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Location-Based Services

A Guide to Location Based Social Networks - Foursquare

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ABSTRACT

Mobile devices (tablets, smart phones, laptops) are proving themselves to be the main means of accessing information of the future. The embodiment of *Recommender Systems (RSs)* into mobile environments, as a matter of fact, has come about to serve as a way to solve the nuisances of data overwhelming. RSs' main advantage is their ability to allow users to find useful information according to the users' preferences and location. Even though they are not free of shortcoming such as the limitation of mobile devices' function capability, the instability of wireless networks in remote regions or the lack of experience of end users, location-aware recommender systems are blessed with two great characteristics: "location-awareness" and "ubiquity" (the ability to be available anywhere, anytime needed). The combination of recommender systems, users' location data and social networks has paved the way for a new type of mobile service: *Location Based Services (LBSs)*, a promising and sophisticated trend for the future of data services. However, LBSs do contain threats due to their ability to determine almost exactly the location of the service users. To make matters worse, since the concept of LBS has not been introduced for long enough time, even people with vast technical experience are not fully aware of such threats. So as to guarantee that LBS-related threats remain at their minimum level of sabotaging ability, several mechanisms dedicated to protecting the location privacy of LBS users has been researched and developed. Such protocols are named: Location Privacy Preserving Mechanisms (LPPMs). Finally, the thesis will dig into the business potentials of LBSs: how would business entities profit from implementing their services on a LBS-based platform and how would customer be pleased to use such services?

Based on the knowledge collected from previous works on LBSs, personal observations and selected interviews of LBS users and experts, this thesis aims at creating a high quality source of references for those who may find it interesting in conducting further studies about LBSs and those who want to get some idea of how LBS-based businesses function.

Keywords: location based service, recommender system, privacy, location based social network, Foursquare.

CONTENTS

1 INTRODUCTION

1.1 Background

The thesis is based on the sole interest of the author for location-based matters. Twenty years ago, it was not possible for an outsider in a foreign country or city to quickly locate an ATM, get some cash and rush to a McDonald's restaurant to grab a nice lunch without the need to ask the locale for direction or running back and forth aimlessly. However, nowadays, a foreigner can confidently locate himself and get to his desired places in short time, all thanks to the development of location-based services.

Mobile communication systems were originally created in order to serve communication purposes. However, with the recent demand from users to have data and transaction services implemented within their own mobile devices, mobile communication service providers have been investing great a amount of resources into creating location sensitive service platforms. Such services use voice or text sequences as input and return geographical information or recommendations.

In order to create valuable outputs, location-based services require properly functional recommender systems to pick up the most suitable information among vast amount of available data. Basically, a typical recommender system combines knowledge about customers (personal preferences, buying habits...) service items (prices, features...) and the interaction between customers and the location-based service platforms (ratings, likes, dislikes) to recommend services that users are likely to find attractive.

However, location-based services are not free of problems. Since they deal with a large amount of data and some of the data is very valuable and sensitive, location-based services have become favorite targets of hackers and data thieves who are skillful and willing enough to get themselves any piece data they want. In location-based services, knowing a user's information usually means knowing that customer's location and whereabouts, which means jeopardizing the user's privacy and security. The knowledge intended to help provide customers with better choices now, having fallen into the wrong hands, becomes an effective weapon against the customers and the service providers themselves. In order to protect their customers' data from intruders, location-based service providers must know what threats they are dealing with and design systems and mechanisms that are able to protect their customers' information and privacy.

Of the available location-based service currently, the social network named Foursquare has proved itself to be one of the most successful participants of the location-based playground. Foursquare has been able to see through the market value of location data and therefore identified the right sector of location-based service to do business with and has managed to, to some considerable extend, satisfy and attract users with timely and pleasant services as well as resolve nuisances and threats that would occur. Foursquare will be introduced in this thesis alongside theories as examples.

1.2 Research Objective

In fact, countless people have been using location-based products for a long time yet not being aware of the true nature of what they are using. To some extents, this lack of knowledge is dangerous because, since people have no clear idea about several aspects of the services they are using, they are exposed to location information security breaches, which may result in disastrous outcomes to the privacy, repuation or even physical well-being of the naive users. In the thesis, an entire chapter is dedicated to studying data security threats of LBSs. This means a considerable amount of clear, simple yet refined knowledge of LBS security that could be easily understood by any average citizen who wants to know and try to protect himself while using LBSs. In addition, the thesis also includes a large section of business-related matters of LBSs. In other words, anybody starting a business can consider the thesis a reliable source of reference to get some idea about what does it mean to do LBS business. Finally, the thesis will come in handy for people who are considering using the Foursquare social network. The thesis utilizes the features and characteristics of Foursquare as the basis to compare, contrast and explain several aspects of LBS, meaning that multiple important points to be considered when deciding whether or not to join

Foursquare are included in or can be answered using information provided in the thesis.

1.3 Thesis Structure

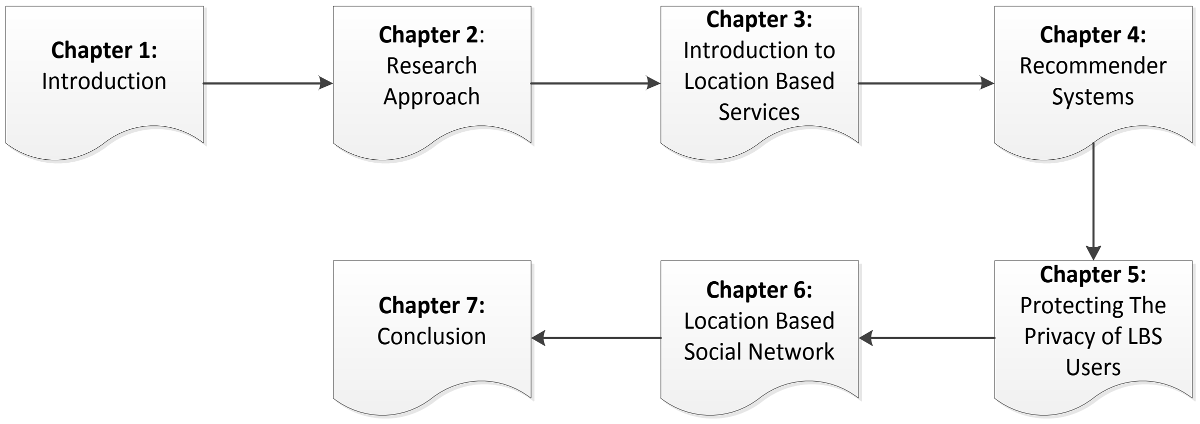


FIGURE 1: Thesis Structure

2 RESEARCH APPROACH

2.1 Research Question and Motivation

Research question: *What value must location-based technologies possess in order to match with the current business environment from the user point of view?*

The research question belongs to the explorative type. The thesis, by giving information and solutions for the above mentioned theories and problems, aims at providing readers with a carefully studied overview of location-based services, recommender systems, security threats and practical application of location data into the service sector. Upon completion, this thesis will become a valuable and reliable source of references for researchers who have just started studying about location-based services because the thesis address problems and theories in the simplest way possible, at the same time using the most basic terms so non-native English speakers won't find it difficult getting used to terms and grammars of the thesis. In addition, this thesis will benefit start-up businesses who dream of taking share from the profitable location-based service sector thanks to the fact that not only technological but also economic matters are discussed in the thesis.

2.2 Research Methods_ Inductive vs. Deductive

In order for the correct research method to be chosen, the nature of each research method must be understood. In the deductive approach, theories are research from general to specific levels. Researchers conducting deductive studies observe what have already been available and draw some conclusions about existing theories or phenomena. In the thesis, the most significant application of the inductive approach is answering the research questions. In addition, some other theories will be developed using inductive methods.

In the inductive approach, ideas and topics are given by introducing observations, material analysis and other context-based sources and then examined by the researchers to access broader data levels or to test if the existing hypotheses are correct or there is still room for improvement. In simple terms, to follow the inductive research path is to begin with a topic and develop that topic into generalizations (Neuman, 2003). Across the thesis, the inductive method is the more commonly used between the two approaches, most commonly applied to introduce and describe theories.

2.3 Literature Review

Literature review is done by collecting information from published sources such as books, news articles, reports, presentations from the libraries or recommended by professors and other electronic sources available across the internet. Data obtained using this method are analyzed, refined and presented across chapters 3 through 5, which introduce the most important topics involving the development of location-based services, including the very concept of location-based service itself. In chapter 6, literature review based data participate in developing the chapter content and structure but only as supporting platforms.

2.4 Empirical Data Collection - Interview

Secondly, empirical data is collected through personal interviews. No other information about the interviewees, except their ideas are provided in the thesis so as to protect the privacy of the interviewees. Interviews are mainly done between the thesis author and location-based service users and experts. To be specific, the thesis author has chosen sixteen users and two former employees of the social network Foursquare for interview.

The reason for interviewing users is that emprical data is most usually applied in chapter 6 where a customer-oriented study is conducted. This means that customers' points of view matters most for the development of the chapter. However, interviewees are not randomly selected. Only people who are personally known by the author to have spent a considerable amount of time using location-based services and who have exclusive original experience with such servicesare invited for interview so as to keep the interview results in high quality and reliability. In addition, idea exchanges and interviews with some former employees of the social network Foursquare also provide valuable, deep and pratical information and experience in the development of location-based services. Interview based data is noted, analyzed, refined and then combined with theoretical data from literature reviews to test whether such theoretical data is correct and applicable or they are mere unreasonable theories.

2.5 Research Framework

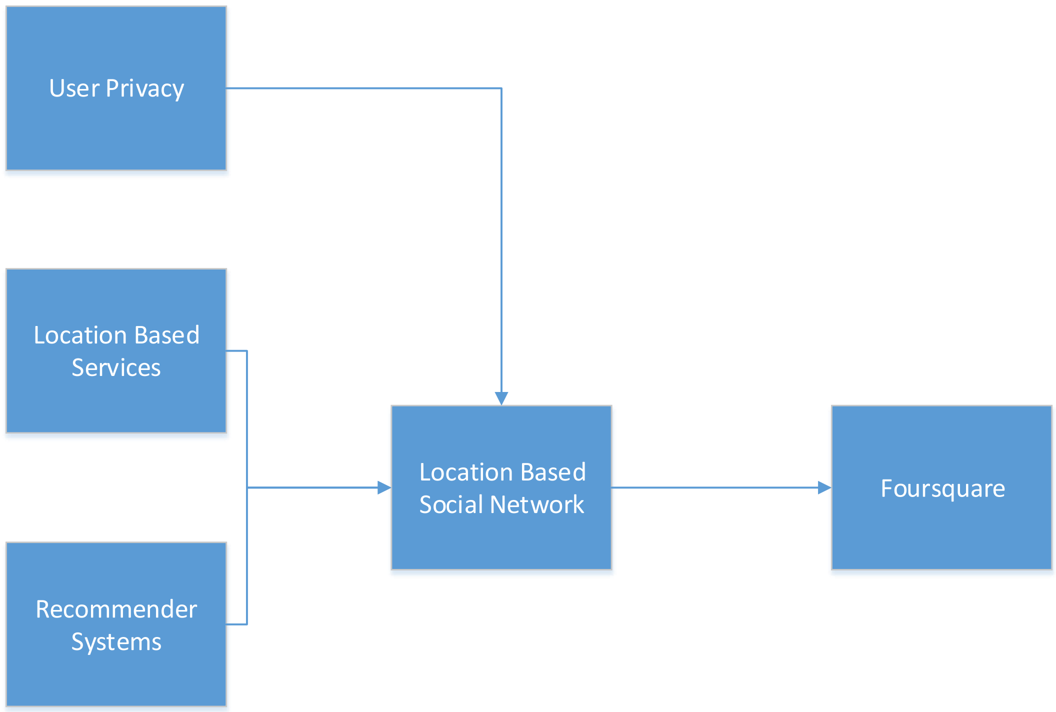


FIGURE 2: Research Framework of the Thesis

3 AN INTRODUCTION TO LOCATION BASED SERVICES (LBS)

3.1 Location-Based Services

3.1.1 The definition of LBS

Location Based Services are information or entertainment applications installed on mobile devices such as laptops, mobile phones or tablets. Location Based Services are able to determine the location of the users through the devices that can obtain their location information via a Wireless Local Area Network (WLAN) or via the Global Positioning System (GPS). With the installed LBS, the devices can, for instance, locate nearby hotels, restaurants or even the whereabouts of some of the users' acquaintances. The function process happens as described: a user provides his location information, a time stamp and a message containing either some keywords or questions so that the Location Service Provider (LSP) can analyze and calculate the user's needs and his demands. After that, the LSP returns a result, which might present a route to the desired places or simply the name and address of the target location (Schiller & Voisard, 2004).

3.1.2 Concepts often confused: LBS versus GIS (Geographic Information Systems)

To some extent, many people tend to have great confusion between the two concepts of LBS and GIS (Geographic Information Systems). It is undeniable that there exist many common points between the two concepts. The most obvious the common points are that both LBS and GIS, since they both have something to do with locations, are capable of providing answer for queries such as:

Where am I?

Is there anything interesting nearby? or

How do I get there?

However, LBS and GIS are actually different concepts.

