdvertLBS system. In the preference record he specifies Indian and Tibetan restaurants. He carefully selects the geographical areas where he wants to receive recommendations and specified time constraints.

As John is visiting Oslo he receives an advertisement of a Tibetan restaurant. The recommendation contains a description of the restaurant with a road description and a map. John walks to the restaurant. The system tracks him to the restaurant and since the GPS signal disappears when he enters the restaurant the system infer that John followed the recommendation.

Since John found the Tibetan restaurant delightful he pulls out his mobile phone and send rating level "Very Good" to the system. He also sends a positive response to a follow up question of whether he wants to found the recommendation useful.

### 3.2.4 Scenario #4 – AdvertLBS Learning Capabilities

An airport decides to implement an information service which will offer airline passengers on their way to the airport information about available parking spaces, the opportunity to pay the parking space by mobile phone, and if the customer is late arriving at the airport hurry it will also announce the departure gate the passenger must go to. The airport adds the airport service announcement together with a description of the service to our push based announcement service system – the advertisement can optionally be extended with a description of a typical consumer profile – let's say business people between thirty and fifty years old, owing a car, not being a taxi or bus driver, and travelling quite frequently from this airport.

## 3.3 Requirements and Use Cases

In this section I present the essential use cases which provide the base functionality in the AdvertLBS recommender. The use cases presented and described in this section are later used to identify and define steel threads for the implementation of the base prototype architecture.

The use cases presented in this section expose the research challenges present in the project. The research challenges will be discussed in more detail in chapter 4.

As it is not possible to include a complete set of use case descriptions in this paper I will only provide the use cases associated with the identified steel threads of the AdvertLBS system. The steel threads define the base architecture and functionality in the system. A detailed description of the base and alternate flows must be described in a business implementation of the system.

We will first have a look at the use case actors in the system.

### **3.3.1 Use Case Actors**

There are three primary actors in the system: ServiceConsumer, ServiceProvider, and SystemCore.

#### ***Actor 1: ServiceConsumer***

The ServiceConsumer actor is an end-user actor. The ServiceConsumer is an individual which interacts with the system in terms of providing profile, preference, and location information. The ServiceConsumer is using a mobile handset with application or interacting with the system on a web portal

#### ***Actor 2: ServiceProvider***

The ServiceProvider actor is an end-user actor. The ServiceProvider is an individual, business, organization providing services and interact with the system via web portal.

#### ***Actor 3: SystemCore***

The SystemCore actor represents the core recommender system. The SystemCore is also identified as an actor because it will use and initiate actions towards external systems in order to harvest context information, such weather, payment, geo-location, and other information.

### **3.3.2 Service Consumer Use Cases**

The ServiceConsumer actor represents a single user (consumer) interacting with the SystemCore.

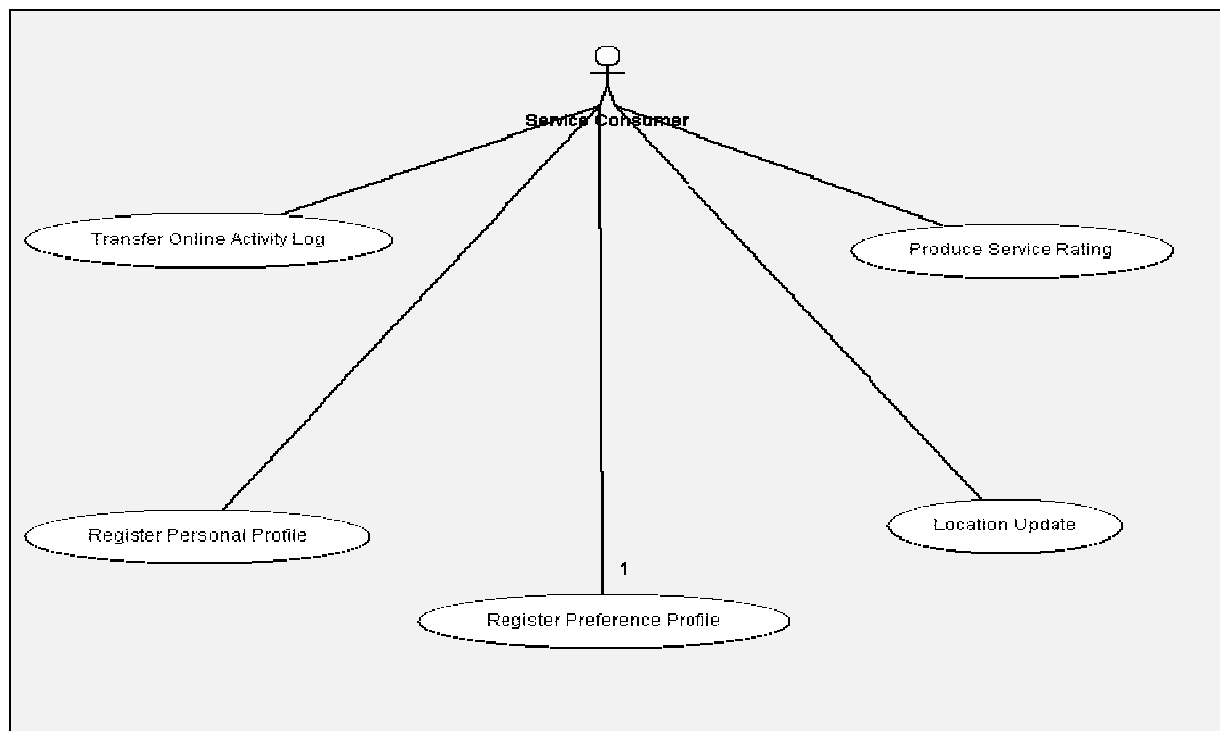


Figure 3.4.1 Service consumer use case model

I will now describe in detail the use cases related to the service consumer as given in the use case diagram in Figure 3.4.1 above. In this report I will only describe a brief version of each use case which contains a description, a thesis justification, and a brief description of the basic use case flow.

I have added detailed descriptions with basic and alternate flows, pre- and post-conditions in appendix A.

### **Use Case #1 – User Register Personal Profile Using Web Portal**

#### **Brief Description**

This use case enables the service consumer to register a personal profile using the AdvertLBS web portal.

#### **Thesis Justification**

It is necessary to establish a service consumer profile to be allowed to use the system. Also, the registration will provide the system knowledge which will be used.

#### **Summary of Basic Flow**

The user loads the AdvertLBS web portal in a browser and clicks a “Service Consumer Registration” link to register in the system. The user is redirected to the registration page and registers personal information. The user receives an email with a registration confirmation link

which must be used to confirm the registration. The user will be provided with a username and password. The user is allowed to log in to personal profile management account.

Personal registration profile is stored in the system database.

### **Use Case #2 – User Register Preference Profile Using Web Portal**

#### **Brief Description**

This use case enables the service consumer to register a preference profile using the AdvertLBS web portal.

#### **Thesis Justification**

It is necessary to establish a service preference profile in order to enable the system to immediately infer correlations between services and users and thereby make recommendations with a certain confidence.

#### **Summary of Basic Flow**

The user log in to the AdvertLBS system using username and password. The user is redirected to the dashboard of her own personal web portal account. The user selects “Register Preferences” from the menu and is redirected into the preference profile editor. They user specifies service business area, domain, category. The user may add a list of keywords which represents her interests. The user may also select a service description record from a list of templates within the service category. The service description record provide the user with the opportunity to specify structured preferences of very detailed products or services within the service domain. The user registers the preference profile.

### **Use Case #3 – Transfer Location Update from AdvertLBS Mobile Application**

#### **Brief Description**

This use case enables the service consumer mobile application to transfer location coordinates to the AdvertLBS system.

#### **Thesis Justification**

Location is the most important context information element in a location based service. In order to ensure the precision of the system it is necessary produce a location update model which balances the regular need for updates with the elimination of not needed updates.

#### **Summary of Basic Flow**

The mobile application transfer location coordinates based on a location update model and policy. The location coordinates are fetched from a GPS device in the mobile handset and

consist of coordinates, longitude and latitude, possibly speed and altitude. The location update is transferred to the system.

The system is aware of current user location and each location update triggers a pre-analysis stage in the system to decide if there are relevant services in the area.

### **Use Case #4 – Rate a Recommended Service**

#### **Brief Description**

This use case enables the service consumer to rate a recommended service and provide feedback on the actual recommendation, using the mobile application.

#### **Thesis Justification**

A service rating provides the necessary corrections to consumer recommendations, and it is the primary fuel of some parts of the recommender logic. This applies in particular to content-based and collaborative filtering mechanisms if employed in the recommendation logic.

#### **Summary of Basic Flow**

The user selects the recommendation and select “Rate service” from the menu. The user is presented with the following rating levels: very bad, bad, good, very good, excellent. The user sends the rating and is at once asked if she found this rating useful or helpful. The user select yes or no and the rating is transferred to the system.

### **3.3.3 Service Provider Use Case Model**

The ServiceProvider actor represents a service provider interacting with system core. Figure 3.3.3 below show the use cases associated with the service provider.

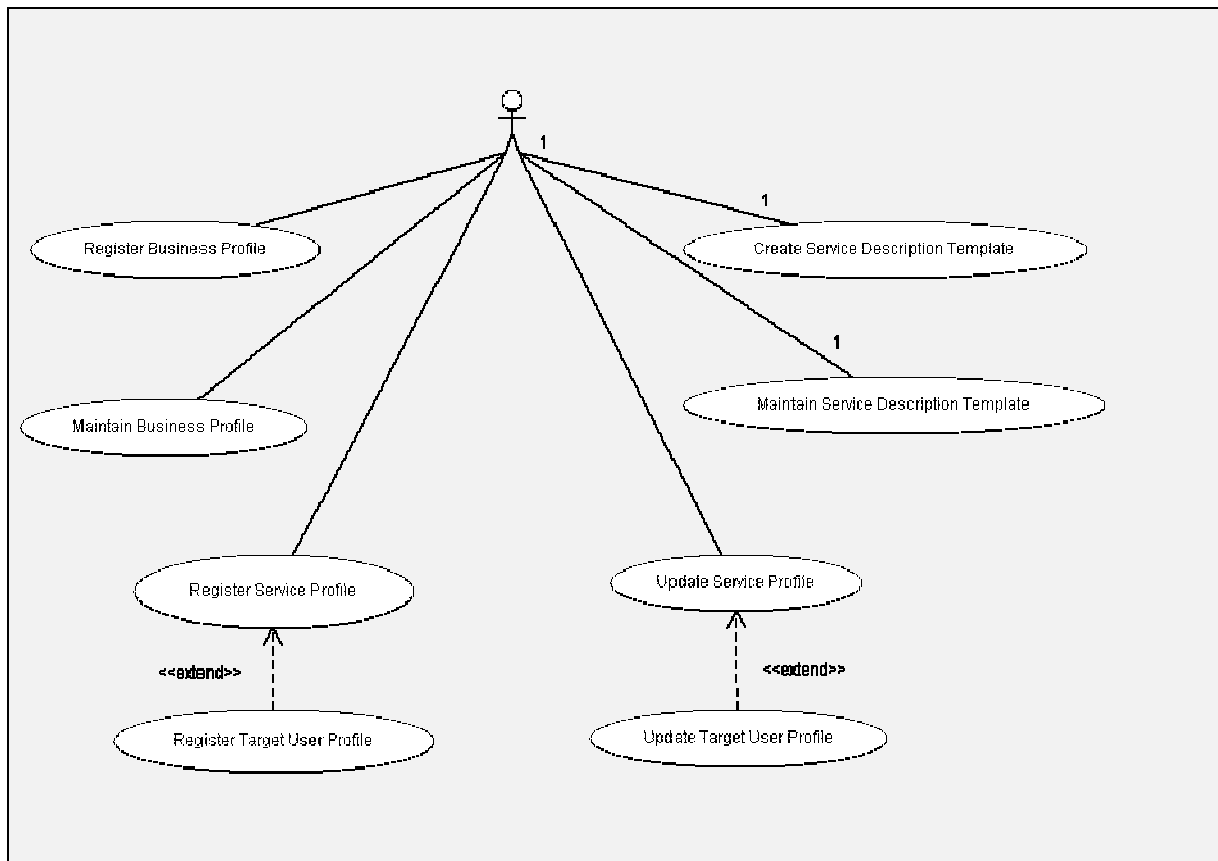


Figure 3.3.3 Service provider use case model

I will now describe in detail the essential use cases related to the service provider as given in the use case diagram in figure 3.3.3. In the report I only describe a brief version of each use case in terms of a use case description, a thesis justification (rationale for using it in the thesis work), and a brief description of the basic flow.

***Use Case #1 – Service Provider Register Business Profile on Web Portal***

**Brief Description**

This use case enables the service provider to register a business profile in the AdvertLBS system.

**Thesis Justification**

Service providers register business information which is required to be allowed to add service descriptions.

**Basic Flow**

Service provider load the AdvertLBS web portal in browser and click a “Register as Service Provider” link to register in the system. The service provider is redirected to the registration page and register business information. Service provider receives an email with a registration

confirmation link which must be used to confirm the registration. The service provider will be provided with a username and password. The user is allowed to log in to profile service management account.

### ***Use Case #2 – User Register Service Description Profile on Web Portal***

#### **Brief Description**

This use case enables the service provider to register a service description profile in the AdvertLBS system.

#### **Thesis Justification**

The service description profiles represent the essential entity in the system in terms of knowledge representation and recommendation logic.

#### **Basic Flow**

The service provider log in to the AdvertLBS system using username and password. The service provider is redirected to personal web management web area. User select “Add service description” link and is redirected to the service description profile registration page. The service provider selects service domain, service category, and a service description template and provides service information. Service provider registers service.

The system stores service description in database.

### ***Use Case #3 – Service Provider Create Service Description Template***

#### **Brief Description**

This use case enables the service provider to create a new service description template in the AdvertLBS system.

#### **Thesis Justification**

The service description profiles represent the essential entities in the system in terms of context representation and recommendation logic. It is a vital tool to be able to customize the templates in order to provide good service descriptions.

#### **Summary of Basic Flow**

The service provider selects the service description template editor. A service template has any number of member elements. Each member element is given a name and type.

### 3.3.4 AdvertLBS SystemCore Use Case Model

The SystemCore actor represents the AdvertLBS core server system. The SystemCore actor interacts with external services.

Figure 3.3.4 below show a selection of use cases related to the functionality of AdvertLBS system core applications.

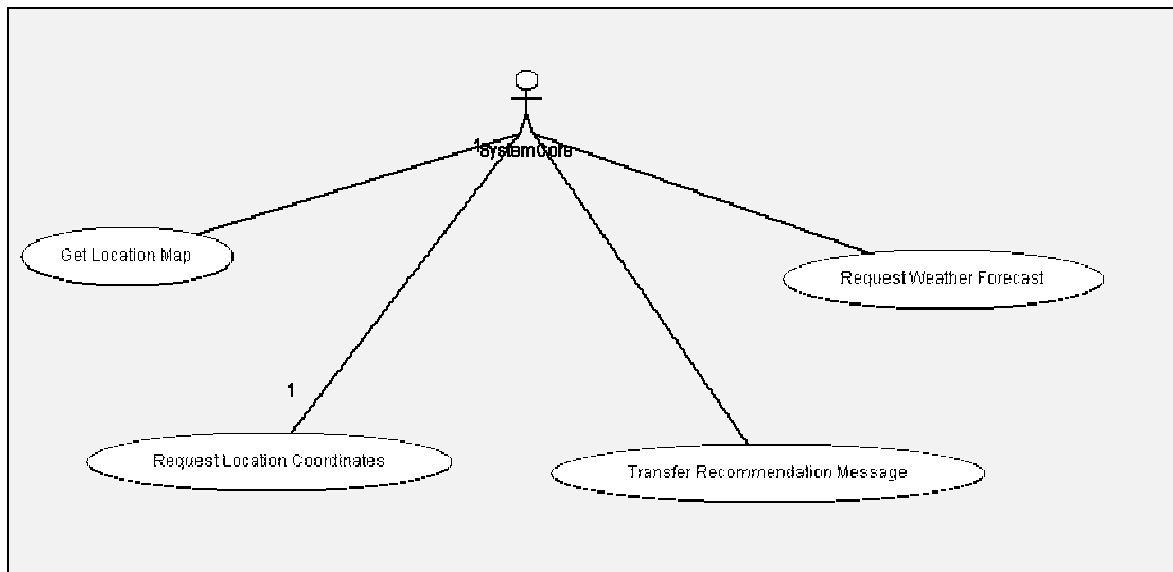


Figure 3.3.4. SystemCore use cases.

I will now describe in the essential use case related to the service core as given in the use case diagram in Figure 3.3.4. In this report I only describe a brief version of essential use cases in terms of a use case description, a thesis justification (rationale for using it in the thesis work), and a brief description of the basic flow.

#### ***Use Case #1 – AdvertLBS SystemCore Transfer Recommendation Message***

##### **Brief Description**

This use case enables the SystemCore to produce and send a recommendation message to the service consumer.

##### **Thesis Justification**

The purpose of the AdvertLBS recommender system is to produce and transfer service recommendation to consumers.

##### **Basic Flow**



SystemCore execute recommendation logic to produce a recommendation. The recommendation is sent to the user.

### ***Use Case #2 – AdvertLBS SystemCore Request External Context Information***

#### **Brief Description**

This use case enables the service provider to request external context information from the system.

#### **Thesis Justification**

In order to establish a rich context around the service consumer it is necessary to be able to require information from external sources. An immediate source is weather forecasts.

#### **Summary of Basic Flow**

SystemCore fetch external contextual information by implementing service specifications and store fetched data in a specified format in database.

## Chapter 4 – Research Challenges

The previous chapter I presented system visions and produced essential requirements in the AdvertLBS system. In this chapter I will identify and describe key research challenges associated with the system visions and requirements.

There are a number of challenges in the project and they are mainly related to the following areas:

1. Context provisioning
2. Context representation
3. Location tracking and harvesting
4. Recommending logic and algorithms
5. Service rating models

I will in the next sections discuss these challenges in order to get the necessary context and understanding of essential concepts used throughout this paper. It is important to realize that there has been a vast amount of research in each of these fields and it is the purpose of this thesis to identify the best solutions described in literature for the AdvertLBS system.

### 4.1 Knowledge and Context Provisioning

In order to provide a high level of recommendation accuracy the system need access to a wide range of consumer and service related context information. I will briefly touch these issues in this section to provide necessary context.

