Possibilities of using Location-based Services in the Public Bicycle Systems

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Abstract—**The problem of the availability and the distribution of bicycles of the traffic models based on conventional stations can be addressed through the introduction of information services based on location. Tracking the location and the movement of each bike can provide better availability of services to the public bike system. The introduction of such forms of information and communication services in public bicycle systems can reduce the cost of introducing and maintaining the system, and create a full range of indirect services providing added value for all participants. This research focuses on the possibilities of using location-based services in the public bicycle systems, and the benefits they provide to the users and to the telecommunications operator. The analysis of the impact of location-based services to the transport process of public bike system provides an overview of the management system of public bicycles. This paper has identified the elements and participants in the value chain of delivery of information and communication services and content based on location as the possibility of their application in the system of public bicycles.**

Keywords- public bicycles system; location-based services; information and communication services

I. INTRODUCTION

Transport infrastructure in big cities has been always primarily subordinated to the car traffic, but the growing trend of the cost of living, especially transportation, begins to force a growing number of city residents to swap their daily commuting by private car to some forms of public transport. Public Bicycle System reduces traffic congestion and alleviates problems created by a lack of parking spaces, reduces air pollution and complements the public transport.

As the use of the system increases users are faced with the inability to return the bike, because the station in which they want to return the bike is already full, as well as the occasional lack of bicycles in the individual stations. While trying to solve the problem by the resettlement of bicycles on various locations in the city by truck, without a rational approach to system management problems with the availability of bikes and the possibility of return are inevitable, as well as the user dissatisfaction.

Location-based services provide the user with the possibility of the mobile terminal device location and are nowadays increasingly used in planning to improve service quality and significantly reduce operating costs.

Data collection and the analysis of user data are important stages in the creation of high-quality services. The findings of certain patterns of behavior can facilitate segmentation of users in groups. By tracking the position of mobile terminal devices installed in the bikes it is possible to predict the movement of the user, and thus through the segmentation of users increase the quality of existing services and provide new and improved contents.

This paper will show the benefits of user location technology, which can be provided by the operator of information and communication services, and the possibilities of the use of obtained information in the system of public bicycles. Previously mentioned user services can provide additional benefits, as well as the total value for all participants of the value chain. The paper will give a proposal for improving the services of existing public bicycle systems with better management and deployment of bicycles and identify potential user requirements for new communication services and content.

The purpose of this paper is successful application of modern technologies in order to design information and communication service applicable to the transport system, providing the users of the transport system with reliable information and additional benefits and the telecom operators with the added value by improving the management of transport systems.

II. LOCATION BASED SERVICES

Location-based services are defined as services that use geographical information to serve mobile users, i.e. it is every application that is using the information on the current position of the mobile terminal [3].

A. LBS ecosystem

LBS are at the top of the architecture of information and communication system so they are not affecting services at lower levels and they vary according to the type of services offered to subscribers, network operator and service providers. It is difficult to determine the exact architecture of the reference model uniquely describing the components of LBS services. A simplified model is shown in Figure 1.

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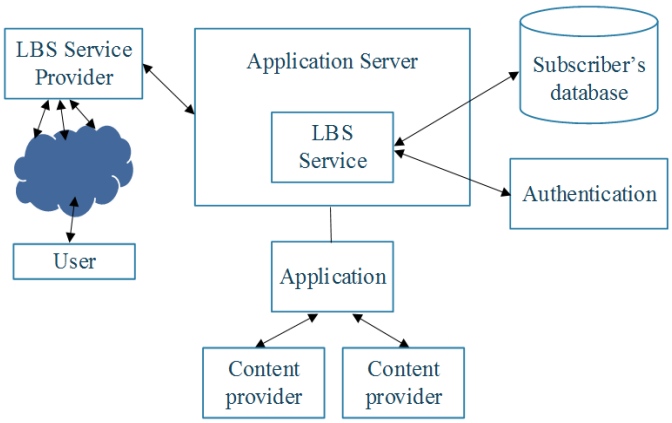

Figure 1. Simplified eco-system of location based services [1, 13]

The basic characteristic of location services is a location information, which can be obtained by different methods of positioning, and varies according to the precision, the place of determined location and the necessary network infrastructure. In addition to the methods in which measured parameters of the signal source are based on a network (i.e. Network-based), most widely used methods are based on the interaction of mobile device and satellite global positioning systems (i.e. Handset-based) [2].

The term of location-based services covers a large area including many services such as navigation and orientation, information services, monitoring of children and disabled persons, increased subscriber's safety, calls for help, advertising, charging for services depending on the current position, intelligent transport systems, management, improvement of mobile network's performance [2, 13]. For example, a company engaged in advertising via LBS has to obtain information from the mobile provider about the location of its users. Keeping track of the change of user's location can help creating his thorough profile that can be used later for marketing, but also for forming different types of control.