GIS (Geographic Information Systems) is a technology applied in gathering, analyzing, editing and storing data related to geographic aspects of the Earth. GIS can also be viewed as a kind of database created especially for spatial data. A proper GIS should be able to answer all kind of questions related to the geographic information sciences. Real applications of GIS can be found in the fields of resource management, environmental sciences and asset planning, etc... GIS is relatively old. It started to prosper with the need to process geographic data obtained from satellites and space stations. As a result, GIS requires extensive technological and computing resources.

LBS, on the other hand, is a kind of service that combines and utilizes GIS (and its database) and mobile telecommunication systems to provide answers and guidance for users who need to acquire information from his current or desired locations (Schiller & Voisard, 2004). The user groups of LBS are, indeed, more individual-oriented and less professional than those of GIS. LBS is new compared with GIS. In fact, LBS originates itself from GIS and is the intersection of several different technologies: GIS, GPS, mobile telecommunication and the Internet.

3.1.3 Types of Location Based Services

LBS, similar to other kinds of service, can be divided in LBS-pull services or LBS-push services. The division is based on whether the provided information comes from the demand of the users.

LBS-pull services: Information is provided upon request of the users (Strout & Schneider, 2011). For example, a user go to Google Maps and start searching for a highway from Helsinki to Rovaniemi or search for a five-star restaurant in Paris from Tripadvisor.

LBS-push services: This kind of service forms the basis for the development of Social Media advertisement. Information is given regardless of the users' request. LBS-push services are most usually activated upon one or a chain of actions of the users (Strout & Schneider, 2011). For instance: a Facebook user just lands in London and connects to a WIFI network to check his new feeds only to find out there is a Vodafone (a UK-based network provider) greeting and advertisement.

However, the LBS-push system is challenged to figure out methods to detect and show exclusively what is appropriate for specific customer individuals or groups so as to avoid becoming intrusive and annoying.

Economically speaking, it is to some extent extremely difficult to gain profit from implementing LBS push services since enormous amount of network resource must be invested in other to constantly update information about user locations and preferences without the actual knowledge of whether the intended customers actually want to hear anything about the recommended services. (Murphy, 2010).

In addition, Location-based services can be classified depending on whether the services are user-oriented or device-oriented.

User-oriented LBS includes those services whose main focus is to determine the location of users or to use such location data to encourage/promote another service. Normally, the located object is in control of the recommended services. For example, friend finder applications allow the user to locate acquaintances within a close distance to him. The user, after receiving the general map of nearby friends, can decide for himself which of the results should he proceed to.

Device-oriented LBS, on the other hands, focus on objects that lack the ability to control the services recommended toward them. In fact, device-oriented LBS are sometimes directed toward human subjects, thought they are not normally designed for such functionality. One obvious example of device-oriented LBS is car tracking services. The services is directly intended to protect the car in case it was stolen or crashed. However, the one who is controlling the service is the car owner while the car itself can do nothing to control the tracking progress. (Kirkpatrick, 2010)

3.1.4 Location Based Services Infrastructure

In order for a LBS to function properly, the combination of the below components is required:

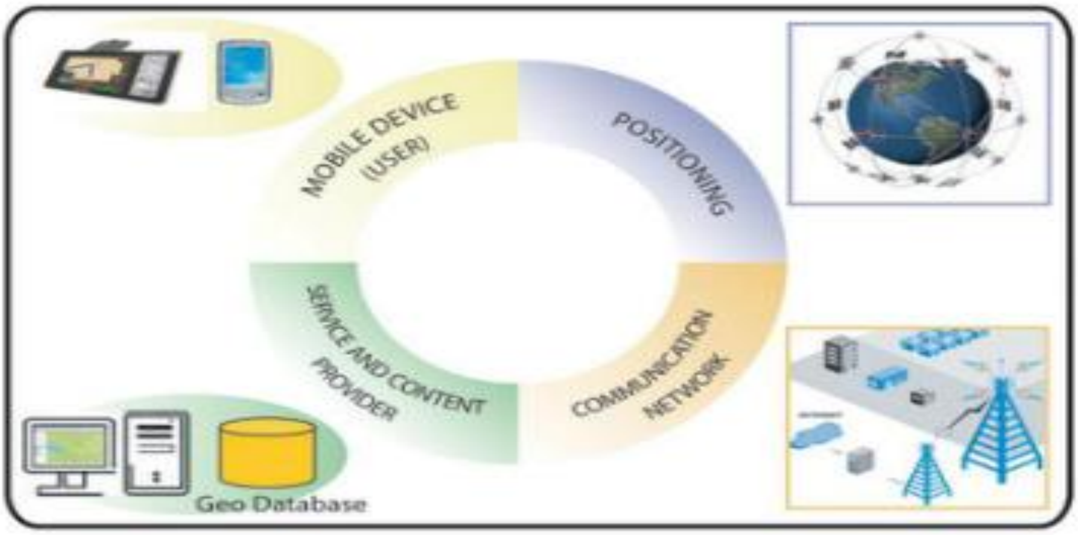


FIGURE3: Components of a LBS

Users & Mobile devices: Users are the operators of the mobile devices and the people who exploit the utilities of other infrastructure components in order to get information. Mobile devices are used to send requests to and receive results from LBS. Mobile devices can be mobile phones, PDAs, laptops, GPS devices or public information stations.

Communication networks: The wireless network plays a vital role in connecting users (through mobile devices) and the LBS providers. The user's requests are sent via the communication network into the Internet then to the LBS provider and vice sera.

Positioning systems: Positioning systems gather and input user's location information into the requests sent to LBS providers. For cases in which the user wants to search for a route, his position will be required to calculate the way to his desired location. When the user demands technical or medical cares, his location information will help the (technical/medical) service providers to provide better and quicker services.

Service and Content Providers: LBS providers distribute the software and services that are able to process the user's query and weaved responses to the user. Content providers (map agencies, yellow pages) store and distribute geographic data that can be requested by the users or the LBS providers.

3.2 Data Collection in LBS

In LBS, location data is collected using different positioning systems; each of the systems provides different aspects and characteristics of spatial data. However, there are basic requirements and general components that make up a positioning system.

Coordinate systems allow LBS data providers to assign different locations with different, unique "address" for the sake of effective and easy geographical identification process. To present locations on a flat space, the choice most often falls the famous Latitude and Longitude model. However, depending on different task requirements and data aspects, other forms of coordinate systems are created and widely used: the Cartesian coordinates, the Shape of the Earth and Universal Polar Stereographic...

Scope

This can be defined as the meaning of the coordinates given. In practice, it would be better if location data services give users names such as "University of..." or "KFC" than showing coordinate numbers.

Coverage

The extent of geographical areas to which the positioning system is able to reach. The coverage is especially related to the scope of the system. However, there are numerous cases in which the coverage level of a system is smaller in area than what is defined by the scope.

Precision

Users and service providers using geographic data must be aware of the fact that the ability of a positioning system to accurately pin-point a location often varies depending on reasons other than the system mechanism. Among the factors that can lead to an inaccurate calculation are environmental conditions (temperature, heat, wind speed...). In short, customers of location data must be ready to often face (from minor to serious) accuracy problems when querying information about locations that usually experience environmental turbulences.

3.2.1 Satellite-Based Positioning Systems

Since the 1960s, the idea of using satellites for positioning purposes has caused great interest. Satellite-based positioning possesses great advantages such as the ability to implement positioning tasks almost everywhere across the globe and the high resilience of positioning process done to environmental conditions and therefore, high precision is guaranteed. Among the satellite-based positioning systems that have been developed so far, GPS proves to be the most prominent.

1984 marks the year in which the first GPS satellite was launched into Earth orbit. In July 1995, the entire GPS system was declared completely functional and was able to work at full operational capacity. The GPS system is divided into three segments: user, space and control. The user segment includes GPS receivers which range from GPS-enabled mobile phones to GPS trackers. Any electronic appliances that can receive GPS satellite signal is considered to belong to the user segment. The price of such devices for civilian usage is generally affordable by average citizens and continues to fall as mobile devices become more widely used among the general population. The space segment comprises of the GPS satellites. The operating system of each satellites is developed with around 25,000 code lines. The satellite hardware weights approximately 2 tons and is equipped with solar cells to be able to generate operative power by itself. Each satellite can expect a functional life circle of seven years before possible replacement is launched. Lastly, the control segment, the headquarter of the entire GPS system, is made up of multiple stations located in Colorado Springs, Colorado, USA. continuously receive, organize and control satellite signal as well as operation protocols (Schiller and Voisard, 2004). GPS services are divided into PPS (Precise Positioning Service) and SPS (Standard Positioning Service). PPS is strictly encrypted in such a way that only USA armed forces possess the right technology to access PPS data and civilian use of PPS is either unavailable or prohibited. The general public is able to use SPS free of charge. However, SPS signal and GPS orbit data were deliberately falsified (the mechanism is named Selective Availability) because the US army isn't fond of the idea that some entities other than itself have access to too precise location data. Besides being artificially manipulated and being designed to resist astmospheric fluctuation, GPS is affected by several other elements such as orbit fluctuation (satellites move away from their calculated orbit, often caused by gravity disturbance), clock error, atmosphere and ionosphere disturbances that distort or disrupt signal transmissions (US Department of Defense, 2001).

Alongside GPS, other satellite-based positioning systems exist. In 1996, Russia brought into use the GLONASS (Globalnaya Navigationnaya Sputnikovaya Sistema), which also employs a double frequencies: one for the public and one saved for army use. However, GLONASS coverage is heavily traumatized due to financial difficulty and short satellite lifetime (around four years). In 2004, the European EGNOS (European Geostationary Navigation Overlay System) was brought into service. EGNOS serves as a correction base which overlay and adjust faulty data from both GPS and GLONASS. (Schiller and Voisard, 2004).

3.2.2 Indoor positioning systems

It is vital that the movement and location of people inside a building be kept track of in order to aid in situations like emergency evacuation and rescue (for example, search and rescue force could know if somebody is still inside a building, their exact location and the number of people that need help when a fire breaks out) or employee work hour tracking (to calculate work hour and salary, the longer a person is sitting in his office, the more work he is dealing with and the more he should be paid). While satellite positioning is known to be a precise and cost-effective means of navigating, it is not free of weakness. It has been proved that satellite signal has difficulty, or even lack the ability to penetrate concrete walls and therefore rendering itself ineffective when dealing with indoor positioning tasks. For this reason, different kinds of positioning systems must be employed so as to improve the task of indoor positioning.

Video-based Installations

In order to implement video-base positioning systems, two basics components are required: cameras and tag patterns. With the two components ready, the positioning process can be done in two ways. In the first, traditional approach, cameras must be installed across desirable corners of the indoor structure. Users should carry the tag patterns with them while moving across the building. In real life, tag patterns mostly exist in form of personnel badges or access cards. As a person moves around, his tag pattern should be detected by cameras. Because the position of the camera is fixed, the position of the person carrying the tag could be determined. In addition, to be able to predict the next direction where the person is heading toward, multiple cameras should be taken into use. When the person is detected by more than one camera, by mapping out the location and order at which the tag carrier is detected by different cameras, one should be able to determine where the person is intending to reach (Ward et al, 1997).

Currently, provided with the fact that almost every person possesses a smart phone with a camera, another method of indoor positioning is created with the same principle as that of the one mentioned above. With the new methods, the moving component is the cameras and tag patterns are stably located across the structure. While phone users move around the building, the phone cameras detect the tags and get information embedded within (Want et al 1992). By analyzing the information, provided that the tags do contain information about their own location, the phones should be able to determine their location, at the same time the users' location, within the construction.

Infrared - Active Beacons

The backbone of the Active Beacons positioning method is sets of infrared receivers fixed at different locations across an indoor structure and mobile beacons whose location varies. Users are equipped with infrared transmitters that continuously send out infrared light beams carrying the users' identification. In turn, each defined area of the structure (usually a room) has one fixed infrared receiver which will detect and read the information given out by the light beams from the infrared transmitter of the users and forward that information to controlling systems to determine the location of the persons carrying the infrared transmitters.

The infrared-based positioning method described above is able to be implemented thanks to multiple factors. Firstly, since infrared beams can't penetrate through solid walls, light beams from the users' infrared transmitters are confined within the room they are actually in only. Thanks to this factor, it is not highly likely for one transmitter to activate more than one infrared receiver at a time, causing confusion and incorrect estimate of user location. Secondly, infrared transmitters consume very little energy. This helps ensure that there won't be situations in which transmitters run out of battery during the working progress, which means the control center losing track of one or more users.

3.2.3 Cellular Network-Based Positioning

With the recent rapid development of mobile devices, cellular network has become more globally available than ever with several billions of people having access to cellular devices. Applying such a readily available system promises to bring about great potential for LBS development and expansion without the need for further investment in infrastructure and facility installation. Among the cellular network platforms in use, GSM (Global System for Mobile communication) is the most well-known for being used in over ninety countries and being the most popular among cellular network platforms. Normally each GSM provider has its own HLR database which records user information. As users move to different location, they are recorded by the VLR (Visitor Location Register) which will relay the information back to the HLR. Each VLR has its own unique LAI (Location Area Identity). Therefore, once the HLR has determined the users' LAI, it is possible for it to determine the location of the users (Borkowski, 1996).