In literature contextual information is normally divided into knowledge and context information. I will follow this established division in the AdvertLBS system.

The distinction between knowledge and context is important. In the following knowledge is defined as information which is provided by the consumer and provider to the system. Context is defined as information obtained by the recommender from external source, such as location, weather data, etc.

### **4.1.1 Static System Knowledge**

The knowledge information is what the service consumer and provider supplies in terms of filling in registration, preference, and service forms and submitting it to the system. The registration is mandatory for both service providers and consumers in AdvertLBS.

The preference profile registration is also mandatory in terms of defining service domain and categories. The user is not required to create extensive preference profiles.

The challenges related harvesting consumer knowledge a balance between the kind of information the service consumer would be happy about sharing and what is considered to be private and non-shareable with a system. This problem is closely related to the topic of trust and security which is I discuss in chapter 6.

#### ***Service Consumer Profile***

The service consumer profile is mandatory and defines static information such as name, address, civil status, gender, age. During registration the user is also required to accept a service consumer agreement which states issues related to legal issues and confirmation related to location tracking and of pushing service recommendations onto the mobile handset.

It is the aim of the AdvertLBS system to be personal tool for a mobile user. This implies a maintaining a very high level of quality in the system. An anonymous profile would not support this goal. Another reason is of a more private character. It is vitally important to get permission to receive and process location coordinates and to be allowed to push advertisement messages to the handset by the actual user of the mobile handset. An anonymous profile would not be sufficient and could cause legal issues if not handled appropriately.

#### ***Service Consumer Preference Profiles***

The service consumer preference profile is also considered mandatory and describes the user's preferences within the domain area of the service recommender. In the case where the domain area is selected in the AdvertLBS the consumer could specify an interest in shopping and electronics equipment. This profile is mandatory on a high service area/domain level, but strong incentives should be provided in order to get the consumer to create detailed preference profiles, as this will improve the recommendation accuracy.

The provisioning, representation, and processing of consumer preferences are described at great length in this paper and is partly based on previous research and partly on my own considerations to what might have the potential to work in AdvertLBS system.

### ***Service Provider Business Profile***

The service provider registers a business profile in the system. In order to use the system the service provider must register a business profile. It is only possible for officially registered businesses, organizations or individuals to register as service providers. In other words, only professional actors in the market can use the system as a marketing channel.

The service provider is required to confirm a service provider license, stating the responsibilities of the service provider and of the AdvertLBS system.

During registration the service provider is presented with various payment options. The subscription scheme is however not considered a major issue in this thesis as this is a business decision and as such not a research challenge.

### ***Service Provider's Service Profiles***

A service provider may register any number of service descriptions. A service description is as the name implies a description of a service. In the AdvertLBS system a service description translates directly into an advertisement of a product, a retailer, or a service.

All service description profiles are based on service description templates (SDT). A concrete instance of a service description template is called a service description record (SDR). There are a limited amount of predefined SDT's in the system which the provider can use to define services. The service provider can also customize or create new SDT's to fit their need and purpose.

## **4.1.2 Dynamic Context**

Dynamic context information is constantly changing. The system is responsible for producing, tracking, and representing the dynamic context information. In this section I will describe the dynamic context information dealt with in the system.

### ***Service and Recommendation Ratings***

Service consumers produce ratings on service content. The service content rating tells the system of the quality of the service the system recommended. This kind of rating provides the system with knowledge about services and will be used to by both recommender logic and service monitoring to improve the quality of recommendations as well as to improve the total

quality of the services in the system. The rating is used in the content-based and collaborative filtering algorithms.

The recommendation rating concerns the actual recommendation, not the service, and is a way to adjust consumer preference profiles. The recommendation accuracy can be as simple as a question to whether the consumer found the recommendation useful or not.

### ***Service Usage History***

Consumers registered in the system will have a service usage history with associated service ratings. It is likely that many consumers will not bother with providing a rating on every service recommendation. It is necessary to find a method which will let the system automatically infer, beyond reasonable doubt, that the consumer used the received recommendation. This could be possibly be realized by providing feedback to the system when user open and read recommendations and use location tracking to see if the user went to the recommended service location.

The service usage history is also used in connection with the formation and maintenance of collaborative groups.

### ***Location Tracking***

Location is the most important context information in the system. It is vitally important that we find a clever location updating model. There are a few challenges associated with location updates which must be resolved in order for the system to be of service to a large number of consumers. I will briefly review some of these issues now and later provide solutions.

A major concern about mobile handsets providing location updates is that that it will overload the system in terms of processing resources when the number of users becomes high enough. The primary reason for this concern is that a location update will trigger the recommendation logic to identify potential services in the neighborhood, and this process will require a fair amount of processing power. It is important to find models which only will transfer significant location updates. So, a method to reduce the number of location updates per consumer without compromising the accuracy of the system is required. Already we can see that the mobile handset must implement some logic in the location updating model.

Another issue is associated with the drain of mobile handset batteries by a continuously operating GPS device. This is a difficult problem as the mobile handset requires a continuous stream of location updates from the device in order to decide if a location update should be transferred to the system. It might turn out difficult to implement some regime to turn the GPS device on or off. We will look into this problem when discussing the location update model in later chapters.

### ***Other Context Sources***

The previous sections described system knowledge and context elicitation related to service and consumer activity. In this section I will discuss a few other sources of context information.

#### **Weather Forecasts**

Weather forecasts represent important information related to a number of services. A weather forecast let the system reason about weather, wind, and temperatures. As the system is not capable of producing this kind of information on its own accord it is necessary to harvest weather information from external sources. In the case of weather a meteorological office providing a web services or and FTP server would provide a viable solution.

A question related to weather information is how it should be harvested. We might consider fetching it in real time (when it is needed) and possibly caching it for defined duration. This would probably be inefficient in terms of processing time and could result in a queue of requests towards the weather service. Another and probably better strategy would be to harvest weather continuously over areas populated with services. As the weather can change by the minute a weather forecast validity must be relatively short.

The actual format and representation of the weather forecast is decided by the weather service and the system must implement parsers to resolve and extract relevant information.

#### ***Route learning***

People move in regular and predictable patterns. People go to work in the morning and go back home in the evening and pretty much at the same time of day. Patterns emerge and disappear. The system is capable of analyzing location data and produce common routes and thus be capable of predicting where users will be at what days and times. The route learning could also be aligned with the list of service recommendations in order to infer whether user visited recommended service location.

I will not go into the details of solutions to the route learning problem, but only mention it as an opportunity for system improvement.

#### ***Online activity logging***

An approach to gather context information about a user is to harvest and analyze information related to online activity in terms of web browsing habits. In this way the system can learn about regularly occurring keywords, URL's and topics of interest. The system can use this

information to weight preferences or to establish new user preferences. A human being is a dynamic entity and sometimes moves in unpredictable directions. Online monitoring might detect this and establish new recommendation paths.

This is particularly relevant context provisioning related to the content-based filtering recommendation algorithms as this algorithm work with auto-generated user profiles based on ratings, service history, and other learning-related context information.

It is off course necessary to obtain permission from the user to harvest and transfer this information to the system for analysis. This matter is strongly correlated to the users perception of the system as a trustworthy, secure, and serious actor.

### **4.2 Context Representation**

The context information must conform to a representational form in the system. Literature describes different ontology description languages, such as W3C Web Ontology Language (OWL) used by some recommenders. Other strategies have also been employed, such as W3C Resource Description Framework (RDF) or by using proprietary ontology's.

The AdvertLBS is a low-profile and compact LBA intended to be used in business areas for efficient and personalized mobile marketing. The system is not all-encompassing and with ambitions of incorporating a centralized repository of context information for all kinds of location based services.

On these considerations I have opted for a context representation in XML, and all definitions of all XML structures are defined in XML Schemas. I go into details on the representation of context information in chapter 5.2.4.

### **4.3 Recommender Logic**

The purpose of the recommender logic is to produce relevant service recommendations to the consumers. The data used by the recommendation logic is produced by the knowledge and context provisioning mechanisms.

As I mentioned in the in the introduction part of this thesis there are a number of different algorithms. The AdvertLBS use a hybrid approach to service recommending.

The hybrid solution applied in the AdvertLBS system is based on three established types of strategies used in most recommender algorithms on the web: knowledge based, content-based,

and collaborative filtering. I have also included a geographical analysis module to make sure location is analyzed and used to perform preprocessing of user and service locations in order to obtain maximum benefit of location context.

### **4.4 Service Monitoring**

It will be necessary to design a service monitoring model. Service monitoring is of crucial importance in order to secure a well-functioning recommender. Services in the system will get old and they will be of different quality. Other services will probably not be according to the regulations and rules in the system (containing obscenity, sexually explicit advertisements, etc) and should be blacklisted.

It is important to keep the repository of services updated and fresh in order to provide high quality recommendations. The model must also ensure the communication with service providers in terms of statistics and rating levels associated with the registered services.



## Chapter 5 – Solutions and Design

In this chapter I will present the suggested design and provide solutions to the research challenges associated with the system.

I intend to define the steel threads in the system. The steel threads identify the most critical or important paths of execution in the system. It is considered important to establish the threads in order to establish confidence in architecture and solutions.

I will discuss solutions to the research challenges associated with the system.

### 5.1 Steel Threads

In this section I describe system steel threads. The set of identified steel threads implements the base system architecture and functionality and ensure that all critical aspects of the system functionality have been covered. This is a common risk reduction technique employed in software design and is in same manner appropriate in this context to provide confidence in the solution.

I have identified 6 steel threads.

#### 5.1.1 Steel Thread #1 – Create Profiles and Service Descriptions

##### **Goals**

1. Establish and represent service taxonomy and knowledge representation
2. Represent and make service consumer and service provider context information available in AdvertLBS system.
3. Establish communication between web server and system core.

##### **Scenario**

1. Service consumer produces personal and preference profile on the web portal and transfer to system.
2. The service provider creates business profile and service description profiles and register in the system.

##### **Result**

Static knowledge information is readily available for the hybrid recommender logic.

### **5.1.2 Steel Thread #2 – Transfer Location Coordinates to System**

#### **Goals**

1. Ensure that location updates is transferred to the system successfully and according to the established location update model
2. Ensure that geographical area of interests filters work on mobile application and in the system.
3. Establish communication session between mobile application and system core.

#### **Scenario**

A consumer set up a communication session with system core front-end. Consumer transfer location coordinates. Depending upon the location update model the session is removed or kept active.

#### **Result**

1. Location update model established.
2. System receives and store location coordinates.

### **5.1.3 Steel Thread #3 – Dynamic Context Provisioning**

#### **Goals**

1. Produce content based consumer profile based on ratings, service history, online activity monitoring, and route learning
2. Produce and maintain collaborative groups of “similar” users.
3. Harvest weather forecasts.

#### **Scenario**

1. Service consumer provides service and recommendation ratings. System receives, analyze, and compute average ratings.
2. Groups of similar users are associated in collaborative groups based on preference profiles.
3. Weather is harvested from weather services. The weather is harvested continuously in areas where there is a large population of consumers.

#### **Results**

Dynamic context is readily available for the hybrid recommender algorithm.

#### **5.1.4 Steel Thread #4 – Service and Recommendation Rating**

##### ***Goals***

The goal of this steel thread is to produce, analyze, and store service and recommendation ratings received from consumers.

##### ***Scenario***

1. A consumer rates a service on a scale from bad to excellent and transfers the rating to the system.
2. A consumer rate a recommendation by answering positively or negatively.

##### ***Result***

1. Service associated with rating.
2. Consumer's content-based preference profile updated.

#### **5.1.5 Steel Thread #5 – Service Hybrid Recommender Logic**

##### ***Goals***

The goal of this steel thread is to trigger the hybrid recommender algorithm. This can be performed or implemented in 4 steps:

1. Recommendation based on geographical analysis of user and service.
2. Recommendation based on match between consumer preference profile and service profile
3. Recommendation based on content based filtering algorithm
4. Recommendation based on collaborative filtering algorithm
5. Recommendation based on hybrid algorithm (combination of all algorithms)

##### ***Scenario***

A location update received from a consumer trigger the matching algorithm. All modules or algorithms in the hybrid recommender logic contribute to the final recommendation message issued to the consumer.

##### ***Result***

For each algorithm in point 1 to 4 a list of services which match the services are produced. A score is associated with each service on the list.

For the hybrid algorithm a total score is computed from averaging the output from the constituent algorithms and the service with the highest score is recommended.

### **5.1.6 Steel Thread #6 – Service Monitoring**

#### ***Goals***

The goal of this steel thread is to establish a service monitoring model.

#### ***Scenario***

A location update from a consumer triggers the hybrid matching algorithm. The collaborative-filtering module

#### ***Results***

A list of services is produced.

## **5.2 Knowledge and Context Provisioning**

In this section I will discuss the solutions to the context provisioning framework in the AdvertLBS recommender system.

### **5.2.1 Knowledge Provisioning**

The primary means of harvesting knowledge about users in the system is by allowing the user to specify personal preference. This applies in all areas of recommender systems, but in particular for systems giving recommendations in privacy sensitive domains, such as in a mobile environment. The AdvertLBS system has therefore opted for an initial registration of preference profiles. Other preference elicitation mechanisms will come into play at a later stage in order to improve the recommendation accuracy.

I will discuss the manual profile registration and service rating model in this section. I will go into details of what kind of information must be provided in order to get information from the user which will maximize the ability of the recommender logic to provide good

recommendations. Other relevant information can be studied in detail in section where the backend database architecture and tables are described in chapter 5.2.7.

**Service Customer Profile Registration**

The service consumer needs to register a personal profile in the AdvertLBS system. This personal profile contains both mandatory and optional information elements. I will now describe the personal profile and explicate on a few important elements.

The consumer registration does not require that the user disclose her identity in the public. The identification is only used internally in the system An identification of the user provides more credibility to the system in terms of responsibility and better chances of receiving credible service ratings. Identification might also be used to induce consumers to improve their preferences, recruit other users, provide more service ratings, maybe in return for some kind of rewards or gifts. There a numerous possibilities to stimulate the use of the system.

As location tracking is questionable from both a legal and ethical point of view it is necessary to inform the user and explicitly request permission to receive and use location coordinates produced on the mobile handset in order to produce recommendations. In the AdvertLBS the consumer is requested to read and sign a consumer contract which permits the mobile application to transfer location coordinates to the system and consequently that the system is allowed to send recommendation messages to the consumer. The contract also states the responsibilities of the system in terms of privacy of information and security. The system will not allow the user to register unless this contract is agreed to.

Table 5.2.1 a) summarize some of the most important information obtained from the user, and highly relevant to recommender logic, in the personal profile registration

<b>Information Element</b>	<b>Description</b>
Age	Age of the user. Age is an important service and product discriminator.
Gender	Gender of the user. Gender is an important service and product discriminator.
Civil status	Civil status of the user.

Table 5.2.1 a) Recommender logic relevant consumer profile information elements

**Service Consumer Preference Profile Registration**

It would be entirely possible to implement a fully automatic learning machine that would learn about user preferences also in a mobile environment. This is however a more feasible solution for recommenders on the web where the user visit web sites, download documents, browse products and items, etc. On a mobile handset this kind of activity is not that common and it is likely that the time used to build a credible preference profile would require too long time to become effective in terms of providing relevant and useful recommendations.

The AdvertLBS system uses a service taxonomy to register services. The same taxonomy is used by consumers to define preferences. A preference profile consists of a specification of the service business area of interests, the service area domain, service domain category, and possibly a service category description record to define specific interests and needs. These elements are outlined in table 5.2.1 b) below. The service taxonomy is described in detail in chapter

<b>Information Element</b>	<b>Description</b>
Service Area	Business area.
Service Domain	Domain within the business area
Service Category	Category within the domain.
Service Description Record	Detailed service description record.

Table 5.2.1 b) Consumer preference profile elements

This service taxonomy makes the AdvertLBS generic in terms of service business areas it is configured to operate within. In the area of service recommender it is common to specialize within a narrow business area, such a shopping, travel, movies, music, etc. The AdvertLBS allow this specialization, but is also capable of representing multiple business areas at the same time. A few examples serve to illustrate the service consumer preference profile registration.

**Example 1**

**A consumer wants to receive recommendations about Nikon single-lens reflex cameras.**

Preference Profile

Service Area: Shopping

Service Domain: Electronics

Service Domain Category: Photo and Video

Service Category Description Record:

Camera: Nikon

Price-Range: 3000 – 5000 nok

Type: Reflex

Figure 5.2.1 a) Example 1. Service preference profile example

In example 1 the consumer is very explicit and is looking for a Nikon reflex camera in the price range from 3000 to 5000 NOK. There are no geographical restrictions or time restrictions in the preference record.

Here is another example which introduces temporal and geographical constraints in the consumer preference profile.

**Example 2**

**A consumer wants restaurant recommendations, either Indian or Chinese.**

Preference Profile

Service Area: Food

Service Domain: Restaurants

Service Domain Category: Indian, Chinese

Time: Friday, From 1600 to 2000

Time: Saturday, From 1900 to 2200

Geographical Area: Oslo, Arendal, Stavanger

Figure 5.2.1 b) Example 2. Service preference profile with geographical temporal constraints

In this example the consumer wants to receive recommendations for either Indian or Chinese restaurants, but only on Friday between 1600 or 2000 and on Saturday between 1900 and 2200. The consumer has put some geographical constraints in the preference profile as he only wants to receive recommendations when he is in Oslo, Arendal, or Stavanger. In the system the geographical constraints would be represented as boxed or by polygonal regions defined by longitude and latitude coordinates.

As we can see from the examples it is pretty much up to the consumer to create preference profiles which will provide him with good recommendations. A preference profile can be extremely simple or it can be extremely complex. This freedom to influence and customize the system is considered important in terms realizing the personalization element referred to in earlier sections. This does not preclude the system from learning from experience and automatically produce consumer preference profiles, or to draw inferences related to what the collaborative group says. These are complimentary to each other.

***Recommendation and Service Ratings***

It is very important to encourage the user to provide service and recommendation ratings. The ratings are the primary key to learn user preferences.

On a mobile platform it might prove quite difficult to get enough ratings. It is not possible to recommend a lot of services to the consumer in order to learn user preferences. This is what



literature refers to as the cold start problem. It is only over time the ratings are going to give significant information about consumer preferences. In AdvertLBS this problem is solved by allowing the consumer to create preference profiles.

The user is encouraged to provide ratings on recommended services. A service typically represents a concrete object which might be a restaurant, a shop, a product, something substantial which the user have been interacting with.