The research of market's possibilities allows retrieval of the information about the market's potential and possible market's share of some services, information about the current sale and prediction of the future sales, as well locating the sales points (directions of distribution) [4]. Collection and analysis of customer data are important stages in the creation of high-quality services, and the finding certain patterns of behavior can facilitate segmentation of users in groups. By tracking the position of mobile devices, it is possible to predict the movement of a user and thereby determine his position within the segmentation.

B. Demand for accuracy of LBS environment

An important question for the development of optimal LBS system is the question of precision of the location-based service in order to provide useful information. Positioning accuracy is one of the four basic, previously mentioned security parameters of positioning. In practice, the accuracy of positioning is represented as a horizontal assessment of positioning errors for each positioning sample.

Scheme of the positioning accuracy levels which are thought to be necessary for different kinds of applications related to location-based services are shown in Table 1 [5].

TABLE I. THE EXAMPLE OF THE DEMAND FOR ACCURACY FOR EACH APPLICATION

Application	Demand for accuracy
News	Low
Routing	High
Traffic information	Low
Advertising	Middle to low
Vehicle navigation	Middle to high
Personal navigation	High
Fleet management	Low
Vechicle tracking	Middle to high
Property tracking	High
Children surveillace	Middle to high
Electronic toll collection	Middle to high
Public management system	Middle to high
Location sensitive collection	Middle to high

Demands for the position accuracy are not the same in all areas. Rural and uninhabited areas will not require a high level of accuracy while high accuracy in urban areas will be crucial because of the potentially large concentration of services.

III. PUBLIC BICYCLES SYSTEM

Public bicycle system brings great benefits to each city: reduces congestion and alleviates problems created by a lack of parking spaces, reduces air pollution and thus has a beneficial effect on human health, encourages physical activity of the population and complements the public transport. The introduction of the system of public bicycles and its maintenance does not create high costs for the cities and it delivers significant benefits.

The basic principle of almost all systems in the world is almost identical: users pay a membership fee, take a bike that was locked in the bike racks or electronic docking station and return the bike to any available station in the system. The basis of the system consists of a relatively dense network of tens to hundreds of separate stations for parking or hiring of these specially designed bicycles [6].

Costs and financing are the key concerns of the public bicycle system. The main costs from the operational point of view can be divided into two main categories: infrastructure and introduction, and labor costs. Depending on the system configuration, implementation costs in large systems can increase the unit price per bike, due to the cost of building the station with a greater capacity [7].

TABLE II. THE EXAMPLE OF THE MAINTAINANCE COSTS FOR THE PUBLIC BICYCLES SYSTEM [7]

Maintainance costs	Share in the total costs
Distribution of bicycles	30%
Maintainance of bicycles	22%
Maintainance of stations	20%
IT support	14%
Administration	13%
Alteration (bicycles, stations)	1%

System configuration without cycling stations can greatly reduce the cost of implementation and maintenance compared to models based on conventional stations.

IV. THE APPLICATION OF LOCATION BASED INFORMATION SERVICES IN THE PUBLIC BICYCLES SYSTEM

The main objective of the concept of public bicycles is an establishment of the sustainable transport. To avoid the problem of the bicycles shortage in one location and the crowded station in another, the optimization of the relocation of public bicycles is aided by the use of new technologies in order to determine the position of bicycles and their movement in a given period.

A. *Advanced information and communication services and technologies*

The user of a transport system does not like the insecurity on his way. If the user can be provided with personalized, real-time information on traffic and public transport, or solutions that help him make decisions about the way to reach his destination, he will have a lot less insecurity in the process of travel.

In order to simplify and cheapen the system of public bicycles, it is necessary to change the conventional way of using the method of taking the bicycle and returning it to the station. This can be achieved with built-in locking devices within the bicycles and with positioning units.

Such an approach access can greatly simplify the use of public bicycles as a service (Figure 2). It enables locating the bicycle on the local area map providing the user with an overview of the bicycles that are offered for the use [8].

Figure 2. Simplified presentation of information and communication service of the use of public bicyleces [9]

Each bicycle can be reserved for a limited time, taken over on the bicycle station location and unlock for the use. After using the bicycle can be locked anywhere and as such will be ready for the next user.

B. *Determining the position of the bicycle*

The position of a bicycle is not much of a use if it is not connected to a map of the road network. In this way, a user can be provided with a quick information for this road segment, as well as with the ability to determine the path between the current and previous position.

Each time when the user is provided with the bicycle position, the system calculates the area around the location in order to find possible segments of the road (i.e. paths), then it sorts out the sets of road segments corresponding to the area of specific geographical characteristics. These road segments must go through a selection process before choosing the one that best corresponds to the position of the bicycle. The segment of road where the bicycle is located has a similar direction and the shortest distance from the location of the bicycle.