Another cellular based positioning platform is the MPS (Mobile Positioning System) which was forged by Ericsson in close co-operation with the traditional GSM technologies with the hope of creating a positioning system that is more accurate in spatial aspects. In addition to being more accurate, MPS also provides its users with the ability to query and check the location of other users. This feature is especially useful in cases where vehicle owners want to locate their stolen cars or for emergency and rescue services to locate an accident site. MPS employs different mechanisms to achieve positioning tasks. The simplest method is called Cell of Global Identity, using the devices' own ID to determine their location. This methods is however very inaccurate so it is only used when other mechanisms have all failed or become unavailable. The second method, Segment Antennas, use base stations antennas to fragment 360 degrees into smaller, equal sectors, by which the MPS can close in the searching range where the cellular users can be in. Other more complex yet more effective positioning methods are Timing Advance and Uplink Time of Arrival. These methods take into use the signal of several base stations to try to predict and map the route of the users, through which being able to determine the true location of those users with high precision (Ericsson, 2002).

4 RECOMMENDER SYSTEM (RS)

4.1 What is a Recommender System (RS)?

Almost every person has to experience cases in which he has to make a choice without actually having any knowledge or personal experience about the situation. Recommender systems are therefore created to aid people finding themselves in such kind of situation. Recommender systems study customers' opinion about products (price, features, color,...) and customers' interaction behaviors (web browsing history, pages liked on social media networks) to pin point and later recommend products that suite the need and personal interest of customers (Ricci et al, 2011). Such recommendations can sometimes be extremely helpful in assisting customers with navigating amidst a vast amount of data to make a right choice. The most common application of recommender systems can be seen on web-based commercial sites such as Amazon or Netflix.

4.2 Types of Recommender Systems

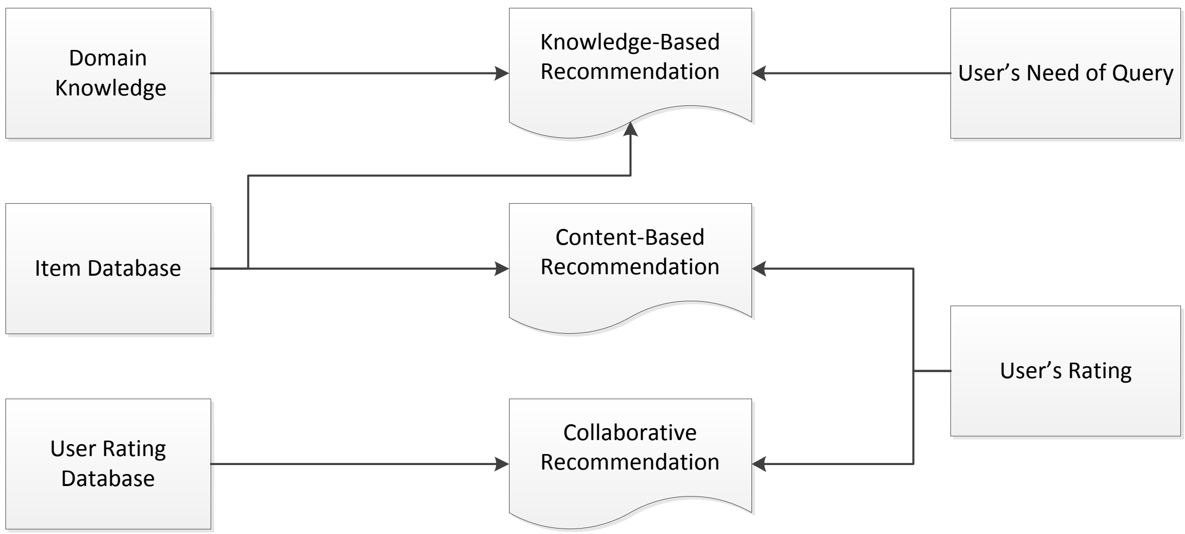
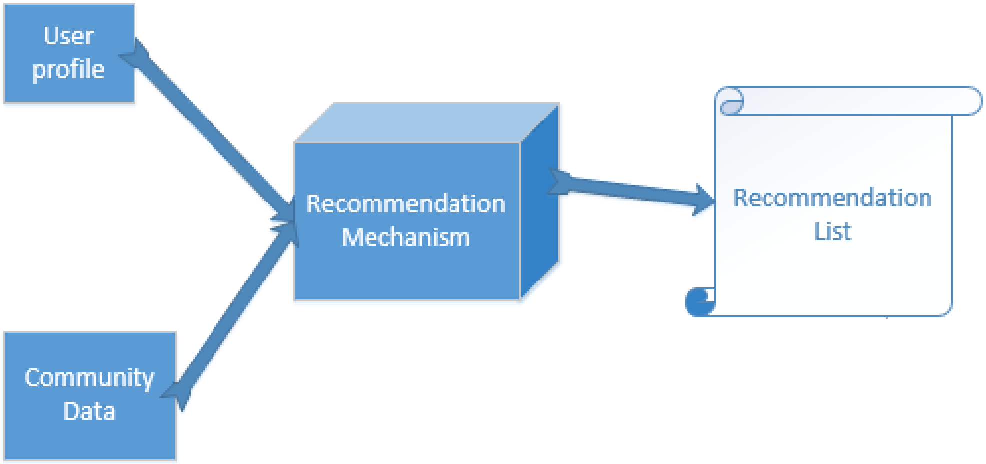


FIGURE 4: Types of Recommender Systems and Their Source of Knowledge

4.2.1 Collaborative-based Recommender Systems (CRS)



ations

Collaborative Recommender Systems utilize Collaborative Filtering (CF), the method of predicting what a customer may be interested in by using preferences made by other customers of the same system (Ricci, et al 2011). The assumption behind the theory of collaborative filtering is that people who were in agreement before will agree with each other again in the future. Firstly, a collaborative-based recommender system will create user profiles by collecting data either explicitly (asking users to rate/rank items on a pre-tailored scale, asking the users to choose the better between two items or asking users to put their favorite products, features on a list) or implicitly (recording user behaviors on websites, recording user purchase/viewing history, analyzing what users like/dislike on social media networks). The recommender system then compares and contrasts the user profiles, marking out the similarities and dissimilarities between the profiles and generates recommendations for the users based on the comparisons and profiles (Ekstrand & Riedl, 2010).

However, some weaknesses and problems do exist in this kind of recommender system, among the problems: Cold Start. The term Cold Start applies to systems that just have been brought into use and therefore haven't acquired enough data and therefore lack or are limited at the ability to give customers proper and useful advices (Gartner & Rehrl, 2009). Bigger and older CRSs which have achieved enormous amount of data and profiles face another kind of obstacle: Scalability, which is very likely to occur when the amount of data is too great and a matching amount of calculation and computing must be invested in order to process the overwhelming data flow (Jannach et al, 2011). Last but not least, Sparsity is another problem that large-sized collaborative recommender systems often encounter. The truth remains that despite great number of items sold on popular and major E-commerce websites, customers tend to rank only a small percentage of those items they actually bought and, unfortunately, are not less likely to vote those items they are not and never intend to purchase. The result of the circumstances is that the most popular items may sometimes receive few ratings while other less significant objects may have better rankings. This paradoxical chain leads to regrettable situations in which unworthy recommendations are shown and those the customers would actually glad to get are bypassed (Jannach et al, 2011).

4.2.2 Content-based Recommender Systems

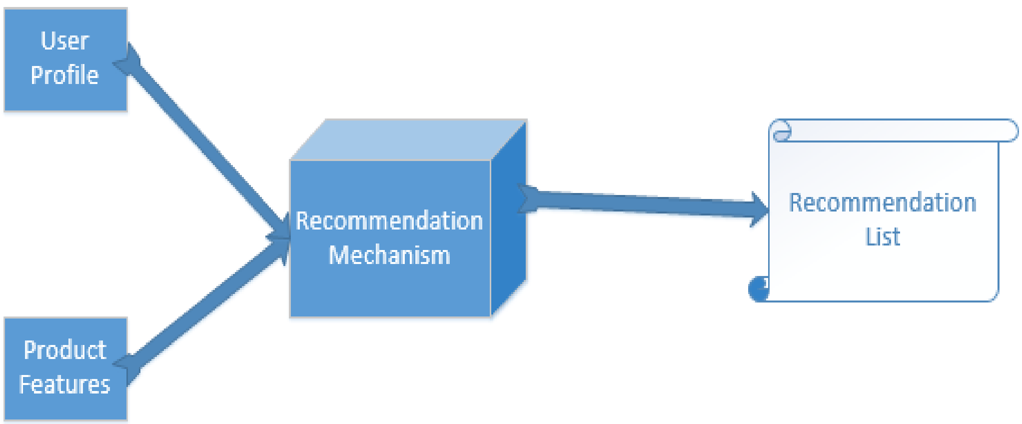


FIGURE 6: A Content-Based Recommender Systems

Content-based Recommender Systems are recommender systems that recommend items for their customers based on each customer's own preferences in the past. Customer behaviors and preferences, most usually in the form of clicking "like" or "dislike" or specific ranking of items by the customers, are collected and stored (Schmitt & Bergmann, 1999). Once the user feedback has been collected, Content-based recommender systems will automatically create user profiles. The recommender systems will then select items that match the features of those falling in the "like" category of each customer profile and send out recommendations. More advanced Content-based recommender systems nowadays are capable of even studying customer preferences of one object category and apply the knowledge across a system of multiple items categories so as to increase the value of each recommendation (Sindhwani, 2006). For instance, if a recommender system is capable of recommending high-quality news articles using information gathered from the customer's history of news browsing, the same system should be upgraded and be able to recommend music, video clips, books or other kinds of products using information from the same browsing history.

Content-based recommender systems, however, suffer from the same start-up problem as their collaborative counterpart: both kinds of system must take some time to gather enough ratings and data if they are to be able to make valid and reliable recommendations. Another drawback of content-based recommender systems is their reliance on information given by the items in the system (Sindhwani, 2006). For example, a content-based system can only give movie suggestions based on information such as actors, genres or published date but cannot utilized fully the very plot of the movies to determine the relationship between the two movies if the plots are not fully and carefully provided. In other words, movies' actual plots are irrelevant in the making of recommendations by content-based recommender systems since the systems lack, or at least having not yet developed, the ability to query information out of the content of the movie. This may result in movies with high relevancy being denied relationships by the recommender systems and, unfortunately, the customers will miss valid recommendations.

4.2.3 Knowledge-based Recommender Systems

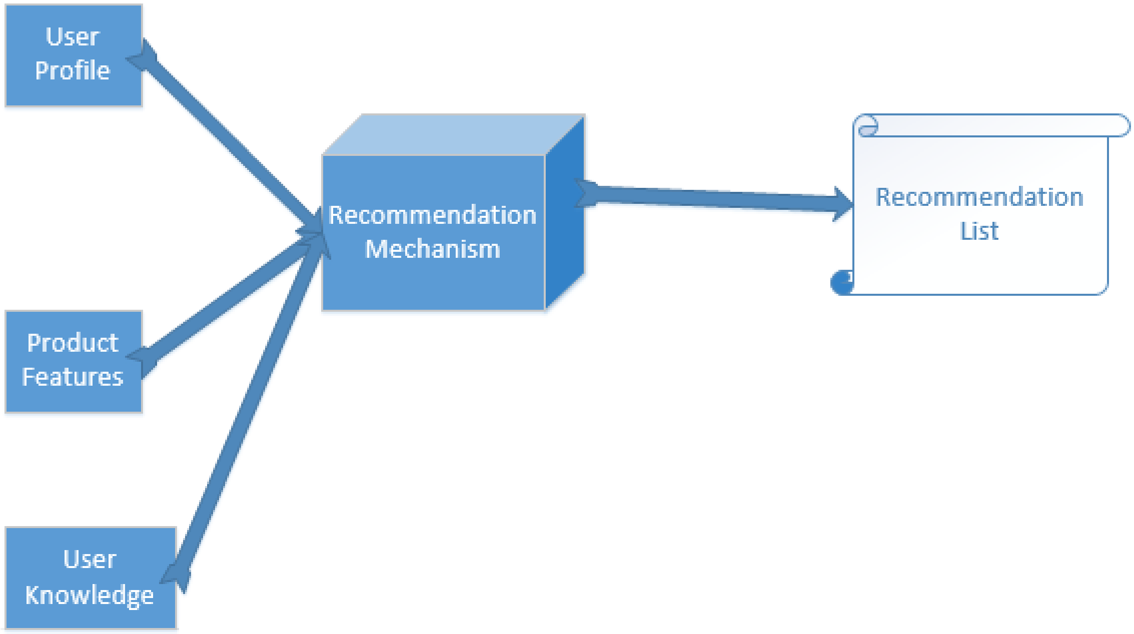


FIGURE 7: A Knowledge-Based Recommender System

Knowledge-based recommender systems make their recommendations using explicit knowledge about the products' given details, recommendation criteria and user preferences and are applied in situations in which other recommender systems techniques such as collaborative or content-based can't be employed. The main advantage of knowledge-based recommender systems over collaborative and content-based ones is that they are free of the infamous "cold-start" and many other problems often encountered by other types of recommender systems. The reason for this advantage knowledge-based recommender systems is that their recommendations are made upon instantly available information given by the items and customers. This fact also makes knowledge-based systems superior to learning-based systems (collaborative, content-based) when dealing with customers whose preferences change over time. Learning-based systems may need some time adapting to the new preferences while knowledge-based systems may respond instantly to the most current needs. (Burke, 1999).