As it is not possible to conclude that the actual recommendation was according to the taste of the user based on the service content rating it is important to receive ratings on the actual recommendation. This must be done in a clever way, preferably in combination with the service rating operation. There can be several ways to obtain this information. In AdvertLBS this is can be solved simply by asking the user a simple question: “Did you find this recommendation useful?” The user is given two answers, yes or no. User select yes or no and ratings are submitted to the system. If the recommendation rating question is given in associations with a service rating it is likely to be done by the user.

In terms of the technical aspects of the recommender logic the ratings are of importance for a well-functioning content- and collaborative filtering algorithms.

In association with a users service history we can hope that the consumer provides ratings of the services he consumes, but we should not count on it. The recommended service together with a rating would over time provide an excellent basis for a system generated consumer preference profile. However, we should not expect the user to contribute with ratings on every service recommendation, so in most cases the system will not know if the recommendation was good or bad.

In order to solve the likely problem of a relatively low frequency of service ratings it is necessary to apply other means and methods to establish credibility to the consumer’s content-based preference profile. I will describe a few indirect methods which will provide some information about a service and if the consumer used the recommended service.

Given that the system issues a recommendation to the consumer. The consumer read the recommendation and decides to try it out. The system tracks the location of the user close to the recommended service. Depending upon the time between the closest point to the service and the disappearance of the GPS signal we can infer with a reasonable level of certainty that the user actually visited the service location This is used by the recommender to confirm a preference element.

### **Rating Model**

The service rating model is based on a range from very bad, bad, good, very good, and excellent. These ratings are represented as integer values in the system, from 1 to 5. Average ratings are continuously computed for each service and stored in the service profile record in the database. It is possible to provide a brief comment with each rating. The comments are are

as such not something to be used by the system, but submitted, together with the rating levels and statistics associated with services, to the service providers as it might contain hints to improvement of services.

In order to prevent consumers to actively try to improve a given service based on false premises, such as friendship, own business, or some other illegitimate reason which could trick the system to recommend bad services, each consumer may only contribute with one rating per service. However, the consumers have the opportunity to modify the rating provided. There are no limitations to the number of times the user can modify the rating.

### **The Expert Rater**

In any domain there will be experts. There will be restaurant experts, shopping experts, electronics experts, etc. The definition of the term expert in the context of the AdvertLBS system is a consumer (user) having provided ratings regularly within a certain service domain/category, and over an extended period of time. The expert rater is identified in the system and is given a stronger influence in the collaborative filtering algorithm than non-expert consumers.

### **Online Activity Logging**

Smartphone's and advanced mobile handsets with suitable displays and web-browsers allow the user to browse web sites. Logging and analyzing the users' online activity is most likely to provide strong leads to user preferences. This is of course another issue which the user must be made aware of and give permission to.

Most browsers save bookmarks and recently visited sites in the file system. It would be possible for the mobile application to collect this information and transfer it to the system core for analysis. Regular analysis of recently visited web sites would provide indications of user preferences.

With access to URL's the context provisioning framework would be able to fetch web page content for text analysis.

## **5.2.2 Context Provisioning**

As we have now discussed the knowledge provisioning scheme used in AdvertLBS we will now have a look at automatic context provisioning in the system. Knowledge based systems would probably in most cases be sufficient if we could rely on each user's interest and participation in producing detailed and qualitatively good preference records. This is however not something to be taken for granted. It is more likely that the majority of users will not

provide good enough preference profiles. This is however resolved by learning and collaborative algorithms implemented in the system.

Even though the system is customer-oriented and highly controllable by the user, it is also a prime motivation to eliminate user interaction as much as possible. It was based on these considerations found necessary to provide other mechanisms in order to improve consumer profiles automatically and thereby also improve the entire recommendation process.

In this section I will discuss issues related to dynamic context elicitation mechanisms and I will start with the most important context element in any location based service, geographical location.

### ***Geographical Location Update***

The location update transferred from the mobile handset to the AdvertLBS system represents the most important piece of dynamic context information. The location update tells the system where the consumer is currently located. The system is able to identify a set of services located around the consumer. This will effectively reduce the number of services to consider during the matching process between service profiles and consumer preferences. In areas of heavy service populations there might still be a quite a lot of services to consider, for example in a city. This will also depend on the proximity settings of the consumer.

Different research papers discuss various location update models. Kupper and Treu [7] investigate and present a number of location updating strategies. I will briefly mention these strategies to provide background behind my selection of three for the AdvertLBS system.

Table 5.2.2 a) provides an overview of the location update strategies presented in their paper.

<b>Strategy</b>	<b>Description</b>
Query	The system request position on demand from mobile device.
Piggybacking	Position data is included in regular messages from the mobile handset to the system.
Immediate	An update is triggered each time the position changes
Periodic	An update is triggered each time a pre-defined time interval elapses
Distance-based	Mobile device compute distance between last and previous position. An update is triggered if the distance exceeds a predefined distance threshold.

Zone-based	An update is triggered if the mobile device enters or leaves pre-defined zones. A zone can be defines as a point, circle, line, or a polygon.
------------	---

Table 5.2.2 a) Location updates strategies (from Kupper and Treu [7])

The query strategy does seem promising from the AdvertLBS point of view as the system is aware of the distribution of services and has immediate knowledge about the distance between services and consumers.

The piggybacking strategy is of no use in AdvertLBS as there are no regular messages moving from the handset to the system, except the location update message itself, where the location update could be piggybacked.

The immediate strategy will be overkill in terms of overloading the system with unnecessary amounts of location updates.

The periodic strategy is possible, but not very helpful since we have to take movement and speed into consideration in the location update model. A consumer moving on the freeway could be way past a service that would otherwise have been recommended but failed to do so because the timer hadn't elapsed and transferred a location update to the system.

The distance-based strategy seems promising as it will take speed into account.

I will now, based on this brief consideration of updating strategies, present the location update strategies selected for the AdvertLBS system.

### **The AdvertLBS Location Update Model**

Consumer location is fetched from a GPS device in the mobile handset. It is the responsibility of the AdvertLBS mobile application to request GPS coordinates from the device, process it, wrap it up in a message and transfer it to the system.

The location update model is divided into three strategies: 1) geographic processing, 2) distance-based strategy, and 3) query strategy. I will explain each of these strategies and their combined effects.

It is very important that the handset contribute with a slight amount of geographical pre-processing before the location update is transferred to the system. The reason for this is to offload the system from a lot of unnecessary processing of location coordinates which in most cases will amount to no recommendation. This is where the concept of geographical areas of interest comes into play.

The concept of geographical areas of interest is important as this can be defined by the consumer during registration of preference profiles. A consumer can select an area where he/she wants to receive recommendations, or alternatively select areas where he/she does not want to receive recommendations. This information is then transferred to the mobile application and stored in the consumer handset application. Location updates are only sent from the handset when the user is within the geographical areas of interest.

The geographical area of interest is however not sufficient as most consumers will not bother to define these areas but will operate with the default, which could be the country they are currently located in or even the whole world for that sake. We need other mechanisms to reduce the number of location updates.

In AdvertLBS the adopted default location update strategy is distance based. A new location update is sent when the distance between the last location update and the previous location update exceeds a threshold value. The threshold is defined to be a dynamic entity which depends on the service population in the area where the consumer is located. To take advantage of the dynamic distance threshold we need to introduce yet another location updating method, the query method.

The query strategy is quite suitable in this respect as the system is capable of doing light-weight analysis of the distribution of services, user location, and direction of movement. When the system query the mobile handset the effect is primarily to increase or decrease the distance-based threshold. This information is used to request the mobile handset to relax or intensify the location update frequency. In this strategy other factors will come into play, such as when user is within an area where there are only previously recommended services, or the user has already received recommendation.

### **GPS Location Log**

Even when location updates are not transferred to the system the mobile application can be configured to produce a location log. The location log can be updated on an regular basis. The location log is regularly transferred to the system for analysis and route learning. The location log is likely to reveal regular patterns in movement and can be used to isolate a subset of services in the proximity of the user paths.

### ***Weather***

Weather information is fetched from weather services, preferably meteorological institutions for accuracy. Weather information can be fetched on a need basis, but this will require a a lot of requests to the weather service, so this method is not viable.

The weather context provider in the AdvertLBS system harvest weather data on a regular basis. Normally the weather service provider update published weather data regularly. The information published is normally global, restricted to country, or regions. The weather harvester in AdvertLBS request and download the weather files.

The harvester parses the weather files and stores a weather forecast associated with geographical location (longitude, latitude) together with a geographical extension expressed in kilometers. The parsed weather forecasts are stored in XML format.

All that is required is a simple lookup in the database table based on position coordinates to find the weather forecast applicable in the context.

The context provisioning framework is responsible for keeping the weather forecasts up to date.

### ***Collaborative Context Elicitation***

The process of forming collaborative groups in the AdvertLBS system is based on two dimensions: the similarity of ratings and preference profiles, and it will adopt a memory-based collaborative filtering approach which means that the algorithm scan preference profiles, service history and rating tables to produce a set of similar users.

The AdvertLBS system continuously scans databases to manage collaborative groups up to date. Each user is given a shared collaborative group identifier which links the users in a collaborative group.

When a location update triggers the collaborative filter algorithm in the recommender logic the algorithm uses this identifier to find the similar users to compute the vote. I will explicate on the recommendation part of the collaborative filtering algorithm in section 5.2.8.

### **5.2.3 Knowledge and Context Representation**

The previous section discussed the methods used to provide context information. Knowledge and context information is complex and need to be organized in a way that makes it comprehensible both to humans and to computers in terms of analysis and transfer of information between different systems. In this section I will describe how context information is represented in the proposed AdvertLBS system.

#### **Service and Preference Profile Taxonomy**

The following generic service classification hierarchy is used in the CLBS to categorize and detail services descriptions. Figure 5.2.3 a) below show the service classification hierarchy.

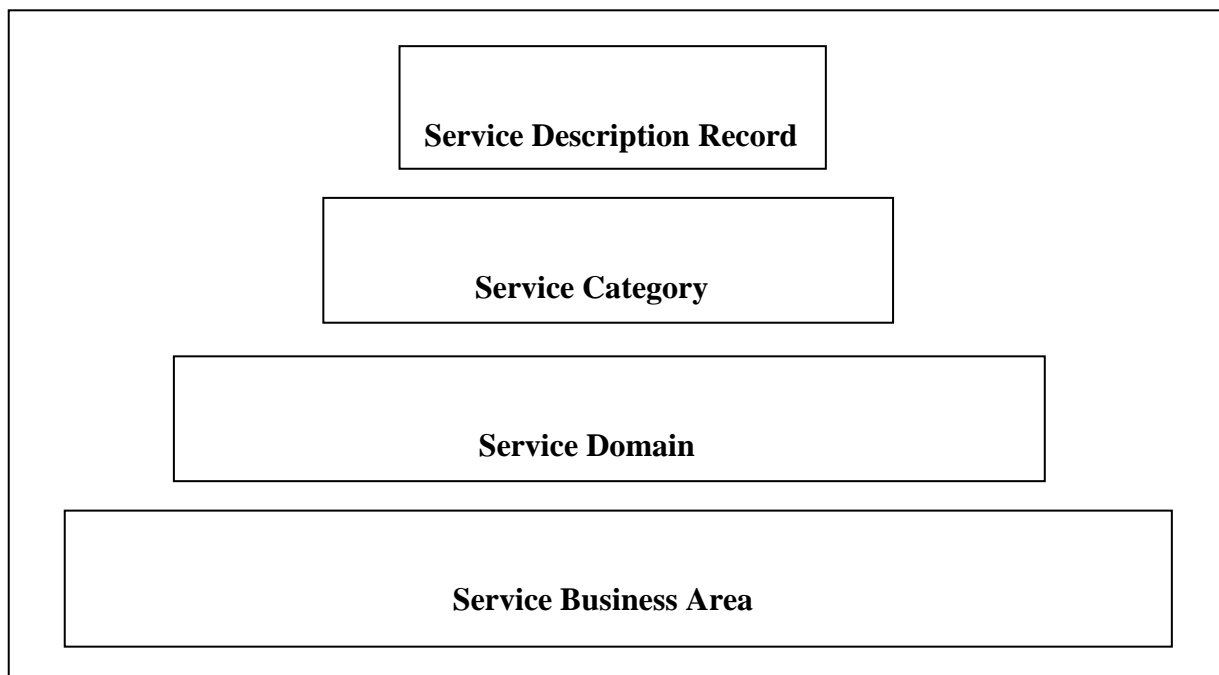


Figure 5.2.3 a) AdvertLBS service classification hierarchy.

We observe that as we climb up the pyramid in the classification hierarchy we increase the level of detail in the service description. I will provide definitions and details about each level in the following sections.

### ***Service Business Area***

The service business area is the base level in the service taxonomy and represents the highest abstraction level of service descriptions related to advertisement and the business areas in which the AdvertLBS is deployed and put into operation.

Examples of some typical service business areas where the AdvertLBS could be put into service could be Entertainment, Food, Shopping, Travel, etc.

A business area will normally consist of a number of business domains and this brings us to the next level in the service description hierarchy, the service domain.

### ***Service Area Domain***

A service domain is a refinement of the service business area and let the service provider specify a domain within the business area. There will typically be numerous domains within a business area. A few examples serve to illustrate the concept of a service area domain:

The Entertainment business area hosts a number of domains, like cinema, music, theatre, opera, circus, and so on. So in the case of selecting the entertainment business area it would be possible to select the music service domain.

In the business area of Shopping we can identify the following service domains: clothing, electronics, furniture, groceries, and so on. So in the case of selecting the shopping business area it would be possible to select electronics as a service domain.

### ***Service Domain Category***

A service category represents a specialization within a service domain. A few examples will service to illustrate the purpose of the service domain category:

In the Music service domain category typical examples of service domain categories could be rock, classic, rap, R&B, techno. It could also music store or a concert.

In the Electronics service domain typical examples of service domain categories could be photo, video, stationary computers, laptops, mobile phones, and so on.

A consumer generally interested in photo could register a very simple preference profile, like: “Shopping – Electronics – Photo”. This would make the consumer a potential candidate for recommendations shops or business dealing with photography.

We understand that the service domain category represents a further refinement of a service area domain.

### ***Service Category Description Record (SCDR)***

A service detailed description record represents the highest level of service and preference description detail in the AdvertLBS and can be used by the service provider in dynamic and customizable manner to detail a service all the way down to a single item or service description.

A few examples of service detailed description record illustrate the purpose:

A cinema creates a service description record within the category action movies. The SCDR details the movie with name, leading actors, time, and price. Service consumers having registered a preference for this particular movie or for movies with the specified leading actors are likely to receive a recommendation message given a favorable context situation.

A Chinese sushi restaurant register a general advertisement description record in the “Chinese” category (under Food – Restaurants – Chinese” and details a few good offers, and opening times. A consumer having registered a preference for sushi restaurants is a candidate



to receive a recommendation. Other consumers having registered preference for Chinese restaurants are also likely to receive a recommendation.

The SCDR's are based on XML schemas. The system offers default templates in the respective service categories, but the service provider are also offered an easy way to customize or create own templates in order to better describe unique services.

It is important to realize that the SCDR represents a rendezvous point between the service provider and the service consumer. The SCDR templates are available for consumers to use when providing detailed information about specific preferences.

### ***The Recommendation Accuracy Estimate***

The recommendation accuracy estimate is a dynamic entity expressed in percent. It expresses the currently perceived accuracy of the system in relation to the consumers. The recommendation accuracy estimate is computed based on the knowledge the system have about the user.

The actual computation of this value can be as simple or as complex as we would like it to be. The solution I've selected for the AdvertLBS compute the accuracy estimate base on the following considerations:

- the level of depth in the preference profile description, pertaining to service descriptions, geographical, and temporal aspects
- the presence of regular updates within geographical areas of interest as location is the all-important context element that will make the system learn on its own accord
- The rating frequency of the user as this implies a better learning rate for the system.
- the size of the collaborative group associated with the user – a smaller group give a higher likelihood of relevant recommendations as they are more tuned in on preferences

A weight is associated with each of these elements and is summed up to produce the accuracy estimate.

The estimate is always available to the user in the mobile application. The user can improve the estimate by improving preference profiles, rate services more frequently, or ensure a regular stream of location updates which will let the system identify services and do recommendations.

## 5.2.4 Knowledge and Context Representation - XML Schemas

The AdvertLBS system is designed to use the W3C XML Schemas, also referred to as XSD, to define the format and structure of XML documents containing knowledge and context information. XML Schemas were selected for this purpose because it is flexible and is an established de facto standard in the industry.

In this section I will provide the details of the XML Schemas used in the AdvertLBS. This is a rather long and detailed section providing elaborate structures, but it contains descriptions of the very core entities of the system and should be carefully studied.

### ***XML Schema Definitions***

This section describes common XML schema definitions which are used to describe services and preference profiles.

#### **Basic Type Definitions**

This section describes common XML Schema type definitions.

##### STRING TYPE

```
<xs:simpleType name="string_t">  
    <xs:restriction base="xs:string"/>  
</xs:simpleType>
```

##### INTEGER TYPE

```
<xs:simpleType name="int_t">  
    <xs:restriction base="xs:positiveInteger"/>  
</xs:simpleType>
```

##### DECIMAL TYPE

```
<xs:simpleType name="decimal_t">  
    <xs:restriction base="xs:decimal"/>  
</xs:simpleType>
```

##### BOOLEAN TYPE

```
<xs:simpleType name="bool_t">
    <xs:restriction base="xs:boolean"/>
</xs:simpleType>
```

### TIME TYPE

```
<xs:simpleType name="time_t">
    <xs:restriction base="xs:time"/>
</xs:simpleType>
```

### DATE TYPE

```
<xs:simpleType name="date_t">
    <xs:restriction base="xs:date"/>
</xs:simpleType>
```

### **Domain Specific Type Definitions**

This section presents a set of more complex schema type definitions.