4.2.4 Hybrid Recommender Systems

It is well known that every one of the above mentioned recommender techniques, especially those used in learning-based recommender systems, has its own or similar problems as those of the others (Burke, 2000). Learning-based techniques all together suffer from the famous cold-start problem. Collaborative recommender systems cannot recommend items that are new to the systems and those items must wait until they have received some user ratings (Burke, 2000). Even when user ratings are available for new items, recommendation of such items may be faulty and irrelevant since the rating base has not reached the level at which it correctly reflects user opinions about the items. The Cold-star problem similarly affects users who have just recently joined the system, failing to give valid recommendations for users whose item preferences have not been recorded and studied. The converse of the cold-start problem is called "stability vs. plasticity" problem. In this kind of problem, the trouble comes from user profiles that have been set in a recommender system for a considerable period of time. In reality, there are times when people change their habits and preferences in their actual lives. However, if such changes are usually too sudden for recommender systems to react and make changes in user profile databases. This results in situations in which people are given recommendations about items that are no longer a part of their preferences. For example, red-meat eaters can become vegans at some part of their lives. Since recommender systems that they use fail to react fast enough to match with their new habit, steakhouse recommendations still appear for some time before vegan restaurants begin to show up on the recommended lists. Several adaptive mechanisms have been developed to counter the "stability vs. plasticity". Among them is the "temporal discount" mechanism which decrease the level of influence older ratings compared to newer ones. In this case, if a customer made red meat preferences a month ago and vegan preferences a week ago, the next time the customer has a look at the recommendation list, vegan options will appear instead of steak houses. However, the implementation of the temporal discount method will do damage to data about preferences that have long term effects yet are only occasionally exercised. For example, people will show special interest when the FIFA World Cup happened last time. However, it is not until another four years later that the championship happens again. Running temporal discount in this kind of situation will make recommender systems fail to recommend World Cup related items that used to attract much attention.

Hybrid Recommender Systems (HRS) are recommender systems that function on the basis of combining multiple recommendation techniques to achieve better recommendation performance through applying good essences as well as eliminating the weaknesses of each component recommender approach. In fact, it is undeniable that different methods of the same type of recommender system may perform and yield great results together. However, in this the paper, the main focus is going to be on hybrid recommender systems that gather, combine and analyze data across different sources.

Weighted

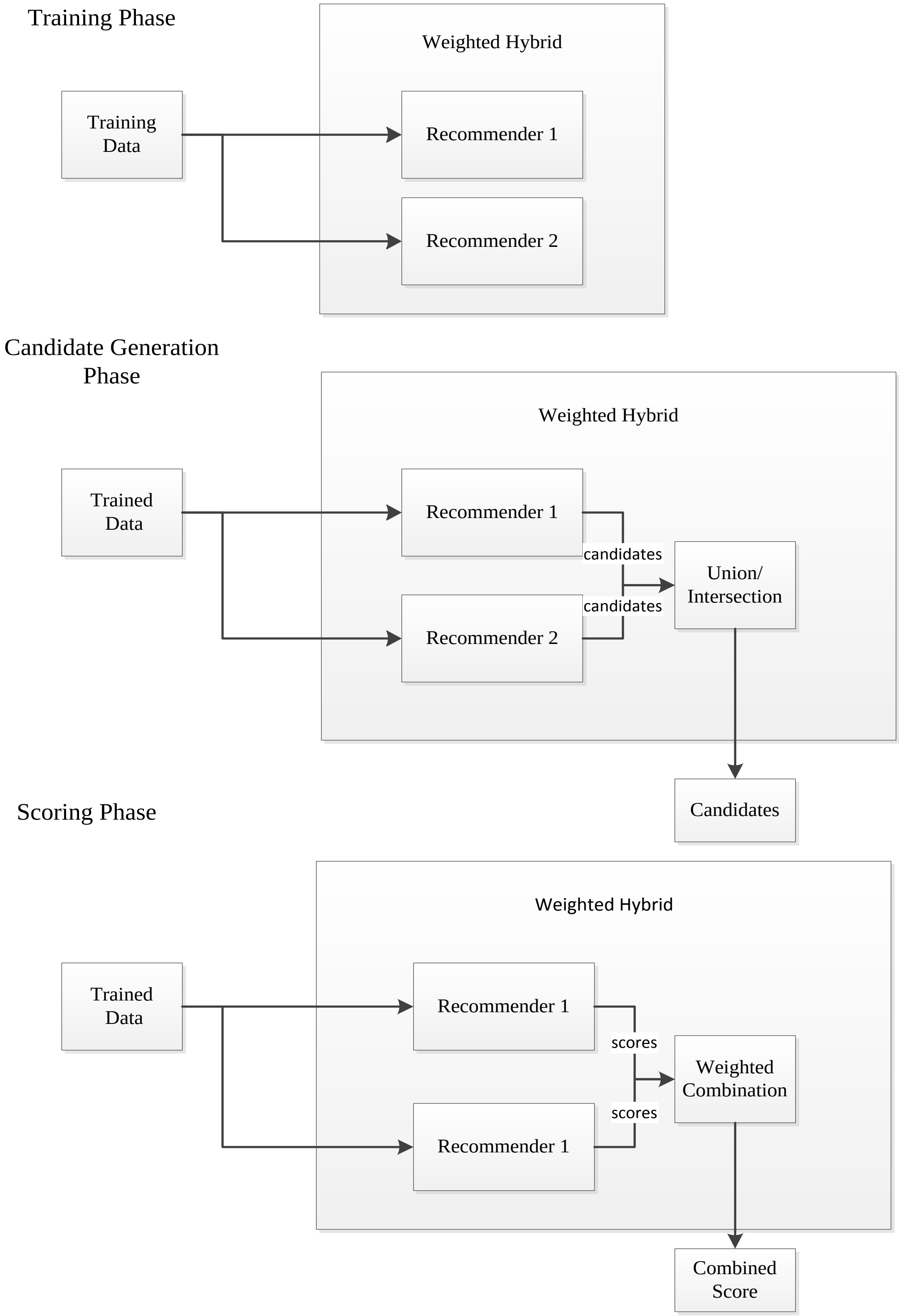


FIGURE 8: A Weighted Hybrid Recommender System

The first and maybe the simplest hybrid mechanism to be discussed in this paper is called the Weighted method. Each one of the recommender components of a weighted systems will give given candidate items a score which will later be combined, using a linear formula, with scores given by other recommender components.

As described in Figure 8 above, the first phase of the weighted mechanism is the training. In the training phase, each component recommender mechanism processes training data. The training process can be understood as a phase in which items' features and data is extracted from the database and classified so that such data is ready for later usages across the recommender systems. This practice is carried out in the same manner across almost every recommender hybrid mechanism. Then comes the process of generating candidate items to be recommended. Interestingly, while some recommendation methods, such as the content-based method, are able to process almost all kind of items (provided that at least some features of the items must be presented, which, in fact, is true almost every time), other approaches are able to process only certain items that come under their coverage (the collaborative recommendation method can only process items that have been user-rated). The point of candidate generation is to limit the number of items that need to be considered by the hybrid recommendation system to only the most relevant ones so as to ensure speedy service rate.

After the generation phase, candidate items are jointly rated by component recommender systems; each recommendation approach has its own way of handling candidates. Normally, either the union or the intersection, each with its own sort of problems, of the candidate sets is considered for scoring. If the union is chosen, the number of cases that need to be processed is normally high and scoring process will get a little complicated. Since it is possible that there will be items that can't be scored by one or some of the component recommender systems, the hybrid must decide either to eliminate the items or to give them neutral scores. When dealing with the intersection of the candidate sets, hybrid systems risks having too few items to score. After that, each candidate item is rated by the component recommender systems using a linear combination approach. At the end of this process are the scores of rated items coming from the candidate sets. Items are then sorted according to their score and those with the highest score are chosen to be sent to the customers (Burke, 2000).

Switching

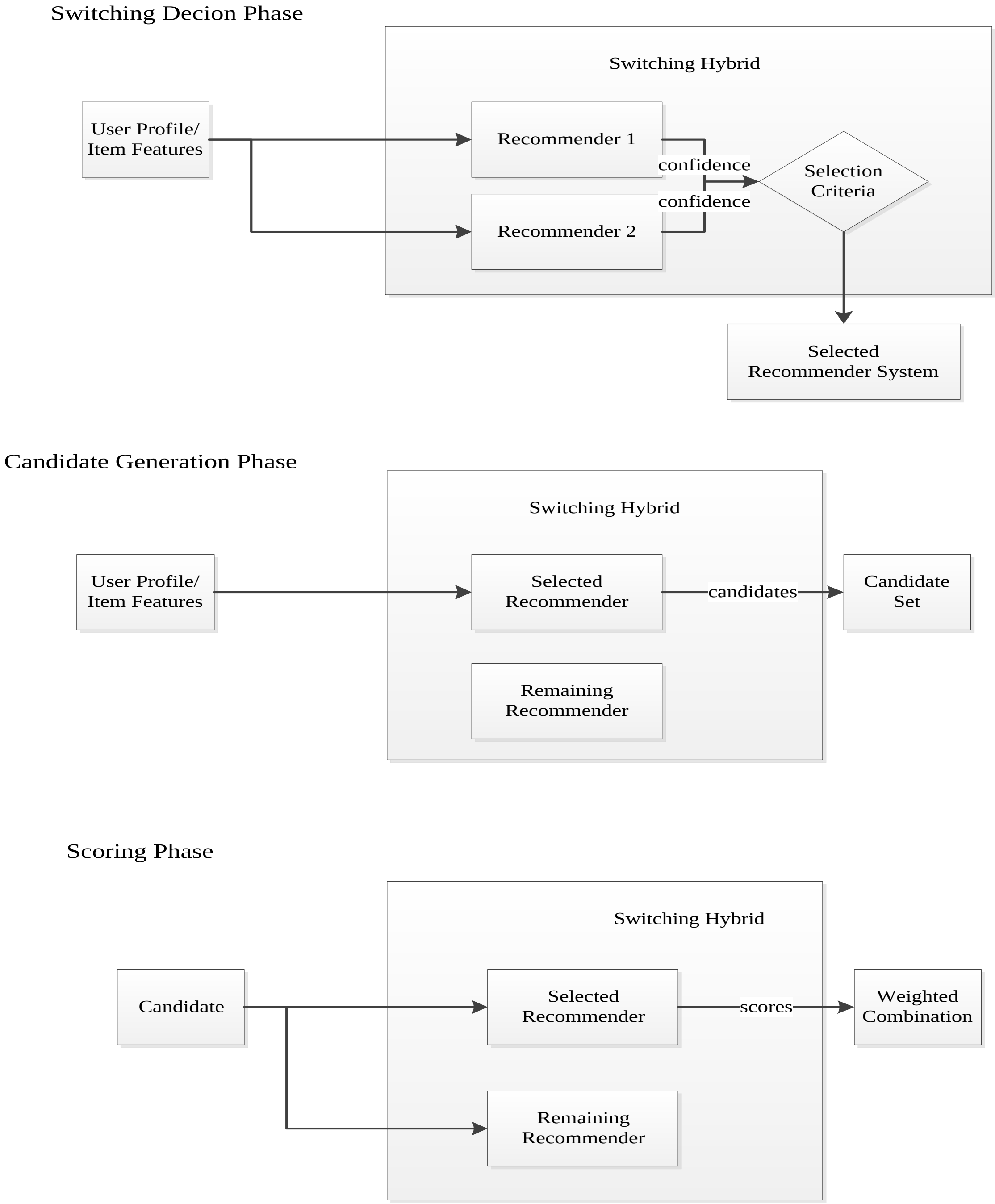


FIGURE 9: A Switching Hybrid Recommender System

Applying switching means a system would apply different criteria to switch among recommender techniques. For instance, in a system that applies collaborative/content-based hybrid, one of the techniques, for example collaborative, would be attempted first. If the first technique fails, the content-based approach will be employed. This kind of approach is implemented based on the idea that certain recommender approaches work perfectly with certain categories of items and users yet are incapable of providing valid output recommendations when applied on other items and user categories. In switching, it is important to define clearly the selection criteria to base the switching decisions on. The point is to create a reliable framework in which recommender approaches are selected so that only the most applicable one is sorted out to be used in each individual case. It is often argued that the switching approach adds extra complexity to the recommendation task since, besides the conventional tasks, the system or system developer must carry out the task of defining the appropriate system selection criteria. However, the advantages that come out of such trouble are considered worth while because, since several selection steps must be taken, the items must undergo multiple filtering layers, which means more carefully sorted item data and only the finest items may be shown as recommendations.

The working mechanism of switching is as shown in Figure 9. Firstly, the hybrid recommender system chooses one of its component recommender mechanisms as the appropriate one for the current task based on the selection criteria. After the decision is made, the remaining mechanisms stop taking part in the recommendation process. After that, normal recommendation activities such as the analysis of user preferences or the selection of items to be recommended take place, depending on the chosen recommender approach.