### SERVICE DOMAIN CATEGORY TYPE

```
<xs:simpleType name="domain_category_t">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
```

### DAY TYPE

```
<xs:simpleType name="day_t">
    <xs:restriction base="xs:string">
        <xs:enumeration value="Monday"/>
        <xs:enumeration value="Tuesday"/>
        <xs:enumeration value="Wednesday"/>
        <xs:enumeration value="Thursday"/>
        <xs:enumeration value="Friday"/>
    </xs:restriction>
</xs:simpleType>
```

```
<xs:enumeration value="Saturday"/>
<xs:enumeration value="Sunday"/>
<xs:enumeration value="All"/>
</xs:restriction>
</xs:simpleType>
```

### CURRENCY TYPE

```
<xs:simpleType name="currency_t">
  <xs:restriction base="xs:string">
    <xs:enumeration value="local"/>
    <xs:enumeration value="nok"/>
    <xs:enumeration value="usd"/>
    <xs:enumeration value="gbp"/>
    <xs:enumeration value="euro"/>
  </xs:restriction>
</xs:simpleType>
```

### AGE RANGE TYPE

```
<xs:complexType name="agerange_t">
  <xs:sequence>
    <xs:element name="from" type="int_t"/>
    <xs:element name="to" type="int_t"/>
  </xs:sequence>
</xs:complexType>
```

### GENDER TYPE

```
<xs:complexType name="gender_t">
```

```
<xs:sequence>
  <xs:element name="male" type="bool_t"/>
  <xs:element name="female" type="bool_t"/>
</xs:sequence>
```

```
</xs:complexType>
```

#### TIME RANGE TYPE

```
<xs:complexType name="timerange_t">
  <xs:sequence>
    <xs:element name="from" type="time_t"/>
    <xs:element name="to" type="time_t"/>
  </xs:sequence>
```

```
</xs:complexType>
```

#### DATE RANGE TYPE

```
<xs:complexType name="daterange_t">
  <xs:sequence>
    <xs:element name="from" type="date_t"/>
    <xs:element name="to" type="date_t"/>
  </xs:sequence>
```

```
</xs:complexType>
```

#### PRICE RANGE TYPE

```
<xs:complexType name="pricerange_t">
  <xs:sequence>
    <xs:element name="from" type="decimal_t"/>
    <xs:element name="to" type="decimal_t"/>
    <xs:element name="currency" type="currency_t"/>
  </xs:sequence>
```

```
</xs:complexType>
```

### **Geographical Definitions**

This section describes XML Schema definitions related to geographical locations, boxed areas, and polygons.

#### POSITION

A geographical position is defined by longitude and latitude coordinates.

```
<xs:complexType name="geopos_t">  
  <xs:sequence>  
    <xs:element name="longitude" type="decimal_t"/>  
    <xs:element name="latitude" type="decimal_t"/>  
  </xs:sequence>  
</xs:complexType>
```

#### BOXED AREA

A geographically boxed area is represented by corners, respectively north-west, south-west, north-east, and south-east. Each point is represented as a `geopos_t` type.

```
<xs:complexType name="geobox_t">  
  <xs:sequence>  
    <xs:element name="northwest" type="geopos_t"/>  
    <xs:element name="southwest" type="geopos_t"/>  
    <xs:element name="northeast" type="geopos_t"/>  
    <xs:element name="southeast" type="geopos_t"/>  
  </xs:sequence>  
</xs:complexType>
```

#### POLYGON

A geographical polygon consists of a set of geographical positions. A polygon can typically be used to represent a route or to isolate an irregular geographical area. Each point is represented as a `geopos_t` type.

```
<xs:complexType name="geopoly_t">
  <xs:sequence>
    <xs:element name=" position" maxOccurs="unbounded" type="geopos_t"/>
  </xs:sequence>
</xs:complexType>
```

### GEOGRAPHICAL LOCATION DATA TYPE

The geographical location data type may consist of zero or more geographical positions, boxed areas, and polygons. This type is used to express geographical information in preference profiles.

```
<xs:complexType name="geodata_t">
  <xs:sequence>
    <xs:element name="geoposition" minOccurs="0" maxOccurs="unbounded"
      type="geopos_t"/>
    <xs:element name="geobox" minOccurs="0" maxOccurs="unbounded"
      type="geopos_t"/>
    <xs:element name="geopoly" minOccurs="0" maxOccurs="unbounded"
      type="geopos_t"/>
  </xs:sequence>
</xs:complexType>
```

### TIME DEFINITION TYPE

This section describes the XML schemas for representation of temporal information. Time can be represented in a number of different ways with this structure, as a timestamp, timerange, datestamp, date range or day. It is also possible to include time zone information.

```
<xs:complexType name="timedata_t">
  <xs:sequence>
    <xs:element name="at_time" type="time_t" minOccurs="0"/>
  </xs:sequence>
```

```
<xs:element name="timerange" type="timerange_t" minOccurs="0"/>
<xs:element name="at_date" type="date_t" minOccurs="0"/>
<xs:element name="daterange" type="daterange_t" minOccurs="0"/>
<xs:element name="day" type="day_t" minOccurs="0"/>
<xs:element name="time_zone" type="string_t" minOccurs="0"/>
</xs:sequence>
</xs:complexType>
```

#### OPTIONS DEFINITION

This section describes the XML schema structure for definition of optional parameters.

```
<xs:complexType name="option_t">
  <xs:sequence>
    <xs:element name="add_route_map" type="bool_t" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
```

### **5.2.5 Service Profile Description Records**

This section presents the XML schema description records used to define service profiles.

#### **Service Profile Description**

This section describes the service profile description XML schema.

#### ***Service Description XML Schema***

The service description schema serves as the template for the description of a service description XML document and may be as simple or complex as is needed to express the particular aspects and semantics of a service.

Other templates based on this may be created either by system administrators or service providers upon need.

```
<xs:complexType name="service_description_t">
  <xs:sequence>
```



```
<xs:element name="description" type="string_t" maxOccurs="1"/>
<xs:element name="content" type="string_t" maxOccurs="1"/>
<xs:element any minOccurs="0"/>
</xs:sequence>
</xs:complexType>
```

Note the <any> element in the XML schema which says that the schema might be extended with any number of non-specified elements and still be considered to be valid.

**Example:**

```
<service_description>
  <description>"Jeans for sale"</description>
  <contents>
    Cheap jeans ! Half price. Please visit Superb Clothes at Bourbon Street 38.
    Walking distance, please follow map. Opening hours: 0800 to 1600. Welcome
    to our shop!
  </contents>
</service-description>
```

***Service Description Extension Template***

As the base service description record provides only a general level of information it is necessary to allow creation and customization of extensions. The extensions are called service description extension templates (SDET).

The AdvertLBS system shall provide pre-defined extension templates to be used by service provider within each service category, but the system will also allow the service provider to create new extension templates.

The service description extension template shall follow this simple template structure:

```
<xs:complexType name="service_description_ext_t">
  <x:sequence>
    <xs:element any minOccurs="0"/>
```

```
</x:sequence>
```

```
</xs:complexType>
```

As an example of an extended service description template imagine the following service description template extension customized to express a concrete advertisement for clothing involving type of clothing, price, size, and producer.

```
<xs:complexType name="service_description_ext_t">
```

```
<x:sequence>
```

```
<xs:element name="clothtype" type="string_t", maxOccurs="1"/>
```

```
<xs:element name="size" type="string_t" minOccurs="0"/>
```

```
<xs:element name="pricerange" type="pricerange_t" minOccurs="0"/>
```

```
<xs:element name="producer" type="string_t" minOccurs="0"/>
```

```
</x:sequence>
```

```
</xs:complexType>
```

This service description extension template can be embedded into the service description template in order to provide more information.

### Example: Extended Service Description

```
<service_description>
```

```
<description>"Jeans for sale"</description>
```

```
<contents>
```

```
Cheap jeans! Half price. Please visit Superb Clothes at Bourbon Street 38.
```

```
Walking distance, please follow map. Opening hours: 0800 to 1600. Welcome  
to our shop!
```

```
</contents>
```

```
<service_description_ext_t>
```

```
<clothtype>jeans</clothtype>
```

```
<size>35</size>
```

```
<pricerange>
```

```
        <from>200</from>
        <to>600</to>
        <currency>nok</currency>
    </pricerange>
    <producer>Lewis</producer>
    <producer>Jack'n Jones</producer>
</service_description_ext_t>
</service-description>
```

The point with the extended service description record is that it provides a rendezvous point between the service provider and the service consumer. The service consumer, when registering a preference profile in a sub-category, will have access to the extended service description template and will be able to specify the same details on her side.

This will enable the service provider to describe detailed and specific services in order to target a specific group of consumers.

### ***Service Target User Profile Structure***

The service target user profile describes details about the target user or target user group associated with service and is another tool to isolate the target consumers. This structure is optional in the service profile description structure.

```
<xs:complexType name="service_target_user_t">
    <xs:sequence>
        <xs:element name="gender" type="gender_t" maxOccurs="1"/>
        <xs:element name="age" type="agerange_t" maxOccurs="1"/>
        <xs:element name="keywords" type="string_t"/>
    </xs:sequence>
</xs:complexType>
```

### **Example:**

```
<service_target_user_t>
```

```
<gender>Male</gender>

<age>

  <From>16</From>

  <To>35</To>

</age>

<keywords>"fashion, clothes"</keywords>

</service_target_user_t>
```

### ***Service Profile Description Structure***

The service profile contains the necessary information related to a service registration. A service profile XML document will consist of the following elements:

- Service name
- Service area
- Service category
- Service sub-category
- Service description
- Temporal Information
- Geographical Information
- Optional parameters related to the service

These information elements translate to the following XML schema structure:

```
<xs:complexType name="service_profile">
  <xs:sequence>
    <xs:element name="name" type="string_t"/>
    <xs:element name="area" type="string_t"/>
    <xs:element name="category" type="string_t"/>
    <xs:element name="subcategory" type="string_t"/>
    <xs:element name="servicedescription" type="service_description_t"/>
    <xs:element name="timedata" maxOccurs="unbounded" type="timedata_t"/>
    <xs:element name="geodata" type="geodata_t"/>
  </xs:sequence>
</xs:complexType>
```

```
<xs:element name="options" type="option_t"/>
```

```
</xs:sequence>
```

```
</xs:complexType>
```

### Example: Service Profile Description

Let's have a look at a complete service profile description. It's an advertisement for men's jeans registered by a shop called "Superb Clothing" with the following attributes:

- It's targeted towards males between 18 and 25 years old as specified in the target user profile.
- The ad is active from 1 of may to 10'th of may, every day between 0800 and 1600.
- The position of the shop is included in the service profile description.
- Options are added. In this case the service provider wants a map appended to the recommendation message. The map contains the route from the user position to the shop.

### Service Profile Description XML Document

```
<service-profile name="jeans frenzy" type="advert" provider-id="12293" area="shopping" category="clothing" sub-category="casual">
```

#### *# Service description with extension.*

```
<service_description>
```

```
<description>"Jeans for sale"</description>
```

```
<contents>
```

```
Cheap jeans! Half price. Please visit Superb Clothes at Bourbon Street  
38. Walking distance, please follow map. Opening hours: 0800 to  
1600. Welcome to our shop!
```

```
</contents>
```

```
</service-description>
```

#### *# Target User Profile*

```
<target-profile>
```

```
<gender>male</gender>
```

```
<fromAge>18</fromAge>
```

```
<toAge>25</toAge>
```

```
        <keywords>"fashion, clothes</keywords>
</target-profile>

# Temporal Information

<time-data>
    <from-date>01-05-2010</from-date>
    <to-date>10-05-2010</to-date>
    <from-time>0800</from-time>
    <to-time>1600</to-time>
</time-data>

# Geographical Information

<geo-data>
    <position>
        <longitude>123</longitude>
        <latitude>122</latitude>
    </position>
</geo-data>

# Additional options

<options>
    <add-route-map>yes</add-route-map>
</options>
</service-profile>
```

A service profile describes one service. A service translates to a single advertisement. A service profile may be general and contain any kind of information, or it may be specific and contain a very narrow and specialized description of a single product or service aimed at a relatively small group of consumers with very specific preference profiles.

A user with a personal profile and preference profile matching the above service profile will receive a recommendation message:

***Recommendation Received!***

*Description: Jeans for sale!*

*Content:*

*Jeans for sale. Half price. Please visit Superb Clothes at Bourbon Street 38. Walking distance from you.*

*Please follow map. Opening hours: 0800 to 1600. Welcome to our shop.*

*View route map here.* *(user select to go to map with route)*

Figure 5.2.5 a) Example: Service Profile Description

Let's have a look at an extended service profile description. It's still an advertisement for men's jeans registered by a shop called "Superb Clothing" with the following attributes, but extended with more details:

- It's targeted towards males between 18 and 25 years old as specified in the target user profile.
- The jeans are in the price range between 200 and 600 pounds
- The jeans brands are Lewis or Jack'n Jones.
- The ad is active from 1 of May to 10'th of May, every day between 0800 and 1600.
- The position of the shop is included in the service profile description.
- Options are added. In this case the service provider wants a map appended to the recommendation message. The map contains the route from the user position to the shop.

This service description profile will only hit users with a registered interest in Lewis or Jack'n Jones jeans and where the price range is between 200 and 600 GBP.

#### **Service Profile Description XML Document with Extensions Template**

```
<service-profile name="jeans frenzy" type="advert" provider-id="12293" area="shopping" domain="clothing" category="casual">
```

```
  # Service description with extension.
```

```
  <service_description>
```

```
    <description>"Jeans for sale"</description>
```

```
    <contents>
```

Cheap jeans from Lewis and Jack'n Jones. Available sizes 30-36. Price range from 200 to 600 GBP.

</contents>

**# Extension record.**

<service\_description\_ext\_t>

<clothtype>jeans</clothtype>

<size>35</size>

<pricerange>

<from>200</from>

<to>600</to>

<currency>gbp</currency>

</pricerange>

<producer>Lewis</producer>

<producer>Jack'n Jones</producer>

</service\_description\_ext\_t>

</service-description>

**# Target User Profile**

<target-profile>

<gender>male</gender>

<fromAge>18</fromAge>

<toAge>25</toAge>

<keywords>"fashion, clothes</keywords>

</target-profile>

**# Temporal Information**

<time-data>

<from-date>01-05-2010</from-date>



```
<to-date>10-05-2010</to-date>

<from-time>0800</from-time>

<to-time>1600</to-time>

</time-data>

# Geographical Information

<geo-data>

  <position>

    <longitude>123</longitude>

    <latitude>231</latitude>

  </position>

</geo-data>

# Additional Options

<options>

  <add-route-map>yes</add-route-map>

</options>

</service-profile>
```

Any user with a personal profile and preference profile matching this service profile will receive the following recommendation message:

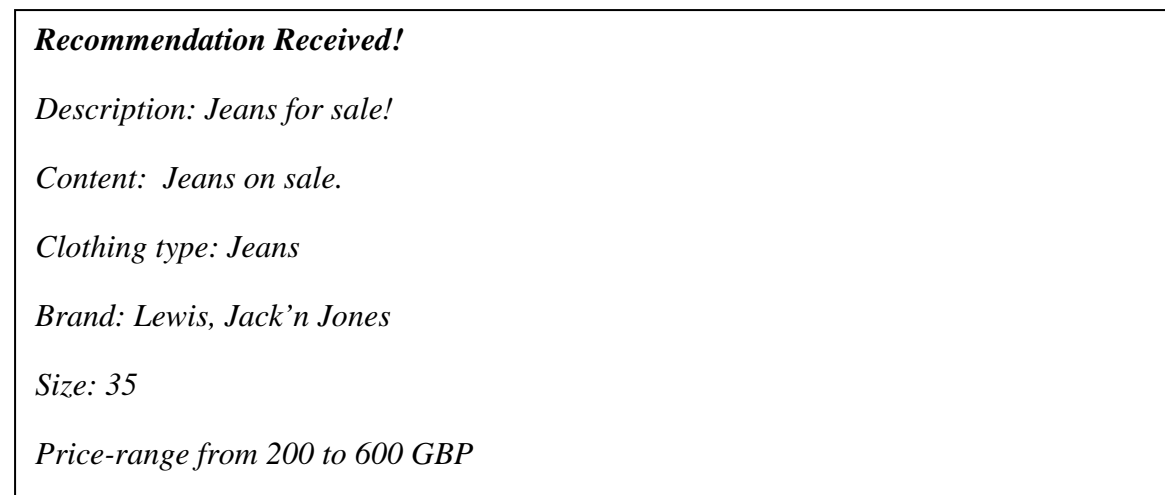


Figure 5.2.5 b) Example: Recommendation message

## **5.2.6 User Preference Context Representation**

Every service consumer (user) can register a general user preference profile and any number of optional service preference records in the CLBS system. The preference profile is used to find matching service profiles.

The user preference profile follows the taxonomy of the service profile:

Level 4 – Service Description Record

Level 3 – Service Category

Level 2 – Service Domain

Level 1 – Service Business Area

Please refer to section 5.2.3 on service profile context representation above to read the definition of each level in the hierarchy.

### **Preference Description Record**

The preference description record describes a specific user preference. The description record may be used to describe a general interest in a business category or to describe a very specific service.

The user preference profile consists of one or more preference description records. A preference description record consists of the following information elements:

- Preference definition name (mandatory)
- Service area (mandatory)
- Service category (mandatory)

- Service sub-category (optional)
- Service description record (optional)
- Temporal information (optional)
- Geographical information (optional)
- Optional parameters related to the service (optional)

These points translate to the following preference description record XML schema:

```
<xs:complexType name="preference ">
  <xs:sequence>
    <xs:element name="name" type="string_t"/>
    <xs:element name="area" type="string_t"/>
    <xs:element name="domain" type="string_t"/>
    <xs:element name="category" type="string_t"/>
    <xs:element name="desc_record" type="service_description_t"
      maxOccurs="1"/>
    <xs:element name="timedata" type="timedata_t maxOccurs="unbounded" "/>
    <xs:element name="geodata" type="geodata_t" maxOccurs="unbounded"/>
    <xs:element name="options" type="option_t"/>
  </xs:sequence>
</xs:complexType>
```

### User Preference Profile

The user preference profile provides information about a user's interest areas and associated categories.

```
<xs:complexType name="preference_profile ">
  <xs:sequence>
    <xs:element name="pref" type="preference" minOccurs="1"/>
  </xs:sequence>
</xs:complexType>
```

### **Example: User Preference Profile**

Let's have a look at a preference profile description record. User has registered a preference record with the following requirements:

- Interested in receiving recommendations about clothes in the casual wear category
- Only receive recommendations on Friday and Saturday between 1000 and 1300
- Only receive recommendations in the geographical region around Arendal and Stavanger

### Preference Profile

```
<preference_profile name="my profile" userid="12293">
```

#### ***# Preference record for casual clothes***

```
<preference area="Shopping" category="Clothing" subcategory="Casual">
```

#### ***# Temporal Information - Friday***

```
<timedata>
```

```
<day>Friday</day>
```

```
<timerange>
```

```
<from>1000</from>
```

```
<to>1300</to>
```

```
</timerange>
```

```
</timedata>
```

#### ***# Temporal information – Saturday.***

```
<timedata>
```

```
<day>Saturday</day>
```

```
<timerange>
```

```
<from>1000</from>
```

```
<to>1300</to>
```

```
</timerange>
```

```
</timedata>
```

**# Geographical Information**

<geo-data>

**# Arendal**

<geobox name="Arendal">

<northwest >

<longitude>xxx</longitude>

<latitude>xxx</latitude>

</northwest >

<southwest >

<longitude>xxx</longitude>

<latitude>xxx</latitude>

</southwest >

<northeast >

<longitude>xxx</longitude>

<latitude>xxx</latitude>

</northeast >

<southeast >

<longitude>xxx</longitude>

<latitude>xxx</latitude>

</southeast >

</geobox>

**# Stavanger**

<geobox>

<northwest >

<longitude>xxx</longitude>

<latitude>xxx</latitude>

```
        </northwest >
        <southwest >
            <longitude>xxx</longitude>
            <latitude>xxx</latitude>
        </southwest >
        <northeast >
            <longitude>xxx</longitude>
            <latitude>xxx</latitude>
        </northeast >
        <southeast >
            <longitude>xxx</longitude>
            <latitude>xxx</latitude>
        </southeast >
    </geobox>
</geodata>
# Additional options
<options>
    <add-route-map>yes</add-route-map>
</options>
</preference>
</service-profile>
```

### **Example: User Preference Profile Record with Extended Service Description**

Let's have a look at a preference profile description record. User has registered a preference record with the following parameters:

- Interested in receiving recommendations about clothes in the casual wear category
- Only receive recommendations between 0900 and 1500
- Only interested in Lewis jeans in the price range from 100 to 300 GBP.

- Receive recommendation anywhere (no geographical constraints imposed).

### Preference Profile Description

```
<preference_profile name="my profile" userid="12293">
  <preference area="Shopping" category="clothing" subcategory="casual">
    <service_description>
      # Using available service description structure
      <service_description_ext_t>
        <clothtype>jeans</clothtype>
        <pricerange>
          <from>100</from>
          <to>300</to>
          <currency>gbp</currency>
        </pricerange>
        <producer>Lewis</producer>
      </service_description_ext_t>
    </service-description>
    # Temporal Information - Friday
    <timedata>
      <day>Friday</day>
      <timerange>
        <from>1000</from>
        <to>1300</to>
      </timerange>
    </timedata>
    # Temporal information – Saturday.
```

```
<timedata>
  <day>All</day>
  <timerange>
    <from>0900</from>
    <to>1500</to>
  </timerange>
</timedata>
</preference>
</service-profile>
```

We can see from this example preference profile that the user have used available extension parameters to create a very specific preference record.

The service provider is free to create service profile extension records in order to customize service profiles. The extension records contain parameters which again can be used by the service consumer to define specific service preference profile records. The service consumer may use any combination of extended service profile parameters to completely customize what he/she is looking for.

All context information is specified in XML schemas and all concrete XML documents must comply with the schemas to be valid.

### 5.2.7 Database Model and Tables

In this section I will present the data model in terms of tables and associated information fields used to represent static and dynamic context information in the AdvertLBS system. XML representation of context data is not a very efficient way to process data in terms of parsing and analysis and should therefore be reduced to a minimum. A database however provides a structured and efficient storage of information with standardized and optimized retrieval and storage methods.

I will discuss the content of the AdvertLBS in terms of the entities involved in the system.

#### Service Consumer Tables

This section describes all database tables related to service consumer profiles and context information. The following points summarize the relevant tables.



- Profile table
- Status table
- Settings
- Preference profile table
- Geographical area of interest table
- GeoLocation tracking table
- Geo-location logging table
- Online activity logging table
- Service recommendation logging table
- Collaboration table
- Route-learning table

Let's have a look at the detail of the tables.

**Consumer Profile Table**

The user profile table consists of personal consumer information. This information is mandatory in order to register in the CLBS system and therefore be able to receive recommendation messages.

Profile Element	Type	Description
Id	Integer	Unique record id.
UserId	Integer	Unique user identifier in CLBS system
FirstName	String	First name.
LastName	String	Last name.
AddressLine	String	Address.
Zip Code	String	Zip code.
Country	String	Country of residence.
AddressLon	Decimal	Longitudes coordinate of user address.
AddressLat	Decimal	Latitude coordinate of user address
EMail	String	E-mail address.
Age	Integer	User age.
Gender	Byte	User gender.

CivilStatus	String	Civil status (Single, married, widowed,...)
Username	String	User name selected by user.
Password	String	Password selected by user.
UserContractSigned	Boolean	User agreed with (signed) user contract/agreement.
Created	Datetime	Datetime of creation.
Modified	Datetime	Datetime of modification.

It is recommended that the user enter address information as this will establish permanent location coordinates.

**Consumer Status Table**

This table contains dynamic information about user status. Information in this table must be accounted for in context management and service matching. The user’s current location, current estimated accuracy estimate, collaborative group ID, mobile IP address.

Profile Element	Type	Description
Id	Integer	Unique preference profile identifier.
UserId	Integer	Associated user profile ID.
RecAccuracyEstimate	Short	Current recommendation accuracy estimate (%).
MobileIp	String	Current mobile IP address (Empty string if no IP).
Status	Integer	Current status.
Longitude	Decimal	Last recorded longitude
Latitude	Decimal	Last recorded latitude
Speed	Decimal	User speed
LastRecServiceId	Integer	ID of last recommended service
CollaborativeGroupId	Integer	Collaborative group identifier
Created	Datetime	Datetime of creation

Modified	Datetime	Datetime of modification
----------	----------	--------------------------

### ***Consumer Settings Table***

This table contains specific user settings and options related to the privacy and reception of recommendation messages.

<b>Profile Element</b>	<b>Type</b>	<b>Description</b>
Id	Integer	Unique preference profile identifier.
UserId	Integer	Associated user ID.
AllowRecommendations	Boolean	True if user allows recommendations.
AllowLocationTracking	Boolean	True if user allow location tracking
ApplyWeatherFilter	Boolean	True if use weather in matching
ApplyCollaborativeFilter	Boolean	True if collaborative filtering should be used.
ApplyRouteLearning	Boolean	True if system is allowed to learn routes.

### ***Consumer Preference Profile Table***

This table contains user preference records. Each preference record is stored in XML document format. A user may create any number of preference profiles.

<b>Profile Element</b>	<b>Type</b>	<b>Description</b>
Id	Integer	Unique preference profile identifier.
UserId	Integer	Associated user ID.
PrefProfileName	String	Preference profile name
InterestRadius	Short	Service interest radius
Description	Text	Profile description in XML format
Created	Datetime	Datetime of creation.

Modified	Datetime	Datetime of modification
----------	----------	--------------------------

The “Description” field contains the actual profile description. This description must conform to W3C XML Schema definitions as given in section 5.2.6 in order to be valid. Only validated preference profile description records are allowed into this table.

***Consumer Geographical Areas of Interest Table***

This table is used to associate service preferences with specific geographical areas. A bounding box is used to represent area of interest. Service described in the preference profile can be recommended in specified areas only.

The geographical area could have been specified in a polygonal manner, but for reasons of simplicity I have opted for a bounded box solution even if this is not entirely correct taken the curvature of the earth into consideration.

The consumer may associate any number of geographical areas with defined preference profiles.

Profile Element	Type	Description
Id	Integer	Unique record ID.
PrefProfileId	Integer	ID of associated preference profile
NWlat	Decimal	North-West latitude
NWlong	Decimal	North-West longitude
SWlat	Decimal	South-West latitude
SWlong	Decimal	South-West longitude
NElat	Decimal	North-East latitude
NElong	Decimal	North-East longitude
SElat	Decimal	South-East latitude
SElong	Decimal	South-East longitude
Created	Datetime	Date of creation.
Modified	Datetime	Date of last modification.

This information is collected when user specify a preference profile record. User selects the area by putting markers on a map.

**Consumer GeoLocation Tracking Table**

This table is used to keep track of user location. Location data is logged by appending each received location to a log document in XML format.

Profile Element	Type	Description
Id	Integer	Unique identifier
UserId	Integer	Associated user ID.
Latitude	String	Last known latitude.
Longitude	string	Last known longitude.
When	Datetime	Date and time of last known position.
LocationLog	Text	Log of all positions (XML format)

**Consumer GeoLocation Logging Table**

This table represents location logs transferred from user mobile device. These logs are subjected to analysis to detect common movement patterns.

Profile Element	Type	Description
Id	Integer	Unique identifier
UserId	Integer	Associated user ID.
When	Datetime	Datetime of when log was received by system
LocationLog	Text	Log of all positions (XML format)
ProcessedWhen	Datetime	Datetime of when log was processed

**Consumer Online Activity Logging Table**

This table contains online activity logs provided by users. The online activity logs are analyzed in order to provide context information about the user. The sensed context information act to reinforce existing user context information.

Profile Element	Type	Description
Id	Integer	Unique identifier
UserId	Integer	Associated user ID.
When	Datetime	Datetime of when log was received by system
OnlineLog	Text	Online activity log in XML format.
ProcessedWhen	Datetime	Datetime of log processing and analysis.

**Consumer Service Recommendation History Table**

This table is used to document recommended services on a historical basis. This table might be analyzed to find commonality between “similar” users and to establish collaborative groups of users. It is also used by content-based filtering to investigate service recommendation on a historical basis.

Profile Element	Type	Description
Id	Integer	Unique identifier
UserId	Integer	User ID
ServiceId	Integer	ID of recommended service
When	Datetime	When service recommendation was issued.
ReadReceipt	Boolean	True if recommendation was read.
VisitedSite	Decimal	Likelihood that user visited recommended site (percent)
RatingProvided	Boolean	True if service rating was provided

**Consumer Collaboration Table**

This table is used to store “similar” consumers (members of collaborative groups). The criteria for selecting “similar” consumers can be based on several criteria’s:

- Service rating patterns (look for users who share rating pattern with active user)
- Service (item)-based

Profile Element	Type	Description
Id	Integer	Unique identifier
UserId	Integer	Unique user ID.
OtherUserId	Integer	Similar user ID.
ProfileWeight	Integer	Profile likeness score.
RatingWeight	Integer	Service rating weight
ServiceWeight	Integer	Recommended services likeness score
PredictionValue	Integer	Total predictive value of this “buddy”.

**Learned Routes Table**

This table contains all learned routes. Each route is modeled as a polygon of connected points. The route is bounded by a minimal bounding box which includes all points in the polygon. The bounding box coordinates makes it easy to test if user is in the area of the route, and if the more complex polygonal routes should be retrieved and decoded in order to anticipate user movement.

Profile Element	Type	Description
Id	Integer	Unique identifier
UserId	Integer	Associated user ID.
RoutePolygon	Text	Route polygon described in XML format.

BoxNWLatitude	Decimal	NW corner of route bounding box.
BoxNWLongitude	Decimal	NW corner of route bounding box.
BoxSWLatitude	Decimal	NW corner of route bounding box.
BoxSWLongitude	Decimal	NW corner of route bounding box.
BoxNELatitude	Decimal	NW corner of route bounding box.
BoxNELongitude	Decimal	NW corner of route bounding box.
BoxSELatitude	Decimal	NW corner of route bounding box.
BoxSELongitude	Decimal	NW corner of route bounding box.
Weight	Integer	Weight of the route, i.e. it trustworthiness
Created	Datetime	Datetime when route was first created
Modified	Datetime	Datetime of when route was modified
LastRead	Datetime	Datetime of when route was last read

### Service Provider Tables

This section describes database tables related to service provider profiles, service registration, and context information.

Please refer to service and preference taxonomy for a detailed description of the following tables:

- Service business area table
- Service area domain table
- Service domain category table
- Service category description record table

### Service Business Area Table

A service business area represents the business area which is the parent of a number of service categories. Service areas can only be created or modified by system administrator.

Profile Element	Type	Description
-----------------	------	-------------



Id	Integer	Unique service area identifier.
Name	String	Name of category.
Description	String	Description of category
Created	Datetime	Date of creation.
Modified	Datetime	Date of last modification.

***Service Area Domain Table***

The service area domain specifies a particular domain within a business area. A service domain is the parent of service category information records.

A service domain can only be created or modified by system administrator.

Profile Element	Type	Description
Id	Integer	Unique service category identifier.
Name	String	Name of service category
Description	String	Service category description.
ServiceAreaId	Integer	Associated service area identifier (parent)
Created	Datetime	Date of creation.
Modified	Datetime	Date of last modification.

***Service Category Table***

The service domain category table represents an even more detailed level in the service representation hierarchy.

Profile Element	Type	Description
Id	Integer	Unique service sub-category identifier.
Name	String	Name of service category area.

Description	String	Service sub-category description.
ServiceDomainId	Integer	Associated service domain identifier
Created	Datetime	Date of creation.
Modified	Datetime	Date of last modification.

### ***Service Provider Business Profile Table***

The service provider business profile table contains all relevant information related to a service provider registration in the CLBS system.

<b>Profile Element</b>	<b>Type</b>	<b>Description</b>
Id	Integer	Unique service provider identifier.
ProviderName	String	Service provider name.
OrgNumber	String	Organizational number (official).
AddresLine	String	Address.
ZipCode	String	Zip code.
Country	String	Country of residence.
ContactPerson	String	Contact person.
PhoneNumber	String	Contact phone number.
ContactEmail	String	Contact e-mail address.
SystemEmail	String	System e-mail address.
Username	String	Username.
Password	String	Password.
BuisnessArea	String	Primary business area of the customer.
ProviderContractSigned	Boolean	True if provider agrees to contract
CreditValid	Boolean	True if credit is ok.

Longitude	Decimal	Longitude of given service provider address
Latitude	Decimal	Latitude of given service provider address
Created	Datetime	Datetime of when profile was created
Modified	Datetime	Datetime of when profile was modified

### ***Service Profile Table***

The service profile describes a service (advertisement).

<b>Profile Element</b>	<b>Type</b>	<b>Description</b>
Id	Integer	Unique service identifier.
ProviderId	Integer	Service provider id associated with service.
ServiceName	String	Human-readable service name.
Description	Text	Service profile description.
AreaId	Integer	Service area ID.
DomainId	Integer	Service domain ID
CategoryId	Integer	Service category ID
Longitude	Decimal	Position of service - longitude
Latitude	Decimal	Position of service – latitude.
ValidFrom	Datetime	Validity from Datetime.
ValidityTo	Datetime	Validity to Datetime.
Status	Short	Service status: Active, Stopped, Expired
RatingLevel	Integer	Total rating as computed from user ratings.
Blacklisted	Boolean	True if service is blacklisted
Created	Datetime	Datetime of creation.

Modified	Datetime	Date of modification
----------	----------	----------------------

### ***Service Description Record Template Table***

The service description record table contains all defined service description templates. All templates are encoded as XML Schemas.

<b>Profile Element</b>	<b>Type</b>	<b>Description</b>
Id	Integer	Unique ID.
DomainId	Integer	Domain ID
CategoryId	Integer	Category ID
Name	String	Name of description record
Schema	Text	XML Schema
ProviderId	Integer	ID of service provider who created schema
Publish	Boolean	True if publish. False otherwise.
CanModify	Boolean	True if template can be modified, false otherwise
Created	Datetime	Datetime when template was created
Modified	Datetime	Datetime when template was modified.

### ***Extended Service Description Record Template Table***

The extended service description record template table contains all service description record templates defined by service providers.

<b>Profile Element</b>	<b>Type</b>	<b>Description</b>
Id	Integer	Unique ID.
ServiceDescrRecordId	Integer	ID of associated service description record

Name	String	Name of service description template.
Schema	Text	XML Schema describing the record
ServiceProviderId	Integer	ID of service provider who created template
Publish	Boolean	True if publish. False otherwise
CanModify	Boolean	True if template can be modified, false otherwise
Created	Datetime	Datetime when template was created
Modified	Datetime	Datetime when template was modified.

### ***Service Rating Table***

This table represents service ratings provided by the users. The rating level is kept simple and is represented by a discrete integer values.

There may be any number of ratings associated with a service. The average rating is stored in the service profile record.

<b>Profile Element</b>	<b>Type</b>	<b>Description</b>
Id	Integer	Unique ID.
ServiceId	Integer	ID of service profile
RatingLevel	Integer	Rating level
UserId	Integer	ID of user who submitted rating
Comment	String	Rating comment
Created	Datetime	Datetime when record was created
Modified	Datetime	Datetime when record was last modified

### ***Service Blacklist Table***

This table contains all blacklisted services. A service may be blacklisted if it contains inappropriate contents or rated below a defined threshold over time.

This table store housekeeping information related to a blacklisted service like a descriptive reason and when service were black-listed as well as a flag telling if the service provider has been notified about the blacklisting.

Profile Element	Type	Description
Id	Integer	Unique ID.
ServiceId	Integer	ID of service profile
Reason	String	Reason of blacklisting
When	Datetime	When blacklisting of service was done
ProviderNotified	Boolean	True if service provider is notified
ProviderNotifiedWhen	Datetime	When provider was notified
Created	Datetime	When record was created
Modified	Datetime	When record was last modified

### ***Service Target User Profile***

The service target user profile is used to create detailed descriptions of a target user group associated with a given service profile. There may be any number of target user profiles associated with a service profile.

Profile Element	Type	Description
Id	Integer	Unique target user profile id.
ServiceId	Integer	Service identifier.
Profile	Text	Profile in RDF/XML format
Created	Datetime	Datetime of creation
Modified	Datetime	Datetime of modification.

**Weather Forecast Description Record Table**

The weather description table consists of continuously updated weather information in specified regions.

Profile Element	Type	Description
Id	Integer	Unique identifier
Longitude	Decimal	Longitude coordinate
Latitude	Decimal	Latitude coordinate
Extension	Integer	Extension of forecast in kilometers.
Forecast	String	Weather forecast in XML format
ValidFrom	Datetime	Validity start time
ValidUntil	Datetime	Validity end time
Created	Datetime	When record was created
Modified	Datetime	When record was last modified

**5.2.8 Hybrid Recommender Algorithm**

In this section I propose a solution to the implementation of hybrid recommender logic in the AdvertLBS system.