Mixed

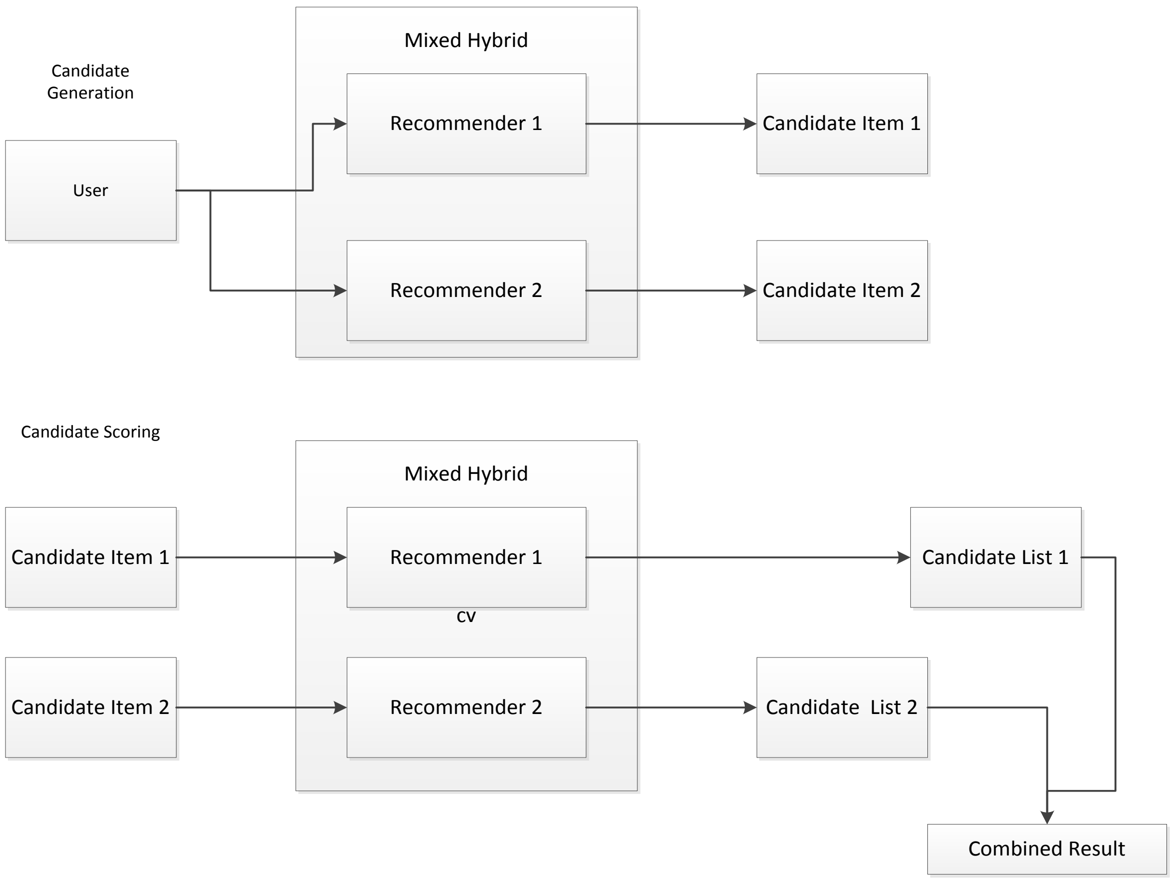


FIGURE 10: A Mixed Hybrid Recommender System

In mixed hybrid systems, recommendation results selected out of different recommender techniques are shown together. For example, to make recommendations for television shows, a mixed hybrid recommender system would first employ the content-based approach to process the contextual description of each show and utilized the collaborative approach to calculate the reaction to the show from past viewers. The results from the two processes will later be combined together so as to decide the recommendation to be shown (Cheetham & Price, 2004).

One advantage of the mixed hybrid systems is that they can avoid the cold-start problems since the content-based recommendation techniques is capable of recommending items based on whatever available product description details regardless of the rating of that product. However, content-based/collaborative mixed hybrid systems may still be ineffective when dealing with the "new user" problems (cold-start problems applied to users who have just registered into the system) because both the collaborative and the content-based techniques require some data about the users' preferences in order to process a recommendation.

The working mechanism of mixed hybrid recommender systems can be seen as from Figure 10. The mechanism includes a training phase, however, the phase is excluded from the figure since it is the same as the training phase of Figure 8.

Feature Combination

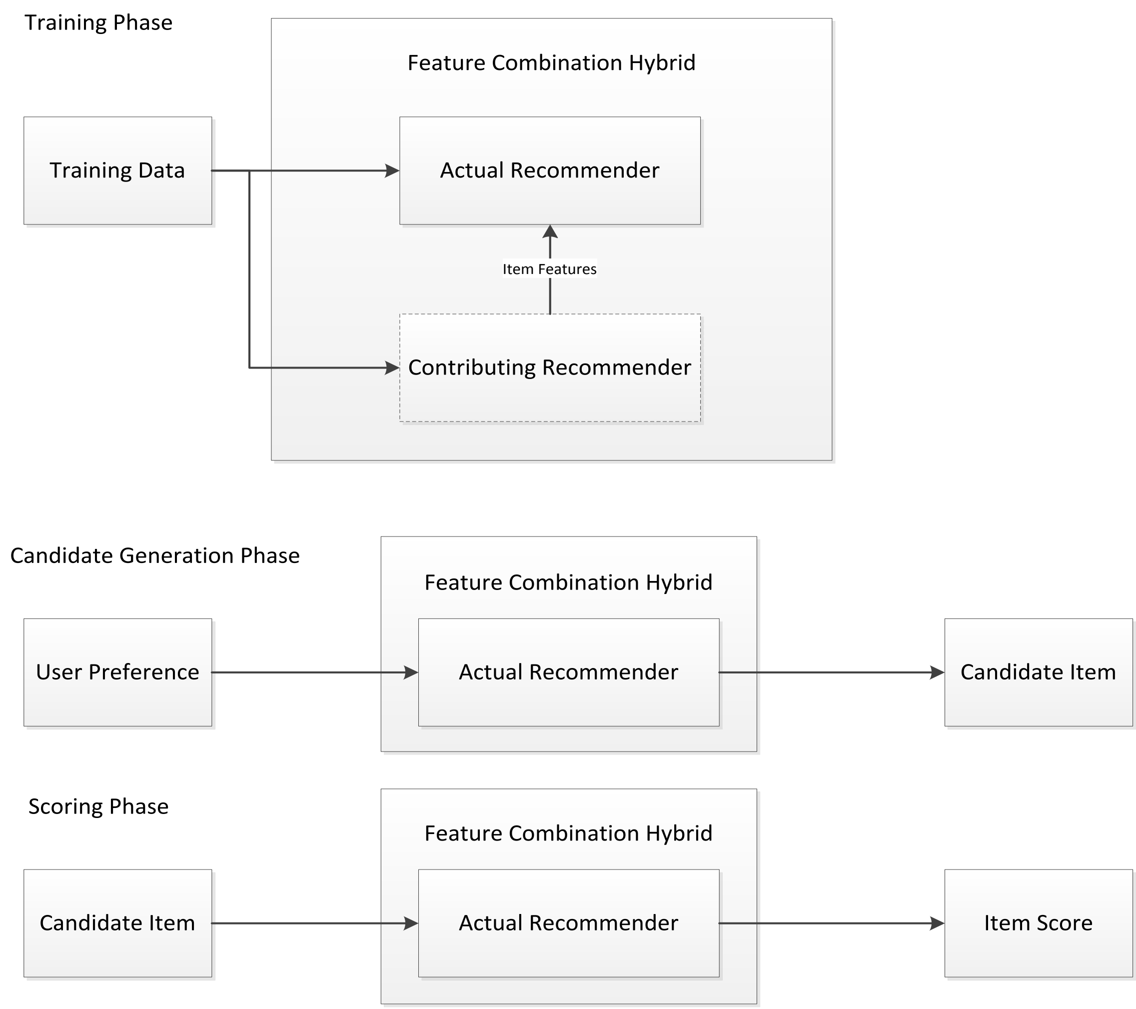


FIGURE 11: A Feature Combination Hybrid Recommender System

Feature combination is created based on the idea that features of one recommendation approach may be fused with the algorithm of another approach (Basu et al, 1998). Feature combination is a recommender hybrid approach that is completely different from the three hybrid approaches discussed above. In feature combination, only one recommender mechanism is used. However, what gives feature combination a hybrid sense is that it makes use of a recommendation logic of one technique and apply that logic into its true technique. For example, a system can employ a content-based recommender mechanism, in which user profiles are built upon studying of user habits and preferences, and, at the same time, combine item features with user ratings, which belongs to the collaborative approach.

From Figure 11, it can be seen that, instead of two parallel component recommender approaches, the hybrid system employs an actual approach and another supporting approach. After the hybrid mechanism has been built, normal recommendation processes go on.

Feature Augmentation

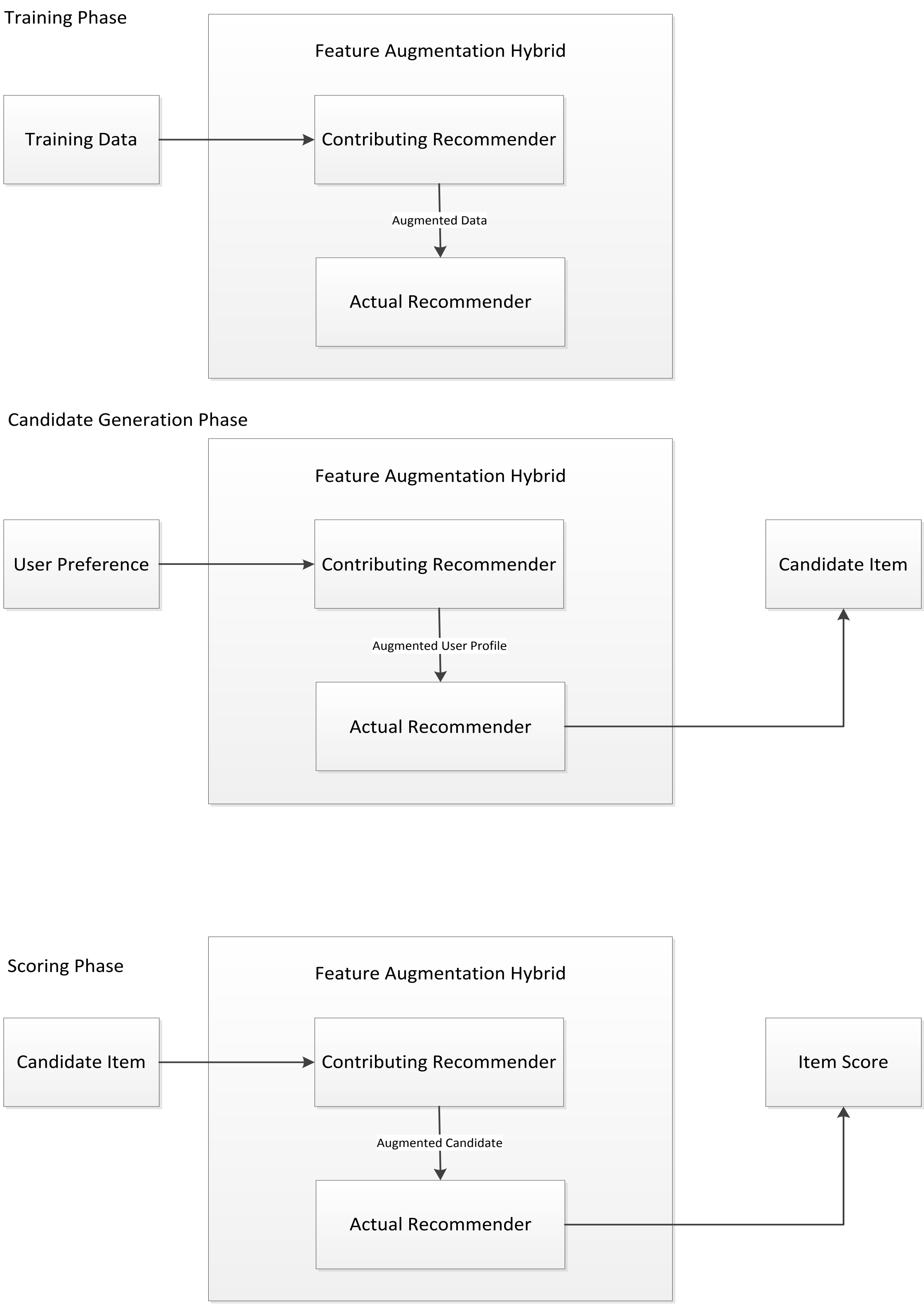


FIGURE 12: A Feature Augmentation Hybrid Recommender System

The practice of feature augmentation is somewhat similar to feature combination. They are similar in that there is only a single recommendation technique that is going to process the input item data and another recommender technique is going to support the main technique with its logical algorithm (Wilson et al, 2003). However, what feature augmentation does is, instead of exploiting features of the supporting approach as a support backbone for the main approach to process, tailor new features, based on the recommendation logic of the supporting recommendation approach, for each of the items that need to be processed in the main recommendation approach (Smyth & Cotter, 2000).

As can be seen from Figure 12, a contributing recommender mechanism intercepts the training data and augments the data with features of its (the supporting mechanism's) own creation before the data heads toward the main recommender mechanism.

Cascade

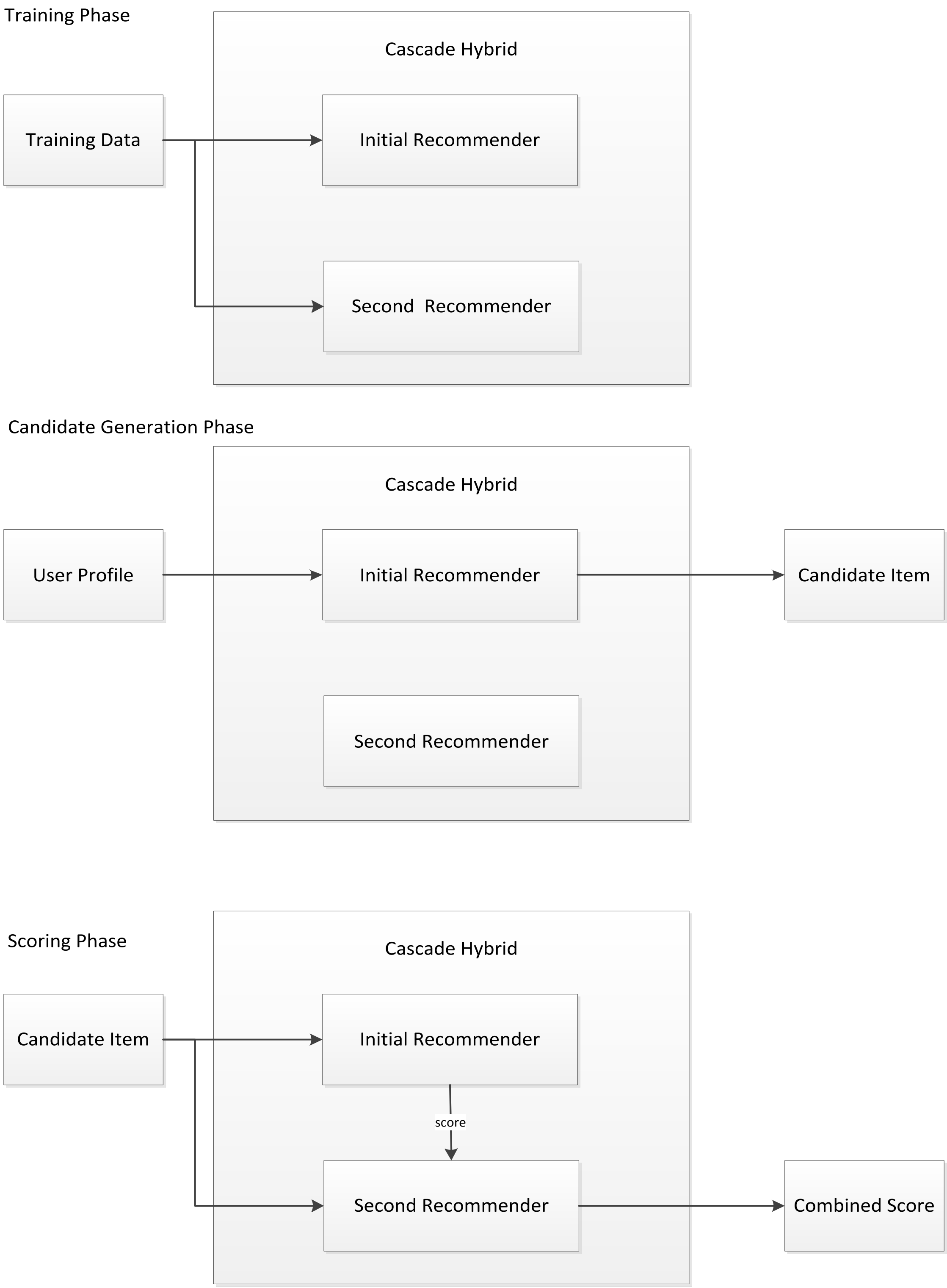


FIGURE 13: A Cascade Hybrid Recommender System

The cascade hybrid, is executed through a stage model process. A recommender technique is first applied to produce an initial list of recommendations. Later, another technique will be employed to refine to initial recommendation list (McSherry, 2002). The progress continues as described until final recommendations can be made.

An advantage of cascade hybrid is that it saves the later applied techniques from having to deal with unworthy and low-priority items by sorting out and eliminating such items during the previous techniques. The later applied techniques, in turn, should be able to perform better since the number of items that need to be processed has already been reduced.

4.3 LARS: Location-Aware Recommender System

4.3.1 An overview of LARS

Location-aware recommender systems (LARS), like traditional recommender systems, make personalized recommendations for users to help them find the items they want among available products based on a database of community preferences. However, while traditional recommender systems are limited in or simply lack the ability to consider the spatial aspect of users or products, location-aware recommender systems are able to produce recommendations that are made upon location-based ratings. LARS deal with user-related location data using "user partitioning", a technique that affects recommendations by considering only user ratings that are spatially close to the querying users such that the system scalability is maximized yet recommendation quality is not negatively affected, and exploits item-related location data with "travel penalty", a practice that is similar to user partitioning such that items that are closer in distance to the querying users are favored over those at far distances. Whether LARS should apply these two techniques separately or together is mostly up to the type of location-based data available. Tests have been carried out using real and large scale data and prove that LARS are so effective that they are able to make recommendations that are twice as accurate as those made by traditional recommender system approaches.

In addition, LARS utilize a taxonomy of three classes of location-based ratings: (1) spatial ratings for non-spatial items, (2) non-spatial ratings for spatial items, and (3) spatial ratings for spatial item.

4.3.2 Spatial Ratings for Non-Spatial Items

LARS generate recommendations for the "Spatial Rating for Non-Spatial items" approach by the tuple (user, user location, rating and item). The main idea of this approach is to exploit the user partioning method which would then applies the preference locality method. In order to create recommendations using spatial rating for non spatial items, there exist three requirements to be fulfilled.

Locality: recommendations are influenced by the preferences of users that are geographically close to the querying user.

Scalability: recommendations procedure and data should scale up to a sizable number of users.

Influence: users of the recommendation system should possess the ability to influence and control the size of the spatial neighborhood.

4.3.3 Non-Spatial Ratings for Spatial Items

This part describe the non-spatial rating for spatial items approach, which utilize the tuple (user, item location, rating and item). LARS achieve this goal by using the travel penalty technique (ratings that are spatially close to the users are favored over those at far distances). Travel penalty, despite being able to produce recommendations within reasonable travel distances, may become very resource-consuming since it needs to calculate travel distance to each rating and item. To counter this costly situation, LARS employ early termination, a technique that would terminate the calculation once the system has determined that there would be no better result even if calculation continues.

4.3.4 Spatial Rating for Spatial Items

In order to produce recommendations for spatial ratings for spatial items approach (presented by the tuple (user location, user, rating, item, item location)), LARS applies both user partioning and travel penalty in order to determine the users' location and item ratings.

4.4 Future Development of Recommender Systems

Currently, studies of recommender systems are mainly conducted for the purpose of improving commercial channels such as

- Entertainment: movies, TV series, music, etc...
- E-commerce: books, electronic goods, PCs, etc...
- Articles: news, documents, websites, online studies, etc...
- Others: tourism services, real-estate rental, etc...

In particular, the combination of data from social media sites, location data and recommender systems have provided a basis for the development of further personalization of services given on the sites. Specific examples are Foursquare or Facebook Places. To be able to choose the right recommender approach and technique, service providers must possess sufficient knowledge and understanding of their field, what is required to bolster the business and the strong points as well as drawbacks of the recommender systems they are going to employ.

With the rapid development of new positioning technologies such as RFID, Wi-Fi beacon-based and GPS, countless studies and projects are being conducted in order to apply these technologies to help recommendation systems expand their market share. New services gradually become available, more numerous and sophisticated than their predecessors.

Elicitation of user preferences: How to quickly and efficiently determine customer demands is still a problem to be solved. Recommender systems, especially context-sensitive ones, will require much more information about demand and preference of users yet lack an adaptive framework and consistent protocols to serve such a purpose. Implicit assumption of customer behaviors seems to be the most obvious answer to the problem. Newly developed technologies such as voice recognition, images and video promise to create a channel between users and recommender systems by producing better user preference input and that have not been possible with tradition input methods (keyboard input).

Proactive and sensor-based recommendations: By default, few recommender systems would actively interrupt users with user preference survey of any kind that have not been required by the users themselves, regardless of how related to the user preferences such surveys are since such action would put the recommender system at the risk of being rejected and boycotted by users for being too intrusive and annoying. Instead, proactive and sensor based technologies are being developed in order to gather user preferences using biometric outputs such as face expressions.

Explanations of recommendations: This kind of problem is most often encountered by recommender systems running on devices with limited display space (smartphones with small screens). In the past, studies about this have been limited. However, as mobile devices become more and more widely used by customers as a tool to access services (and not every single one of such devices can afford to have a sizeable display screen, which means less information will be shown during each session), the matter has brought in more interest from developers.

Portable recommender systems: With recent rapid development of mobile devices, recommender system developers have now been introduced to a new challenge: how to create systems that match exclusively with mobile devices. Of course it is possible for several recommender systems to function on novice (smartphones, tablets) and traditional (PCs, laptops) devices alike. However, mobile device users have recently and increasingly demanded that services on portable devices have their own identity as portable systems.

Security and user privacy: Users of recommender systems supply information to the systems so that they receive recommendations. In return, customers require that their information be used for recommendation purposes only and therefore be kept away from intruding parties. As technologies develop, more complex and sophisticate methods of gaining customer data have been implemented. This means that service providers must continuously research new approaches and methods to protect the sensitive and secret data of their customers.

5 PROTECTING THE PRIVACY OF LBS USERS

5.1 Location privacy

Privacy can be defined as the ability and the right of a person to protect and prevent intruding parties from invading his own personal information. A person can be considered in possession of location privacy provided that he fulfills two qualifications: first, he must be able to control information about his location and whereabouts in that location and second, he must perform such control with his values (Senicar et al 2003).

While, in fact, the first factor is somewhat easy to achieve since, excluding normal and pure commercial transactions, people can deliberately decide who can receive their information, satisfying the second factor is more difficult. Internet users surfing the internet have little awareness of how the information economy works and of the fact that they are part of that economy. Information about a user's behavior is gathered without the user knowing about it (Senicar et al, 2003). Some users have such little sense of privacy that not even the practice of sharing their information on the broadest means of communication affects their concern about their privacy. However, other users have very high sensitivity toward their privacy such as customers of infectious medical, banking or location services (Barnes, 2010).

5.2 Threats to Location Privacy

Before analyzing data privacy protective mechanisms, it is necessary to first get a clear image of threats in communication networks that could be able to jeopardize location privacy such as user identity disclosure, data disclosure, location disclosure in mobile networks, linkability and observability of data.

5.2.1 HTTP chattering

Web browsing, the most frequently used service on the Internet, is enabled by the HTTP protocol. Web users, in fact, except for cases in which they takes steps to conceal their personal data, are considered anonymous any time they browse the web. To establish a browsing session, data variables are transmitted from the users' work stations to the web servers. By default IP addresses are transmitted automatically (from users' computers to servers) regardless of the explicit consent of the web browsers. With the combination of IP addresses and with TCP/IP packet tracing technologies, any capable party can approximately deduce the actual geographical location of the users. Provided that IP addresses are unique to each work-station on the Internet, individuals using devices with IP addresses that have not been anyhow altered or tampered with face the risk of being traced using Internet Service Provider (ISP) record. To make matters worse, the introduction of IPv6, which contains far more geographical information in HTTP headers, even bolsters the threat to privacy (Senicar et al, 2003).

For example, there are mechanisms, available throughout the internet, to business administrators, especially ones that mostly deal with e-commerce cases, to identify, both by visiting users' real names and IP addresses, the information (especially location data) of customers' who are browsing a site. These practices happen without the need for an e-customer to participate in any process at the web site or fill in any kind of forms. This kind of identification mechanism, with the aid of the famous web technology so called cookie, can be applied to track, monitor and profile the activities of web browsers. Fortunately, despite the fact that there is little they could do to completely disable this HTTP chattering practice, users may apply the method of anonymization or anonymazation services to partly help themselves concealing their own personal location data. (Tatli et al, 2005)

5.2.2 Cookies

Cookie files store customers' data such as personal ID numbers, activity histories at web sites or site accounts. In addition, cookies can also provide multiple convenient e-commerce applications such as shopping carts and organization of customer preferences. In short, cookies are a powerful technology that provides a basis for further automatic interactivity between web servers and users. However, cookies are also a technology that contains flaws that would become the root of many e-privacy matters and threats for user data security.

Security Failures & Limited User Control

As said above, sensitive data are often stored in cookies. However, cookie contents are, in fact, accessible to anybody with the right technologies that are capable of intercepting the cookie on the Internet. As a result, cookies should be encoded when containing sensitive data of customers. However, in practice, an e-customer has barely any authority or control over the security protocols taken with cookie management, storage or transfer of websites they use. (Senicar et al, 2003). In fact, a large percentage of users are completely blind to such technologies.