**Overview**

Figure 5.2.8 a) below show the weighted hybrid recommendation model used in the AdvertLBS system is based on a sequence of filters applied to the user. Each module takes input and produces output.

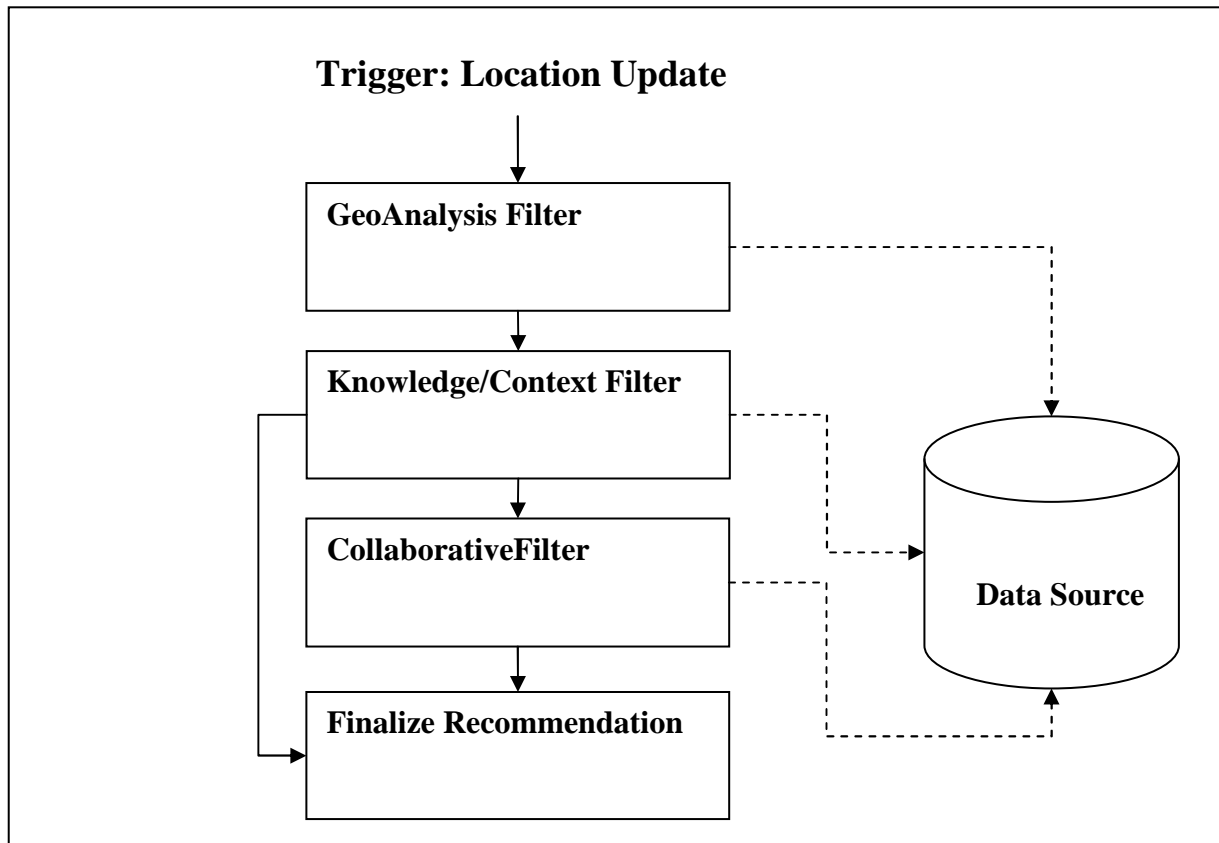


Figure 5.2.8 a) Overview of module in AdvertLBS hybrid recommendation algorithm.

Each filter or module provides a recommendation score. If a module produces as score higher than the recommendation threshold the algorithm breaks off and moves directly to the recommendation process. In the AdvertLBS algorithm this happened only for the knowledge/context filter module.

I will in the next sections describe in detail the individual modules and their functionality in the algorithm.

### **GeoAnalysis Filter Module**

In this section I will discuss the purpose, design, and functionality of the GeoAnalysis module in the hybrid recommender algorithm.

#### **Overview**

The purpose of the geographical analysis filter is to analyze the geographical location of the user in relation to available services in the geographical area where the user is located.

This module takes the geographical location of a user (consumer) and produces a list of services within different proximity zones. The proximity zones are defined by the user as they



are likely to be dependent on personal taste and physique – a walking distance for one user may be no more than 100 meters, but for another it might very well be 1 km or more.

The proximity zones are divided into 3 zones: present location, walking distance, and driving distance. The default values for present location are 30m, walking distance is 500m and driving distance is more than 500m.

Each service is given a score based on which zone it is located within. The GeoAnalysis module does not make any conclusions to what kind of service or relevance to user preferences, but deals only with proximity issues. A service closer to the user is given a higher score than a service further away.

Figure 5.2.8 b) below illustrates service proximity zones with a defined geographical area.

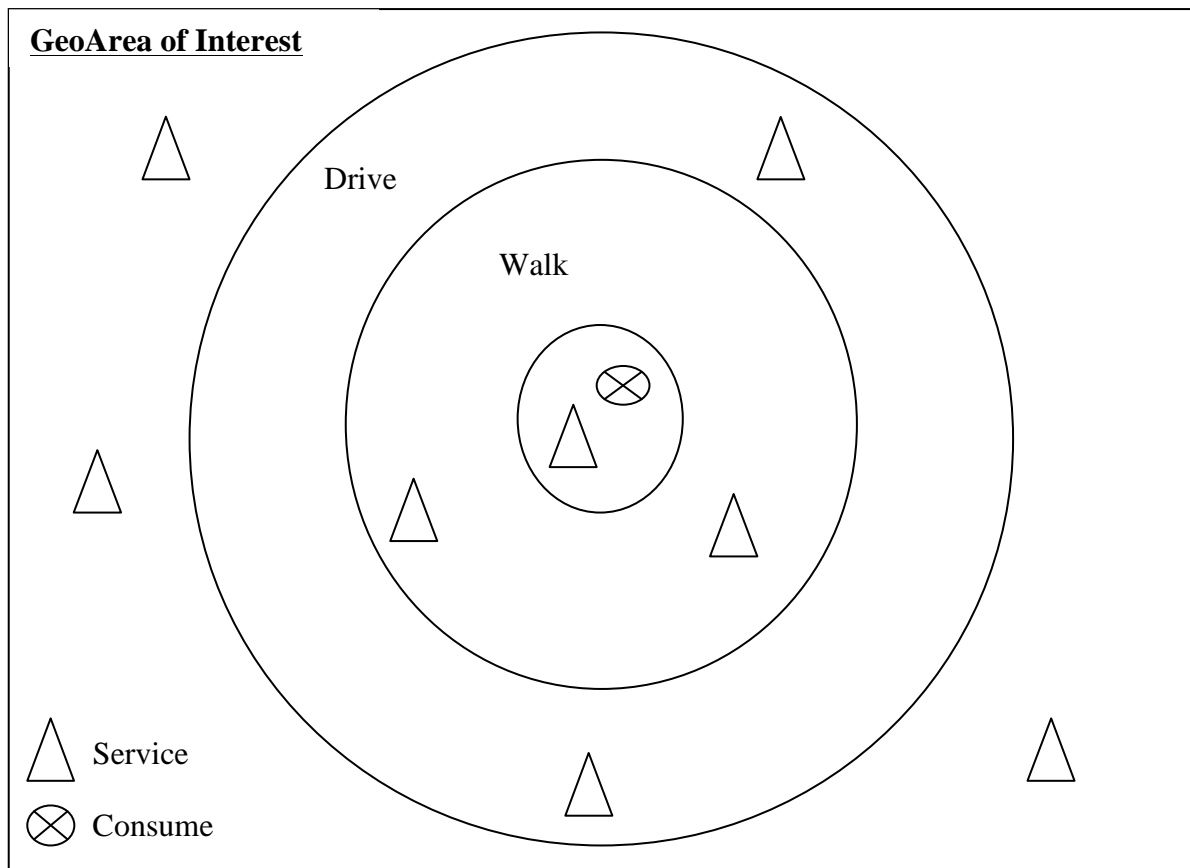


Figure 5.2.8 b) Geographical area of interest

### **Theoretical Background**

Location is the most important kind of information in the AdvertLBS system. A consumer's location triggers the recommendation logic and ultimately leads to a service recommendation. In this respect it is important to get the location tracking and analysis model correct.

The AdvertLBS uses a location tracking model based on a shared responsibility between the consumer mobile application and the core system. The consumer defines geographical areas in which it is interesting to receive recommendations during the preference profile registration. The mobile application will only send location updates when the consumer is located inside these defined geographical areas.

The mobile application does not have an overview of the location of services. This would also be possible and attractive from a system point of view, but it would require too much processing on in the mobile device, additionally draining local power resources.

**Module Activity Chart**

The activity chart below illustrates the main logic of the GeoAnalysis module.

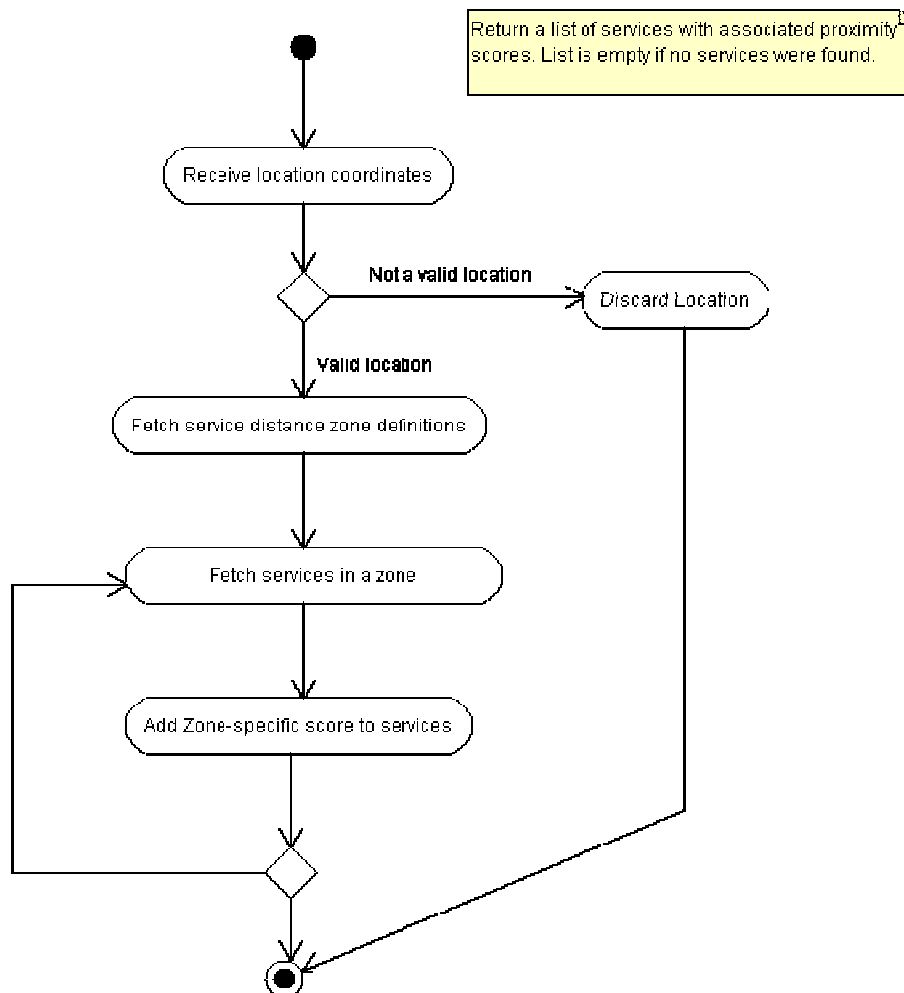


Figure 5.2.8 c) GeoAnalysis module activity diagram.

### **Knowledge Filter Module**

#### **Overview**

The knowledge filter module performs matching operations between registered service profile descriptions and user preference profile. It also uses the knowledge of the user's previous service history and service ratings.

This module takes a list of geographically relevant services, as produced by the GeoAnalysis module, as input. Each service description is matched against the user's preference profiles. The result of this process is a list of services matching the user's preference profile.

As the AdvertLBS system is highly accepting in terms of user contributed context information there is likely to be a huge variation in preference profile availability and quality. A user with no preference profile will be ignored by this module as it is impossible to reason with knowledge about user preferences.

As we can see from figure 5.2.8 d) below it is entirely possible for the recommender algorithm to close the recommendation reasoning process in this module and finalize the recommendation. This will only occur in the case where a service score exceeds the required estimation accuracy threshold level, i.e. the match between the service and the consumer profile is considered to be so strong that the contribution of modules further down the line will only add marginal value to the total score.

This is likely to happen in cases where the consumer and the service provider meet in a common service description record.

A score is associated with each service in the list. A better match is given a higher score.

#### **Theoretical Background**

The knowledge filter uses static consumer preference profile and matches it with a selection of service profiles.

The logic of the matching process follows closely the hierarchical levels in the service taxonomy. Please refer to section 5.2.3 for a detailed description of the service taxonomy levels.

The user preference profile is structured according to the taxonomy. The algorithm is simple and consists essentially of answering the following questions:

1. Does service business area match user preference profile?
2. Does service domain area match user preference profile?
3. Does service category match user preference profile?

4. Does service description record match user preference profile service description record?
5. Does any keywords provided in the preference profile match service profiles?

The score is increased by each positively answered question.

Also weather context is evaluated by a simple lookup in the weather forecast database table based on the users coordinates. Services can be marked as weather sensitive as the system will not be able to discriminate weather sensitive preferences or services.

### ***Module Activity Diagram***

The activity diagram illustrates the major activities in the module.

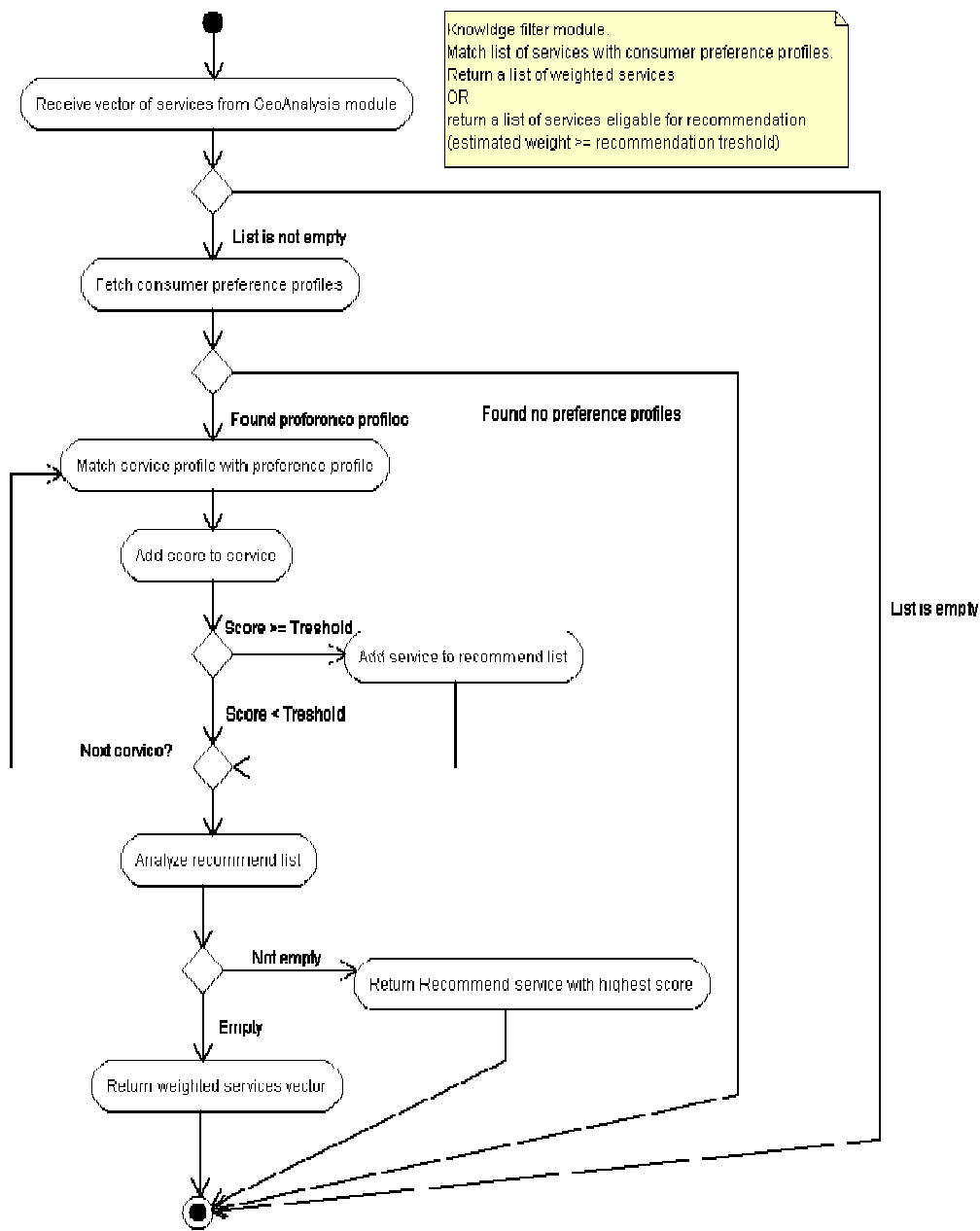


Figure 5.2.8 d) Knowledge filter algorithm

### Collaborative Filtering Module

The purpose of the collaborative filter module is to improve the estimated accuracy of a recommendation by performing an analysis of how members of the collaborative group have rated the services before.

By analyzing the service history of users with similar preferences and also their rating of the services it is possible to draw conclusions as to whether the service should be recommended to the user or not.

This module takes as input a list of services produced by any of the other previous filtering modules and updates this list with a collaborative score. A common recommended service with good ratings is given a higher score.

### ***Theoretical Background***

Collaborative filtering has been applied in many recommender systems, particularly web recommenders, to great success. There is however one big disadvantage of the algorithm; it requires a quite high number of users to find enough individuals which share the same kind of service preferences and rating patterns. This is what makes it so difficult to rely solely on this algorithm. I will now first have a look at how research literature defines the collaborative filtering method. I refer to [3] in the following dissemination of the collaborative recommender algorithm.