To counter this kind of situation, multiple web browsers give their user the option to disable cookies. Unfortunately, for those customers who decide to tolerate cookies, there exists little or even zero browser mechanisms that provide users with the information about what information of them is being stored in the website's cookies and what the cookies are intended to be used for.

Data Disclosure

In practice, websites that possess customer information stored in their cookies tend to synchronize and share such information at their will with third party such as business partners or advertisers. This is in some way unfair and dangerous for customers since the information they provide could be shared with parties which they (the customers) may not be willing to share information with initially (Curtin, 2002).

User Monitoring

While customers of physical, real-world stores are free to enter and exit such stores without having their own information recorded and regulated (except for cases when credit cards are used as the payment method), users of website don't have such liberty as cookies would have recorded their information, especially the IP address that could reveal the users' location. Many people see this method of identification and regulation as privacy intrusion as cookies could be accessed and investigated by third parties provided that they (third parties) have the capable resources. (Curtin, 2002).

5.2.3 E-Profiling

E-profiling stands for the practice of creating databases upon contents such as characteristics and preferences of e-customers. Recently, the practice of e-profiling has grown to such an extent that it is not impossible or even common for e-profiling databases to contain data of millions of users. E-profiling is in fact related to cookies. It is not untrue to comment that the practice of e-profiling is possible thanks to the invention of cookies. Many e-commerce web sites build connections with data brokerage business entities. These sites make use of cookies to record and monitor customer data that were fed to the sites' servers. User information such as interest and characteristics are added in to databases without the permission and knowledge of the users about the process (Curtin, 2002). The collected data are latter used to determine what services or advertisements would be shown to customers as they browse the web. Organizations that practice e-profiling try continuously to persuade customer that such activities are conducted for the interest of the customers and the collected information is non-personally identifiable, which serve solely the purpose of providing more customized and directed services. However, it is reasonable for many users see e-profiling as intrusive to their privacy since the data is gathered and distributed without their knowledge and consent.

5.3 Location Privacy Preserving Mechanism (LPPM)

LPPM is developed to serve as a means of protecting users' location data. The idea is that LPPM prevents any entity, neither human nor technical tools, from being able to query out the actual location of LBS users even if such information is anyhow available.

5.3.1 Anonymization

Anonymization applies the tactic of pseudonymity: encoding or altering data, therefore eliminating the electronic trail, which can be used to trade LBS users' location or personal information. In Location Based Services, this method most commonly gives out pseudo and random data such as name, location and query content which distract any intending tracker party from the real user location. (Bambi et al, 2009)

5.3.2 Obfuscation

The technique of obfuscation purposely scrambles data, creating inaccurate records of data that are defined as personally or commercially confidential and sensitive data so as to prevent unauthorized access to such data. Obfuscated data, however, should appear as real and trustworthy as possible so as to conceal itself from being identified as falsified data.

5.3.3 Elimination

Elimination means deleting some chosen data of users from their record. Data elimination is most usually applied when dealing with users whose query habits last for anomalously long amount of time. When users spend too much time using a system/service and with high frequency, they may unintentionally expose some information about themselves. In addition, users who are locating themselves at a same place or keep repeating a same query or asking questions with identical contents also unintentionally mark themselves as different from others and can be distinguished very easily by intending parties. For the sake of protecting personal data of users in these cases, data elimination must be employed in such a manner that some actual events or data record must be deleted so that the users' profiles look decently normal and therefore can prevent unnecessary intentions.

5.3.4 Introduction of dummy event

This kind of mechanism adds fake events to users' profile in order to mislead any intruding parties. Users whose profiles have been introduced dummy events will look like they are in a location that they are in fact not. (Bambi et al, 2009)

5.3.5 K-anonymity

K-anonymity is a hybrid privacy preserve solution. K-anonymity applies both the techniques and essences of anonymization and obfuscation. First of all, the anonymization approach is employed to protect the personal data of users and obfuscation techniques are employed to protect location data and time stamps where and when the users would be present. When intruding individuals and parties observe K-anonymity results, they will be presented with events that are hard, if not impossible to distinguish from each other; all seem alike and lack vital identity factors and, for the worse, all events seem to be happening at the same time and the same location.

5.4 LPPM design methodology

5.4.1 Privacy mechanism

Privacy mechanism is developed so as to help users control the flow of information which they, regardless of their knowledge about it, have allowed to leak through online transmissions. Privacy mechanisms promise to allow the users the ability to control how their data are collected online by online agents. The ultimate objective is to help the users who possess little technological power and understanding to even the odds between the users who want to protect their data and parties that want to get their data.

5.4.2 Encryption

This is the oldest method of data protection. In encryption, data is transformed in such a way that they become irretrievable without appropriate authorizations or pre-defined knowledge. Another way to retrieve encrypted data is by using a reserve process named decryption is applied. In decryption, data is reverted from its irretrievable form into meaningful information.

5.4.3 Steganography

With the recent pace of technological development, encryption alone can no longer handle the task of protecting data. In practice, users must somehow figure out a way to hide the reality that their data is encrypted from intruding parties. This is called innocent data. These innocent forms of data sometimes allow themselves to be found and seen by intruding parties. However, whatever data shown does not reveal any information that can do harm to the intended recipient of the real data.

After the appropriate knowledge has been collected, the implementation of LPPM can be started. Several privacy mechanisms are taken into consideration so as to find out the most suitable mechanism to start the implementation of the LPPM. The mechanism to be chosen depends on the type of customers, available resources, the level of security required, how skillful and resourceful intruding parties can be and what damage would possibly occur in case the LPPM fails. Encryption and Steganography methods will undergo the same process to pick out the most suitable candidate to be used to create the content of the LPPM.

6 CASE STUDY - LOCATION BASED SOCIAL NETWORKS (LBSN) - FOURSQUARE

6.1 Introduction

The main principal behind the functioning mechanism of every recommender system is making use of community ratings of products to give customers clues to determine the most suitable products among a vast number of available choices, especially from mass commercial platforms such as Amazon or Netflix. Among multiple recommender mechanisms, collaborative filtering seems to be the most frequently used method. The idea is to analyze community and user preferences so as to mark out the significant product preferences of people with similar points of view.

With the recent development of GPS-enabled mobile devices, there is a countless number of applications and platforms that can generate location-based recommendations using location-aware data collected from the community within a close geographical area of the querying user. The most obvious examples come from location-based social networks, namely Foursquare, which allow users to "check-in" to some places of interest such as restaurants, tourist attractions or hotels and give their own opinions and ratings about such places and their products or services. In fact, location-based social networks are created based on the knowledge of the people' desire to interact with each other through the means of exchanging personal location information. LBSNs provide services that provide users with a platform to share and discuss places they have been to.

Among active location based social networks, Foursquare has proved itself to be one of the most successful. Foursquare makes use of GPS technology and is able to run on most of he well known web platforms and mobile operating systems. Users will perform "check-in" at locations they are in to have been to and leave comments, opinions and recommendations for these places. The recommendations would later be shared and viewed by friends and acquaintances of the user who originally performed the check-in. The most active user (who check-in most frequently and numerously) of a location (mostly a city or district) will be given the title of "Mayor" and remains so until somebody manages to overthrow him (by doing more check-ins). The Mayors are eligible for discounts and secret deals from local business of the district he was granted the title (Foursquare, 2012).

6.2 Why Location Based Social Networks (LBSN)

As wide and varied location-based applications can be, the key focus and the future of LBS is the development and improvement of location-based social networks. It is undeniable that the uptake of LBSNs in the last few years has met with enormous success. For example, Foursquare, which was launched in March 2009 has grown to more than 55 million with over six billion check-ins done worldwide and millions more coming everyday (Foursquare, 2015). This rapid expansion sets the question of why LBSNs are so famous among the general public.

6.2.1 Access to Information

Of the reasons behind the rise of LBSN, information updates seem to be the most relevant. It is human nature to desire to know and update on what is happening around them, especially about topics that have something in relation to their current interests and about people that they care for. This is among the reasons for the interest for and the creation of traditional social networks. According to interviewee number GB03, the location information of his acquantainces contains much information about them, what they are doing, what they are interested in. If he (the interviewee) would like to know about his friends, he would start by asking where they are and then infer about their whereabouts from the location they provided. For example, if a friend responds that he is in a library, GB03 would assume that the friend is either busy or in need of silence so that he (GB03) would try to avoid further disturbance to that friend. However, if another friend says that she is spending time in a cafe, GB03 infers that the friend may like to have a company and will come to join her if conditions allow.

In short, the inclusion of geographic data into social network services means providing more relevant information about the users or places. By querying that amount of additional information, people have a better idea what is the right course of actions to engage in.

6.2.2 The Need for Convenient Exploration

Many people take great pride in their exploring hobby. To these people, finding desirable locations of interest is a very satisfactory experience, especially visitors to foreign countries or cities. However, to explore an area with no hints and to wander around aimlessly is a total waste of time and the result is sure to be uncomfortable. Interviewee number LT01 is an explorer type, she has spent five years travelling Europe. According to LT01, it is possible that people will bypass worthy locations and end up choosing low-quality services due to the fact that they are not familiar with the area. Also according to LT01, using LBSNs avoids unnecessary hassle and dissatisfaction by providing a vast database of ratings from other users, suggesting locations with high reputation and outstanding features and services.

*"It is very easy to understand why people would subscribe to LBSNs. It is simply because they would like to know more so that they will have less difficulty making the right decisions." (*Interviewee LT01)

For example, when searching for a restaurant in Paris, LT01 would appreciates being able to see what people who were at that restaurant think about the place. In LBSNs such as Foursquare, people who have been at the restaurant may perform check-ins and recommend certain dishes that they find worthy or warn other prospective customers about pricey alcoholic drinks.

6.2.3 Meeting Arrangement

With the help of LBSNs, users, especially those at large cities where chances to meet an acquaintance is quite small, are more likely to have real-life meetings. By accessing to a LBSN service, users can be notified of the location of their friends, namely those who are geographically close to them, and can easily contact and invite them for a meeting (the friends) by leaving comments or using the instant messaging services (Facebook). As said above, meeting by chance used to be unlikely in busy cities since people used to have no way to know if any of their friends were close to them. It is possible that a person is in a cafe and his friend is passing by the cafe window and yet the two persons never know they are that close to each other. Nowadays, a person can come to a cafe, sit in and perform a check-in on his favorite LBSN. His friends nearby, provided that they are using the same LBSN, would know his location and will come to see him, either by chance or intentionally.

In addition, as suggested by interviewee number LT04, another way users can arrange meetings with LBSNs, most usually experienced by people organizing an event, is that a user may choose and mark a place and then those who involved in the event will know where should they be. Almost every LBSN comes with an interactive map (many with pictures and clear guidance) so users who are not familiar with the area should be able to navigate and locate the destinations. This feature helps ease the communication burden of the event manager. Instead of having to call to text all the involved people (sometimes amounting to a few dozens or a hundred people), the event organizer now only has to pin-point the event location and the invitee will go there.

6.2.4 Reward Systems

As strange as it may sound, several users are addicted to the gaming and reward systems featured by LBSN providers. Foursquare features the practice of giving its users rewards, giving points and achievement titles or even rewards with real-life values to users with an active history of check-ins and vast contributions to the enrichment of service ratings and comments. As said by former LBSN employee numbered FE02, LBSNs implement their reward systems such that it is fun and competitive and, to some certain extent, profitable, which are characteristics that can be found in gaming. The main idea is to motivate users to keep on using the LSBNs since the more users perform and spend time on the social platforms, the more rewards they are likely to receive.

From the users' points of view, as said by interviewees FI04 and VN01, acquiring the rewards and titles give themselves a sense of identity, pride and achievement. Getting a higher score, earning a higher rank or having more interesting rewards, etc. are all together very appealing to the vast majority of the LBSNs user population.

6.2.5 Personal Location History

Most LBSNs record the history of check-ins that their members have performed ever since they have started using the LBSN and make it as simple as possible for users to review, edit, add information and share the check-ins across the network. Records include location, date and time, photos, captions that users provide when they perform the check-ins. To interviewee GB03, history recording is an excellent sort of diary that they may view over and over again, recalling and cherishing the happy moments.

Apart from keeping memory, LBSN location history has many more practical uses. LT01 suggests that by viewing her check-in records, she is able to review places she has been to and compare with spending history of her credit card. If a payment doesn't seem to make sense with the check-in record, it is possible that there have been some kinds of credit card fraud during her travel. This information helps the traveler-type interviewee to react quickly to the situation and maybe draw some experiences to avoid future unfortunate situations.

In addition, check-in history can sometimes and to certain levels be considered part of a resume. Interviewee CH07 states that the travel agency she is working for hire its employees based on criteria other than their certificates alone. Among the criteria, travel experience seems to be on top consideration. Coincidentlly, CH07 has a habit of taking good care of her check-in records. During her job application, CH07 included her travel history in her application as proof of extensive travel knowledge and easily outweighted other applicants who had just graduated from tourism schools and had less travel knowledge.

6.3 Challenges

This development trend paves the way for the implementation of location-based recommender systems which exploit the spatial aspect of community ratings. The main concern when building a location-aware recommender system is how to make the most out of location data.

For this concern, according the former Foursquare developer FE01, locations with higher check-in frequencies are more likely to be shown as recommendations.

This means that the location owner must somehow encourage visitors to perform check-ins if the location is to be famous among the user community. Businesses whose services are execellent but fail to receive sufficient amount of check-ins often get forgotten and are more often visited by loyal customers than by new customers; the situation is described as the "hidden germ" effect in which truly remarkable premises are lowly-ranked and moderate-ranking bussiness thrives as the recommender systems perform unfairly. This is when hybrid recommender systems are brought into use, being able to draw more information and connections out of check-ins rather than just mere locations and ratings. However, the methods and orders in which the hybrid recommender systems are applied remain Foursquare's business and technology secret and the thesis author has no way to access and study deeper into the field.

Another problem when implementing Foursquare recommender systems, as given also by FE01, is that Foursquare staff lacks completely the ability to control the ratings' reliability since service rating is done entirely by customers of such services.

"We have no idea whether the check-ins are done deliberately by the users themselves are are they urged by the business owner. We can't even be sure whether the users are checking-in from the premise or are they just randomly checking-in for unknown reason. You often encouter cases in which a user checks in to a hotel somewhere in Bangkok while he is exactly no where more than 5 meters away from his apartment in New York." (FE01)

In practice, however, it is possible to track weather the users are telling honestly about their geographical location. The devices users use to perform check-ins are connected to the internet via Wi-Fi signal or mobile data services such as GPRS and 3G. The real location of the Wi-Fi user is indeed tracerable since Wi-Fi beacons have fixed location data provided by the internet service providers. The same applies to mobile data services. Devices connected to the net using mobile data can be traced using satellite systems such as the GPS or Russian GLONASS. Indoor tracking devices are another means of determining the real location data of users. In short, if Foursquare wants to evaluate the exact whereabouts of its users, it has every available means to do so. However, it is easier said than done since privacy issues are sure to be raised against Foursquare if the social network puts it hands into the tasks. In addition, Foursquare has next to nothing to gain from pointing out if a user has performed a false check-in to his fellow users.

6.4 Business Value of Location Based Social Networks

As hundreds of thousands of new users joining LBSNs every passing week, business entities have shown increasing interest in taking a share in this profitable market. LBSNs, aside from being reliable and appealing platforms for users communication and interaction, have also placed great concerns in attracting businesses into partnership by proving themselves to be promising a commercial arena where organizations and companies can compete and invest in so as to get more customers.

It is stated above that ordinary users of LBSNs enjoy an abundance of information that is related to their interest and preferences according to their real, physical locations. To commercial entities, the same data advantage can be applied in doing business. Businesses in catering and retail sectors have been working together with LBSNs in such a way that "catchment zones" are established. When users using LBSNs enter the zones, they are alerted, mostly through the form of push notifications, about the services available nearby (Foursquare, 2015). While initially only big businesses such as Starbucks or McDonald's would enter the location-based sector, since they are the only entities that have enough resources and influence to do so, smaller businesses are starting to take part more and more actively into the sector upon realizing that such investment may rather be profitable. Prior to the era of LBSNs, small service providers, especially those in large urban areas, were often ignored or unnoticed by customers since they were suppressed by business with enormous banners and real estate properties. However, with the aid of LBSNs, all it take for small businesses to be noticed and start getting customers is proper marketing policies and practices on LBSN sites and chances are they may manage to attract customers. Any business managing to satisfy its initial customers will be checked-in, rated and recommended and, as the LBSN user community continues to grow, more customers may keep coming in.

The location-based marketing mechanism is also ideal for businesses aiming at building customer loyalty and thereby secure the return of their customers to use their services. One of the most common methods of building customer loyalty widely practiced by businesses is by offering small promotions to users checking in to the business premises from a LBSN, the same method applied by LBSNs themselves to keep users coming back. For example, Domino's Pizza would offer a free garlic bread for customer who have checked in at one of its outlets. Domino's Pizza is also known for preserving special privileges for LBSN users who have earned some sort of achievements or recognitions. Foursquare grants the user who performs the most check-ins at a place on a period of sixty days the title of "mayor" of the place. The "mayors" are the most qualified for rewards of many businesses collaborating with Foursquare. In the case of Domino's Pizza, the "mayor" of each Domino's store is entitled to a free pizza every Wednesday.

By introducing their business on LBSNs, besides getting more customers, service providers enjoy many more advantages. For example, businesses that have been famous among customers, they are exempted from the need to posting their premises' location themselves. Customers who are fond of certain locations are encouraged to add the location of such places to the LBSN. In fact, customers will be happy to do so voluntarily if they truly like the services that much. Moreover, when LBSN users check in to stores, posting photos and comments along, they unintentionally do a free yet very effective marketing service for the business owners. In conclusion, by bringing a part of their businesses onto the LBSN platforms, business can save themselves considerable amounts of advertisement effort and resources.

6.5 Privacy Issue of LBSNs

Like in other sectors of LBS, the recent rapid expansion of LBSNs and related businesses has raised much concerns about the possibility of user information, especially location-related ones, being leaked into the wrong hands and the level of damage if such unfortunate events occur. The frustration is reasonable since the outcome of a location data leak, either it involve real-time locations (stores the users have visited) or permanent ones (home/office address) could be ranging from damages to the privacy and, in extreme cases, the physical safety of LBSN users.

The LBSN operation mechanism relies on the practice of location information sharing which require the connecting of the users' real identities and their current location. Unfortunately, intruders can exploit this feature of LBSN and interfere with devices accessing LBSNs to extract information, thereby determining the true identity of the device user. Such activities have been considered the primary threat menacing user privacy across LBS service sectors with LBSN included. Once holding the knowledge of places where other people are and have gone to, intruders are very likely to use such information for purposes such as stalking, market spamming or worse. To counter the threats, several factors must be taken into consideration during the implementation and delivery of LBSNs and related services. The factors can be classified in such a way that they belong to one of the three categories (1) how LBSN mechanisms determine user locations, (2) the methods used in sharing location information and (3) how LBSN service providers use and store acquired user location information.

One of the most debatable issues in the sector of location privacy is that whether users should be granted the right to choose to have their location determined automatically by the LBSN providers or should they deliberately initiate the determination process at their (users') own will. The privacy policy of Foursquare clearly states that the determination mechanism of user location is activated every time the users run the Foursquare application on their devices, regardless of whether the users have decided to or not to publish their real-time location at the moment. However, the policy does make certain that the determined location will not be published until the users decide to do so deliberately by performing check-ins (Foursquare, 2015). Even so, and even with the fact that the action of activating the Foursquare application is performed at the will of the users, the determination of user location is still regarded as implicit as it happens without the users having any ideas about the process. This concern, at least from the users' point of view, requires that users have more access and control of the extent to which their data is stored and shared across the network. Currently, it is possible for users to, to some extent, control the viewers of their data. Users may choose to customize who (different viewer groups, as may be defined by the users themselves) is allowed to view data that is published and which part of the published may each category of visitors may view. For example, while the users decide to let the general public know where they are, some viewers may only see general information such as city or street names while some other, more trustable (at least as far as the original posters think so) may know exactly which premise their fellow users are in.

In addition, even if user information is placed under strict protection and regulation, it is not entirely safe considering the fact that intruders nowadays possess sophisticated skills and have access to the latest data collection technologies. To counter the rising amount of threats, LBSN providers must adjust their positioning technologies. It is known that for location determination, two most common approaches are device-based, in which the devices, operated by users, take the role of determining their own locations through channels such as SMS or unassisted GPS, and network-based positioning, the approach in which network services either support mobile devices or take full control of the positioning tasks. Of the two, the latter is the faster and more effective option, capable of carrying out a massive number of positioning queries at rapid paces, and, at the same time, the more likely one to be abused by unauthorized parties to access sensitive information. The fact that network-based positioning is more likely to come under attack is caused by two main reasons: (1) the communication between the users and the service providers must go across the internet where it is easy for intruders to interrupt and manipulate the transmission anywhere at any time and (2) the fact that information collected and provided by network-based positioning is more accurate and numerous since network-based location determination gets data from reliable network infrastructure such as WiFi beacons which contain precise information such as the MAC broadcast address which could be traced to infer the exact location of the beacon and devices connected to it. Knowing this, LBSN service providers must determine whether their systems are secure and powerful enough to withstand attacks. If LBSN providers felt themselves ready, they may want to go with the network-based approach to be able to process enormous flow of data and rapid, numerous and efficient response rates to customer requests. On the other hand, LBSNs and services with weaker defense may choose for themselves the safe passage.

7 CONCLUSIONS

7.1 Thesis Summary

The thesis' primary aim is to clarify the required characteristics for location based social networks to define themselves in the current business environment. The author carries out the thesis by dividing it into several chapters; two of the chapters are introduction and research approaches.

Each following chapter clarifies one important aspect of location based services to provide background knowledge and understanding to the readers. Specifically, the first chapter identifies the concept of location-based services, different categories of LBS and describes methods and systems that could serve the purpose of gathering geographical data to create LBS databases. Next, chapter 4 features recommender systems, basic concepts and classifications. Recommender systems are important because they are the backbone of the functioning mechanism of LBSs, determining the right pieces of data to advise LBS users with. The main focus of chapter 4 is hybrid recommender systems which is applied with high frequency in the development of recent recommender systems. After that is chapter 5, in which the location privacy is the top concern. The chapter first lists and describes different threats that could menace the privacy of LBS users and later the methods that allow better protection for LBS users.

Lastly, the final chapter includes the concept of LBSN and its main features and users' opinions to answer the reasearch question, using Foursquare as the model of LBSN developement. The chapter starts with introducting the idea and the recent significant rise of location based social networks, one of the most important business sectors of location based services. Next, user ideas obtained through interviews are taken into consideration to clarify the reasons behind the recent boom of LBSN. After that, the thesis aims to make clear how LBSN may be important and profitable to business providers. The points are made using the observable nature and practices of for the social network Foursquare as well as supported with expert theories about the business aspect of LBSNs.

7.2 Answering The Research Question

The research question, as defined earlier is this thesis is

"What value must location-based technologies possess in order to match with the current business environment from the user point of view?"

In fact, the question is answered using mainly the ideas and facts from chapter 6. Since the question dues with LBSN customer users, it is best to answer it with points of view given by the users themselves.

From sub-chapter 6.2: Why Location Based Social Networks, five requirements are given by the users. The reasons include:

- The need to access more information.
- The need to explore conveniently.
- The need for meeting arrangement.
- The need for reward systems for motivation.
- The need for personal records.

From sub-chapter 6.3: Challenges for a Recommender System, another requirement is identified:

- The need for the RS to make valuable recommendations.

From sub-chapter 6.4: Business Value of LBSN shows the requirements set by business users:

- The need to advertise with high efficiency yet with little cost.
- The need for attractive LBSN features that keep users coming back

In sub-chapter 6.5: Privacy Issues of LBSNs, exist the conditions demanded by both ordinary and business users

- A safe channel of location information sharing.
- The need for users to control the extent to which their data is shared.

Upon fulfilling all of the above mentioned conditions and requirements, a LBSN should have no problem finding its place in the current business environments.

7.3 Limitations

Althought the theoretical data are collected from varied and reliable sources, empirical data do not enjoy such luxuries. Empirical data is indeed reliable since they are collected from people with experience and commitment to LBSN, yet, the sample size of both users and experts is too small that it could not possibly have covered every important issue. In addition, the thesis did not fully uncover the secret behind the development of Foursquare since such information is secret enterprise data.

The theoretical part has also several drawbacks. The first limit comes from sub-chapter 5.3 and 5.4 where methods for protecting the privacy of LBS users are identified. Even with the methodologies described, the thesis fails to provide specific examples and features of a working privacy preserving mechanism since the task is too complex to be included within the range and focus of the thesis. Secondly, the thesis does not completely explain how the positioning methods identified in sub-chapter 3.2 are applied in the development of LBSN or LBS as a whole. Examples are scattered and unrelated as well.

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APPENDICE

List of questions for LBSN users:

1. What LBSN(s) are you using? What makes you choose the LBSN(s) at the first place?
2. What features of the LBSN (s) you are currently using keep you continue with the LBSN(s)?
3. Please tell a personal experience/case/story which you have about using LBSN(s)
4. Other than for entertainment purposes, what do you use LBSN(s) for?
5. Do you think that LBSN(s)has/have great potentials? Why do you think so?
6. Other than for entertaining purposes, what do you use LBSN(s) for?
7. What future features/services do you expect from the LBSN(s) you are using?
8. Please state any additional information you would like to share.

Note: You are welcome to provide answers for any LBSN you are interested in, but I would prefer you tell about your experience with Foursquare. Thanks you for your participation!

List of questions for former Foursquare employees

1. What is the function mechanism of Foursquare's recommender system in general?
2. What kinds of difficulty did you and your colleagues encounter when implementing a recommender system during your time at Foursquare?
3. How did you and your colleagues manage to overcome such obstacles
4. Were you satisfied by the system you implemented? Or are there anything that could have been done better?
5. What features do you think users like the most when using Foursquare?
6. How do you think about check-ins and reviews given by users?
7. Please state any additional information you would like to share