According to [3] the collaboration algorithm can be divided into three sub-tasks: 1) representation, 2) neighborhood forming, and 3) recommendation generation. As [3] discusses items the user browses and view on the web, I will relate the approach to the AdvertLBS system.

The representation task concerns how services are represented in the system and how the system tracks recommended services and associated ratings. The neighborhood formation task focuses on finding similar users and the recommendation generation task is, according to [3], about finding the top-N best recommended services and recommending the better.

In the AdvertLBS I have chosen to represent the consumer-service relationship in database tables. Each consumer is given a collaborative group identifier. This identifier can be used to effectively find all members of the group. Each consumer has a service and rating history

The recommendation generation process follows the most-frequently, best rated service policy. This information can be extracted by scanning the database and producing a matrix consisting of consumer-service matrix consisting of ratings. The recommendation generation algorithm processes the consumer-service matrix and computes the top-N, or most frequently recommended, services. The rating for each service is averaged and computed to rank the top-N services. The best rated service in the top-N classified services is recommended.

### ***Module Activity Diagrams***

Below are diagrams of the neighborhood forming and recommendation process.

#### **Neighborhood Forming**

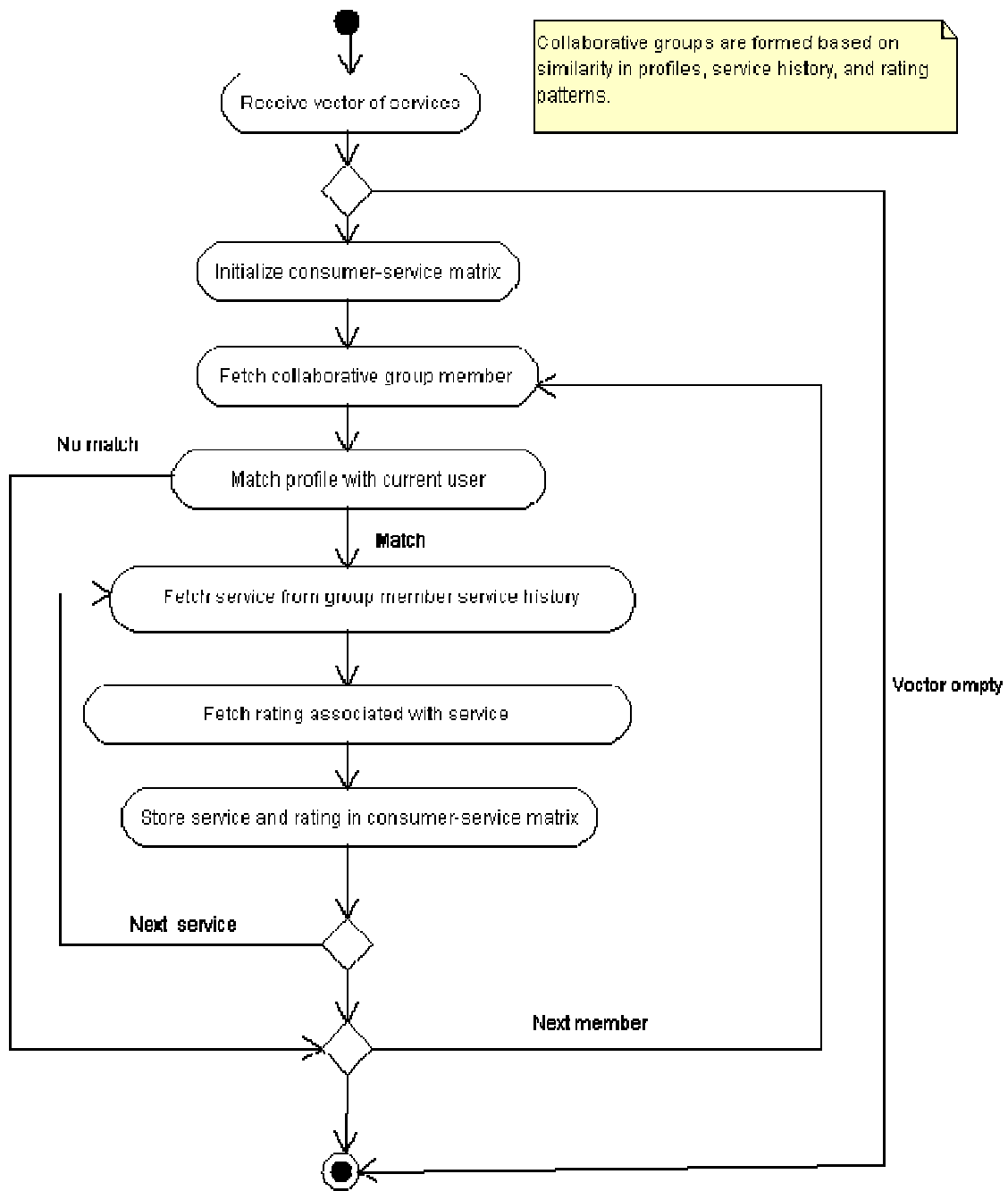


Figure 5.2.8 e). Collaborative filtering. Neighborhood formation algorithm.

**Recommendation Generation**

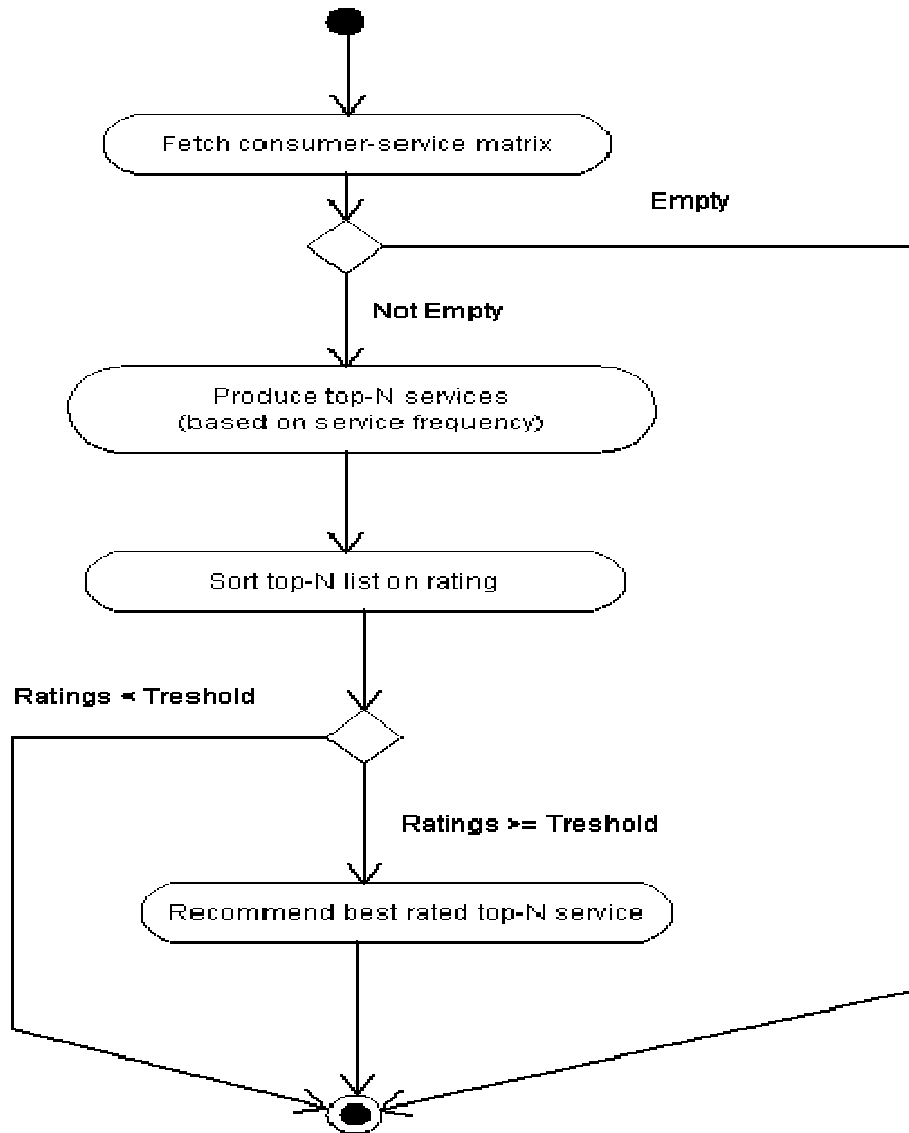


Figure 5.2.8 f). Collaborative filtering. Recommendation generation process.

**Finalize Recommendation Module**

This module is to sum up the recommendation scores from the modules and check if it exceeds the recommendation threshold. A recommendation message is produced and transferred to customer.



### **5.2.9 Service Monitoring Model**

A well-designed and managed service monitoring model is essential in a recommender system. In the case of AdvertLBS the monitoring of services is related to the quality of services, service ratings, removal of outdated services, renewal of services, and giving the service provider statistical and housekeeping information about their registered services.

#### **Quality of Service Monitoring**

In order to keep a high quality of services and to attract professional service providers it is necessary to implement a set of functionalities which will keep the service quality at a high level. This is one of the most important characteristics of the AdvertLBS system and which is a major factor in the perceived trustworthiness of the system from both a service consumer and provider point of view. This is closely related to what I mentioned in the introduction part of this paper, it is a personalized recommender intended to be an extension of the self. In order to realize this ambition the concept of professionalism, quality of service, privacy, and security must be key priorities. In this section I will discuss quality of service.

Quality of service is related to a number of elements in the system, amongst them the quality of the actual services (advertisements) in terms of content, validity, and trustworthiness. Other elements included in this are ratings, and general housekeeping issues. I will now present to key elements to the success of the service monitoring model.

#### ***Service Validity Period***

The service validity is defined by a start date and an end date (expiry date). The service will not be recommended after expiry. The expiry of a service will be notified to the service provider in due time before the actual expiry, so that the service provider can take action to renew the service.

It is relatively important to keep the service validity period relatively short. This will cause frequent updates of the services profiles and thereby avoiding service profiles no longer connected to the actual services. The length of a validity period is a business decision and is related to the business models implemented in the system.

#### ***Service Content Analysis***

In order to prevent services containing content of violent or sexually explicit content a content analysis is performed to detect words and phrases associated with these topics. The analyzer

brings these services to the attention of a system administrator which decides if the services should be blacklisted or not.

A simple text analyzer with a dictionary of keywords will suffice in terms of text contents. There is however a problem with analysis of image or video content as this is not easily analyzed with simple methods, but this is considered to be matter which is a bit outside the primary scope of this thesis, so I will primarily focus on textual service profiles.

### ***Service Rating Analysis***

Service consumer can rate a service, but as this is optional it is likely that not all services necessarily will be rated or that it will be given enough ratings sufficient to produce a credible average rating. It is there necessary to delay the computation of an average rating until there is statistically significant number of ratings associated with the service.

However, when an average rating is computed the service monitoring will use the rating to evaluate if a service is fit to be recommended or not. If the rating is below a given minimum average rating threshold a warning about this is sent to the service provider. The warning is sent because the low rating level will forever block the service from being recommended.

Another important issue related to credible ratings is that each service consumer only have the opportunity to rate a service once. A service consumer having issued a rating may only change the rating. This will effectively eliminate the possibility of consumer overrating or underrating services by doing repetitive ratings on same service. The service will keep track of the number of time a service recommender have tried to rate a service.

### ***Service Statistics***

Services are recommended and rated. It is necessary to count and keep statistics on a number of different elements in order to review the efficiency and precision of the recommender. Statistics on their own services is also interesting to the service provider.

Statistics internal to the service recommender is typically the number of recommendations of services in the different service areas, domains, and categories, rating levels, total number of active system providers and consumers.

The primary purpose of providing the service consumer with statistics on services is to give an indication to the usefulness of spending time and money on using a recommender. The system must somehow reflect reality and provide a gain in order to be worth using. The statistics provides the data from the system side, and include total number of recommendations of each registered service. Each service is also associated with the average rating and the user has the opportunity to view all ratings with service consumer comments

inclusive. It is considered important to provide an opportunity for the consumer to add brief comment with the rating as it provides concrete feedback to the service provider.

### ***Service Provider Communication***

As mentioned in the previous paragraphs there is regular communication with the service providers in terms of providing statistics on service recommendations and ratings.

The communication between the system and the service provider occur via the web portal (statistics) and via e-mail. The e-mail is primarily used to inform about critical issues, such as the expiry of a service, blacklisting of services, or a service which is never recommended due to a low rating.

However, the communication should also provide information about positive events, such as a good rating on a service or a high number of recommendations.

## Chapter 6 – Security and Trust

On the web the recommender system have the advantage of providing the user an illusion of being anonymous. Switching a recommender from the web to a mobile handset makes the users self-aware and concerned about privacy issues related to personal information, location tracking, and not least the possibility of being spammed with unwanted and annoying information. Most people will shun recommender systems poking into their privacy sphere, unless we are able to produce recommenders characterized by features such as high level of personalization, security, privacy, and sensitivity in terms of recommendation relevance and accuracy. Only by providing a strong focus and proving the applied policies and concepts, can we establish a large user base for a mobile recommender system.

In this chapter I describe possible solutions to the problem domains of security and trust in a push-based recommender system of the type discussed in this paper.

### 6.1 Security

Security is related to a wide range of elements, entities, and operations in the system. I will start out with secure communication, and then talk about security related to external context services and last but not least data management and the integrity and confidentiality of personal information.

The communication between the system and service provider and consumers is potentially packed with personal information and preferences. The consumers personal or the provider's business profile represents as such the most sensitive information in the system with names, addresses, e-mail address, civil status, credit card information, etc. So it speaks for itself that all communication between actors flowing across the public Internet must be encrypted to avoid eavesdropping.

The security related to data management and confidentiality of information provided by both providers and consumer is of vital importance. As the data contains personal information, though for the consumer not very much more than would be found on any social media system or by doing a lookup on the Yellow pages, it does provide a link between the individual and preference. This link would be indeed interesting both to other recommender systems and other actors with honest or dishonest intentions. The security policy adopted by a recommender is that the data do not leave the system in unencrypted mode and that indeed the most personal data, stored location data, and preferences are kept encrypted also in the database.

Another key security feature of the system is authentication. Service provider and consumer interfacing with the system must authenticate with a unique username and password. This also applies to the communication with professional context service providers. All external systems must be authenticated in order to know that we are talking with the right service. An encrypted communication channel must be set up before information transfer can occur. The external system shall only provide information and never be allowed to request information. The information obtained from the external context provider must be scanned to identify potential attacks, like sql injection or others. Only information in text format shall be allowed. Binary data is not accepted as valid input from an external system into the system core applications.

### 6.2 Trust

Trust is closely connected to the ability to control the systems around us. Trust is associated with professional conduct and confidence. I may speak about the security measures implemented in the system from a technical point of view and the user will still keep his skeptical position. It is only by building a good reputation in terms of appropriate and functioning control policies, privacy of data, and reliable functionality that a system can win trust with the consumer.

Any new technical system is likely to draw the attention of users with a personality profile characterized by curiosity, technical interests and abilities, and perhaps a higher tolerance of possible failure. These are the people which will approve or disprove the system. An approval from this initial group of people will pave the way for the next group of users who require more predictability and stability than the first group. This is the primary road to success for any product or system. A recommender is also recommended.

The AdvertLBS system attempts to establish trust by allowing the user to freely configure the system as he sees fit. The user is not a passive receiver of information from a source he doesn't know anything about. The user is involved and is made aware of the system responsibilities related to privacy and security.

Also, the user can choose to reveal more personal information as he become comfortable with the system. This gradual intimacy with the system is likely to motivate the user to both use and grow with it.

The user may request that information be deleted within regular intervals. The user is offered a try period after which all information about the user is eradicated.

But only in the long run is it possible to establish a true sense of trust with the system. The system must prove itself by providing relevant recommendations. Relevant and meaningful

recommendation is based on provisioning of relevant and qualitatively good context information and profiles.

An effective service monitoring model will keep the service space free from bad services and unwanted content.

## Chapter 7 – Architecture and Platform

The proposed AdvertLBS system is described graphically in figure 7 a). The system communicates with end users on a web portal. Additionally it communicates with the service consumer via an application running on the mobile handset. In order to collect context information, obtain geographical information, weather services, and other context data it implements web service interfaces.

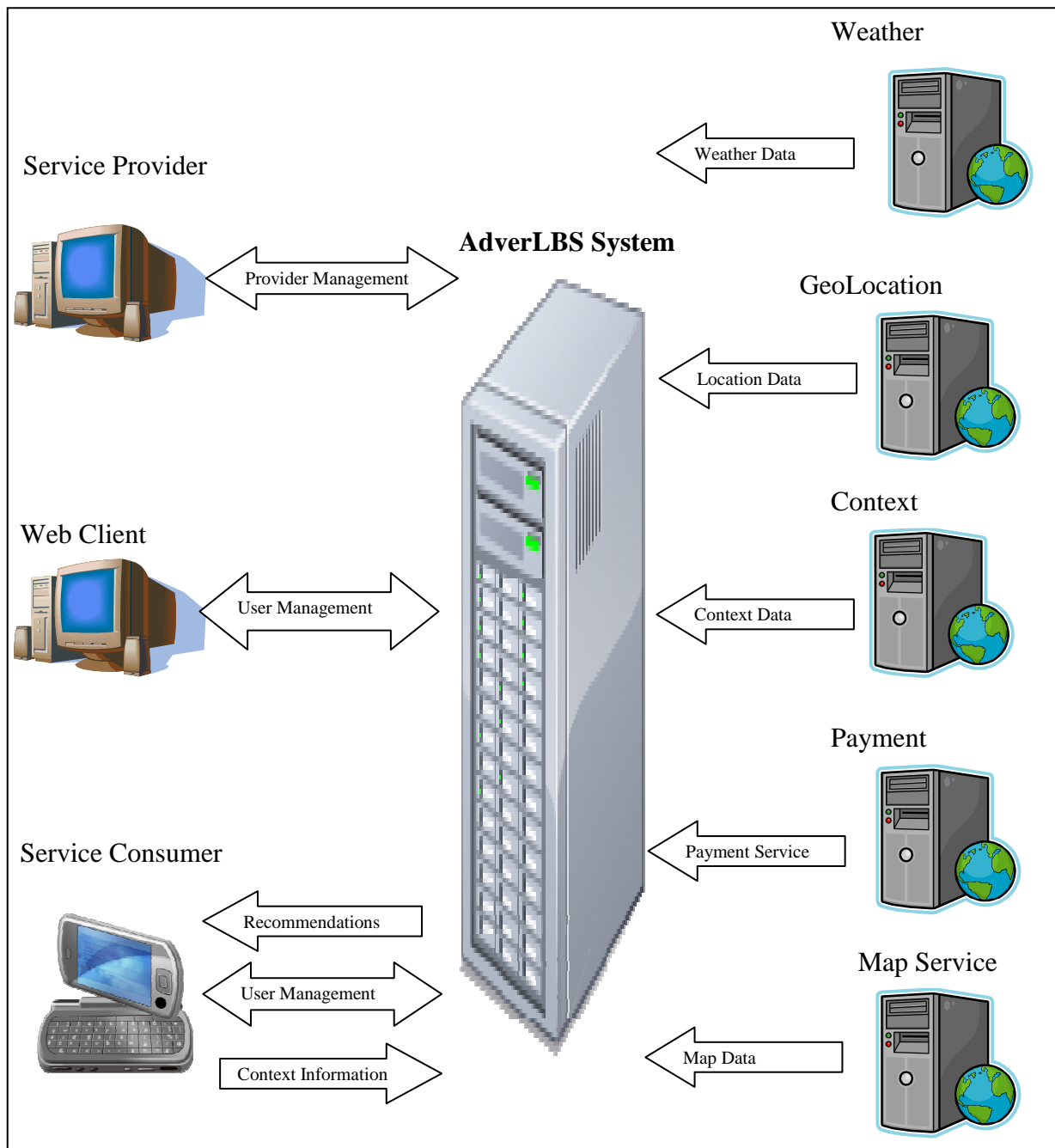


Figure 7 a) The AdvertLBS system.

## 7.1 System Deployment Diagram

I present a system deployment diagram which serves to illustrate the entities involved in the system. The system consists basically of a communication front-end, a processing back-end, a data center, and external services. The service provider communicates via web portal. The service consumer registers and does housekeeping issues via the web server and receives recommendations and is able to perform simple modification to profiles and preferences on the mobile application.

The packages in the system illustrate functional components.

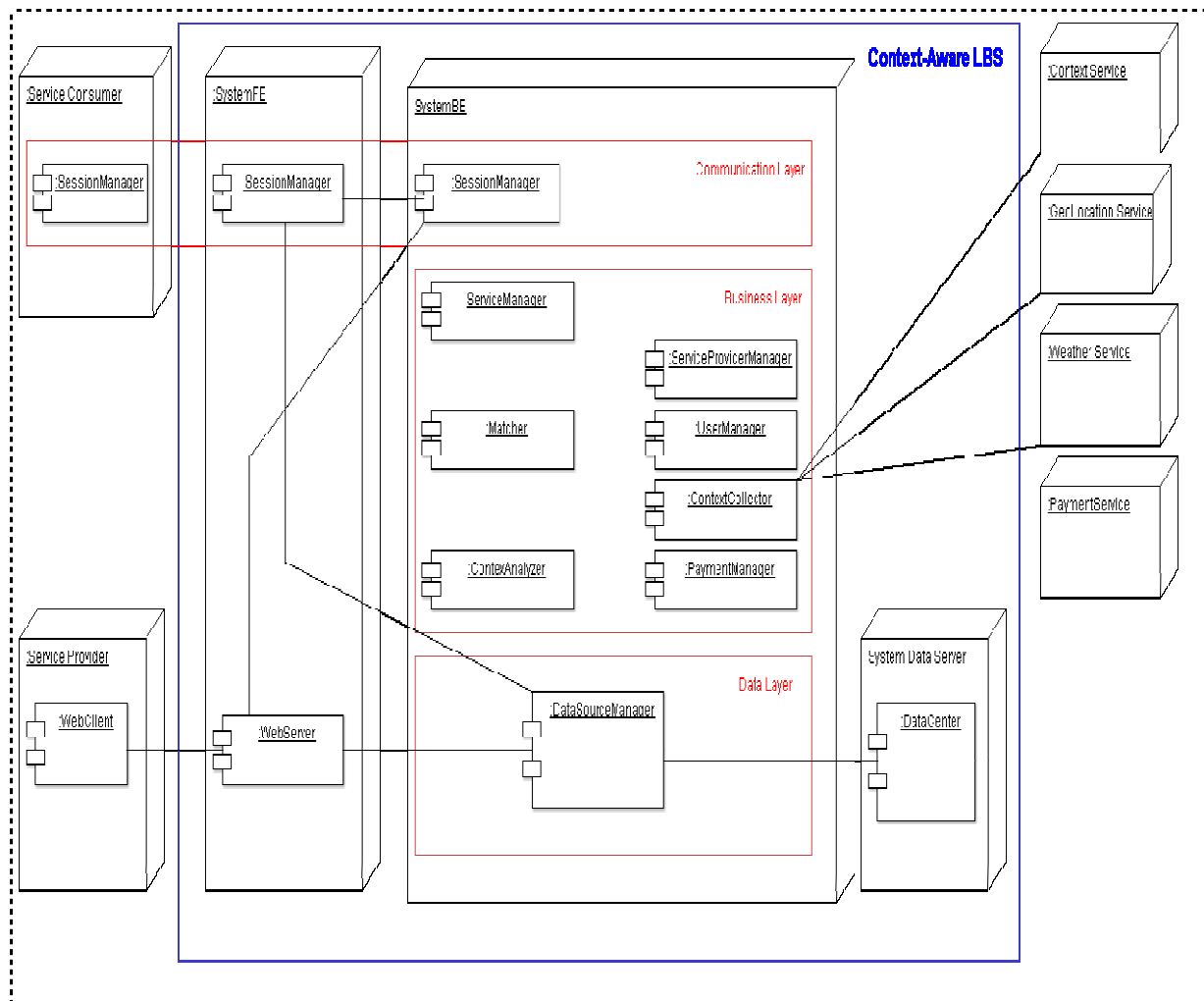


Figure 7.1 AdvertLBS deployment diagram



### **7.1.1 Front-End Subsystem**

The front-end subsystem is responsible for the communication with the end-user (consumer). The front-end create and manage communication sessions with the consumer. It offers communication services to the mobile service consumer and to the back-end subsystem.

The front-end server is also responsible for authentication of users. This is considered a front-end issue as it will act as protective layer before the back-end system. A web server hosting the AdvertLBS web portal is located in the front-end subsystem.

### **7.1.2 Back-End Subsystem**

The back-end subsystem is exclusively responsible for maintaining consumers, service providers, context provisioning, representation, management, and production of recommendations. The back-end can request a communication session to be set up towards an end-user (mobile user).

The back-end consists of database servers which contains a structured representation of all context information in the system.

### **7.1.3 Service Consumer**

The service consumer (user) is the receiver of service recommendations. The user is equipped with a mobile phone application. The application is simple in terms of operation and gives the user a few select functionalities, including reception and display of recommendation messages, simple preference profile management, provisioning of service ratings and access to application settings. The application run in the background and does not interfere with the normal operation of the handset. It displays an icon or a produce a configurable sound when a recommendation message is received.

All communication between service consumers via the web portal is encrypted over https. The communication between the mobile application and the front-end is also encrypted; this applies for profile modifications, recommendation messages, and location updates.

### **7.1.4 Service Provider**

The service provider registers services (advertisements) in the system via the system web portal. A service provider is given a user and password is able create service, administrate existing services, view statistics.

All communication between service provider and web server uses secure http (https).

### **7.1.5 External Services**

The external services provide context information which can be used to increase the level of context information to be used in the recommender logic. I will present some of the services used by the AdvertLBS system.

#### ***GeoLocation Service***

A geographical location service provides location coordinates (longitude, latitude) based on valid addresses. There are many providers of location coordinates and in a commercial system the geo-location provider should be an established organization or business. I have opted for a simple solution for this version of the AdvertLBS and uses Yahoo GeoLocation web service to fetch location coordinates for given addresses.

This service is primarily used during registration of service consumers, service providers, and service profile registrations to fetch longitude and latitude coordinates from registered addresses.

#### ***GeoMap Service***

A geographical map service provides maps, marked maps, and routes on maps. This is used by the AdvertLBS to provide the user graphical tool to produce service location and geographical restrictions to the preference profiles.

The geographical map service is typically used to fetch section of maps with embedded routes that is appended to recommendation messages.

#### ***Weather Service***

Provide weather information in specified areas and regions. The weather reports must be kept updated on a continuous basis as it might not just influence what kind of service is recommended, but actually block any attempts to recommend services at all.

#### ***Context Service***

This is currently just a placeholder for other context provider services which might prove valuable depending on the work area the system operates in.

## Chapter 8 – Evaluation of Proposal

In order to justify and explain how the AdvertLBS system realizes the system requirements I will follow two paths of reasoning, first I want to explain how the architecture covers scope of the requirements. In this section I will also refer to other proposals and show that the system takes great care to Second, I will show how the proposed solution and architecture comply with the WWRf guidelines for I-centric services.

### 8.1 Evaluation of Requirements

In this section I discuss and explain the reasons of why I consider the proposed system architecture fulfill the requirements and the design rationale expressed in the problem statement. I will first evaluate the actual recommendation logic adopted in AdvertLBS.

#### 8.1.1 Recommendation Accuracy

The recommendation logic is based on knowledge-based and collaborative filtering algorithms. The algorithms complement each other in the following sense: the collaborative filtering produces rather bad recommendations when there are few users or the number of ratings in the system is few. This limitation is resolved by the knowledge based logic which contains both static information provided by the user and inferred knowledge learned by the system.

#### 8.1.2 Registration

There are three issues I would like to reason about related to the registration requirements presented in section 3.3.2.

First, a push-based recommending system operating towards mobile users must be partly based on knowledge and information provided by the users in order to avoid the cold start problem which affects the efficiency and accuracy of learning algorithm operating in an environment where there are few opportunities to learn from user activity. The user must tell the system something about self to get it started. Later, when the interactivity and the number of user's in the system grow, the system will start to learn more about the user and new paths will be established through the recommendation logic.

The AdvertLBS system solves this problem by forcing the user to register a tiny amount of preference information to get the recommendation process started.

Second, from a legal and ethical point of view it is necessary to gain permission to track the location of the user and to be allowed to push recommendations onto the user's mobile handset. The proposals in this thesis suggest an implementation which will secure that the consumer is made aware of, by being forced to register, these system activities.

### **8.1.3 Location Updates**

Use case 3 in section 3.3.2 state that the consumer must transfer location coordinates to the system. This is needed in order to enable the system to reason about proximity to relevant services.

The location update model, described in section 5.2.2, chosen for the AdvertLBS is based on recognition of the need to limit the amount of updates received by the system, but still receive the significant updates which occur when the mobile user close in on relevant services. Three methods were chosen: geographical filtering, distance-based, and query based.

The geographical filtering mechanism will ensure that the mobile application only transfer coordinates if the user is within a pre-defined geographical area of interests, i.e. an area where the user wants to receive recommendations given the presence of relevant services.

As it is likely that most users will not define geographical areas of interest another method was required to limit the number of location updates. The distance based approach was adopted as this method requires that a certain distance be travelled between each location update. The advantage of this is simplicity and that also the speed of the user can be inferred by the system based on the frequency of location updates. In most cases this will eliminate unnecessary network traffic as it enables the mobile handset to know when to send updates.

Once inside an area populated with services, both relevant and irrelevant, it might be necessary to speed up the location update to improve the precision of the user location. As the mobile don't know where the services are it was deemed necessary to enable the system to request more or less frequent updates.

By combining these three methods the location update model provides the following advantages: reduction of location updates, flexible update frequency based on proximity to relevant services.

### **8.1.4 Knowledge and Context Elicitation**

As a reaction to the current trend within research in the area of LBS's, LBA's and recommender systems in general to focus on optimizing learning algorithms and prediction algorithms I decided to place the subject matter in a broader perspective where the customer is in control and have the opportunity to both improve the system and to shape his own experience of the service. I suggested viable solutions to context provisioning and showed representation of context information.

I believe it is essential to involve the user in the system. This is one of the primary reasons for adopting the knowledge-based approach in AdvertLBS. I claim that this is indeed necessary to establish the necessary trust with the user base. By involving the user and let him decide how much or little he wants to contribute we immediately establish a connection between the user and the system. Once this initial rendezvous has is over the systems collaborative filtering algorithms will continue to improve the knowledge and context around the user and provide better service recommendations.

### **8.1.5 Service and Recommendation Rating**

Requirements related to service and recommendation rating is considered to be covered in the AdvertLBS system by implementing a simple mechanism which rate the content of the service and at the same time provides feedback on the actual recommendation.

The service rating scale is divided into five levels represented by integers from 1 to 5, ranging from very bad to excellent. This scale is simple, but gives the necessary information to compute average ratings, identify and form collaborative groups, and provides context information to the content-based algorithm.

The recommendation rating tells the system if it should continue recommending the same kind of services or not.

## **8.2 Evaluation of Compliance with WWRF I-Centric Model**

In this section I will explain how the AdvertLBS system adhere to the I-centric guidelines stated as the leading design guidelines in the very beginning off this paper.

### **8.2.1 Personalization**

The systems primary concern is to produce relevant recommendations to the consumer. This noble concern will also gain the service provider.

In order to produce good and relevant recommendations it is necessary to have knowledge about the consumer. There are essentially two ways to obtain knowledge about the consumer, either the system learn or the consumer provides the information manually by filling out forms or by some other means.

Once we have knowledge, the system seeks context information, such as location,

In a mobile recommender, learning based on rating of services or collaborative-filtering requires a large group of users. In literature I have surveyed there seems to be agreement that it takes too long time to become effective and accurate. An example of this can be found in [11].

It is important to bear in mind that the user is entirely free to provide a very shallow preference profile in order to receive more recommendations. Personalization also means that the user has a responsibility to improve the recommendation relevance and accuracy, or at least that he can affect it by specific actions, such as improving profiles and rating services.

### **8.2.2 Ambient Awareness**

The location update model ensures that we are made aware of the consumer location when he is in geographical areas where he wants to receive recommendations. Further, the system constantly monitors the user in terms of service ratings, changes in profiles, and notices when GPS signals disappear indicating that the user may be inside a building or just turned off the GPS device or mobile handset altogether.

There is not much the system can do towards the user when location updates are missing. The system must patiently wait for a new update.

Ambient awareness in terms of location awareness and changes in profiles, ratings, service history is central part of the AdvertLBS system and the mechanisms are described in this paper.

### **8.2.3 Adaptation**

An adaptable system is capable of delivering service in different situations. The proposed AdvertLBS system is capable of delivering services to mobile handsets based on location-awareness.

The primary weakness which makes the system fail is when there are no location updates available and the system lose track of the consumer. This is a likely scenario in cities with tall buildings or when the user move indoors.

### **8.3 Comparison to Other Location Based Services**

I mentioned briefly three papers which describe location based service recommendation in section 1.4.

The Dynamos approach described in section 1.4.1 is not a business marketing system as such and does not provide a fair comparison, but it is within the same domain and proposes user profiling with registration. The recommendation algorithm is based on knowledge about context. The system is however a social system where users can add content and tag locations and places with comments. It is a viable solution for this kind of systems as the system encourages the user to actively use the system to provide information, tag locations, etc.

The AdvertLBS system mirror elements of the Dynamos solution, but as it works in a professional arena of business and advertisement it does move in the direction of transparency, of only being present when there is something valuable and relevant to inform to provide the user with.

The CityVoyager system described in section 1.4.2 is rather technical attempt to implement a push-based advertisement system based on GPS tracing alone. As we have seen this is not nearly good enough.

The Bluetooth LBA described in section 1.4.3. The major drawback with this proposal is the lack of personalization and profiling leading to a very high frequency of irrelevant recommendations which tends to annoy the consumers. This problem is solve in the AdvertLBS system by personalization and profiling is described in the paper.

## **Chapter 9 – Conclusion and Further Work**

The research in this paper has focused on a broad range of factors related to realization of push-based LBS. I have investigated and proposed a viable solution of a system called AdvertLBS and provided a qualitative evaluation of the requirements and shown compliance to the WWRF guidelines for future information services: personalization, ambient awareness, and adaptability. The evaluation show a system which promises to dramatically improve the performance, trustworthiness, accuracy of push-based LBS's in mobile pervasive environments.

It is hoped that his thesis will provide the theoretical basis for an actual implementation of the system, followed by a quantitative analysis of performance and accuracy related to service recommendations, rating mechanisms, service monitoring, and the context provisioning mechanisms.

There are also improvements in terms of harvesting context information from other sources than I have described. The reliance on GPS to provide location information and GPRS/UMTS mobile networks as a carrier of information is obviously not enough and other methods should be investigated; also indoor location tracking using WLAN or Bluetooth could be a feasible way to follow up in order to improve the recommender even further.



## References

- [1] Oriana Riva a; Santtu Toivonen: The DYNAMOS Approach to Support Context-aware Service Provisioning in Mobile Environments
- [2] Yuichiro Takeuchi and Masanori Sugimoto: An Outdoor Recommendation System based on User Location History
- [3] Badrul Sarwar, George Karypis, Joseph Konstan, and John Riedl: Analysis of Recommendation Algorithms for Ecommerce
- [4] Loren Terveen and Will Hill: Beyond Recommender Systems: Helping People Help Each Other
- [5] Robin Burke: Knowledge-based recommender systems
- [6] Emmanouil Vozalis, Konstantinos G. Margaritis: Analysis of Recommender Systems Algorithms
- [7] Axel Kupper and Georg Treu: From Location to Position Management: User Tracking for Location-based Service
- [8] MUKUND DESHPANDE and GEORGE KARYPIS: Item-Based Top-N Recommendation Algorithms
- [9] Robin Burke: Hybrid Recommender Systems: Survey and Experiments
- [10] WWRF Briefing WG2-br4 –Strategic Vision: [wg2.wwrf.org/documents/Briefings/WWRF-Briefing-WG2-br4.ppt](http://wg2.wwrf.org/documents/Briefings/WWRF-Briefing-WG2-br4.ppt)
- [11] Ahn, Kim, Han: Location-Based Advertisement Recommendation Model for Customer Relationship Management under the Mobile Communication Environment
- [12] Aalto, Gothlin, Korhonen, Ojala: Bluetooth and WAP Push Based Location-Aware Mobile Advertising System
- [13] Badrul Sarwar, George Karypis, Joseph Konstan, and John Riedl Analysis of Recommendation Algorithms for ECommerce