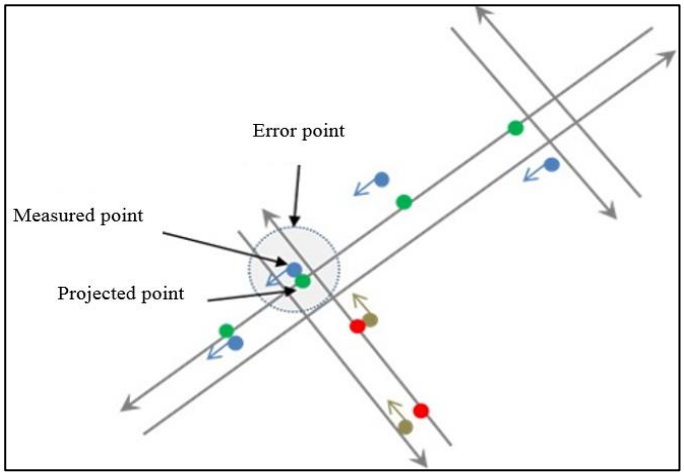

Figure 3. Adjustment of the GPS location and the road network map [10]

To calculate the speed of the travel, it is necessary to know bicycle's path between the two recorded times. The reconstitution of the speed data provides the information on the speed of the road segments where there is no data. This ensures that users continuously receive reliable information on the speed.

C. *Composition of the system*

The modern view on the information and communication services is user-oriented, i.e. it is moving in a direction of user requirements to access services using network capacity. In the implementation of solutions of a system, participants express their needs and show their interest and contribute with their knowledge and skills. Participants (i.e. stakeholders) are persons, groups or institutions whose needs and interests can contribute to the solution of a problem [11].

The end user is the main participant in the value chain generating the demand for a particular service. The user requests a service of using the bicycle and uses an application offered by the system via the mobile network.

The mobile operator (i.e. mobile service provider) is a legal or physical person who provides or is authorized to provide public communications services in the mobile network or to

rent public communications mobile network's resources and connected equipment. In the context of information services based on the location, the mobile operator provides the service of user location, and monitors and maintains information and communication systems involved in the process of locating users.

The service provider offers a system of public use of the bicycles in response to markets demand or the need for more efficient public transport. It deals with the management system, the deployment and maintaining of the bicycles.

The service provider creates a system, as well as an application for the use of the system. The application manages the information on the position of bicycles, the ability of the reservation, the pause and release of the bicycle.

Supplementary services providers are participants who are indirectly engaged in participation in the public bicycle system, and that as partners or subcontractors providing the various types of information, services and products based on sales and marketing activities. Provided information may be those of traffic or the current time, as well as the prognosis for a shorter time period that is of interest to the end user of the system.Various types of services and products can be advertised and associated with the location, i.e. the movement of the user, as well as with patterns of user behavior.

The value chain is quite fragmented with stakeholders who are in various ways involved in the design and development of the system, as well as the supply of services and products, shown in Figure 4.

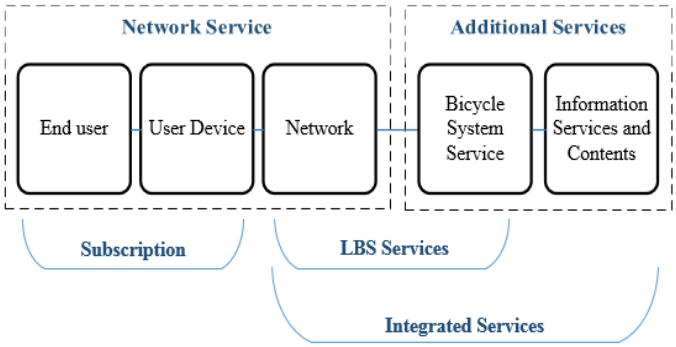

Figure 4. The value chain of the use of information location service of the use of the public bicycles system [12]

The user is in a subscriber relationship with the mobile operator. On the other hand, the mobile network operator has the equipment and the technology for positioning, providing the service provider of the cycling system. The user provides a cycling system with a request for a service, and therefore user requests location-based services. While using these services the user creates the value for himself, but to make the service viable he must simultaneously create the value for service providers and mobile network and the provider of the cycling system service.

Accordingly, the provider of the bicycle system service system offers advertising service, supplementary services and products connecting the user with supplementary service providers, as well as the offered products. The providers of supplementary services and products are interested in increasing their own market, so they reduce the cost of using the bicycle system, and thereby create added value for users as well as for the service provider of the bicycle system through the charges for advertising.

Ultimately, provider of the bicycle system service has an additional interest in collecting data on the user habits and profiles, which can be offered to other parties in order to improve their business, as well as other companies engaged in direct marketing.

D. System architecture and the possibility of use

The system consists of a control center, public bicycles, users, applications available via mobile phone, access to the Internet network or fixed points in the city. The control center is mainly responsible for the background management of the system functions, including management of the information on bicycles, management of the equipment and the movement of bicycles and management of user's information (Figure 5).

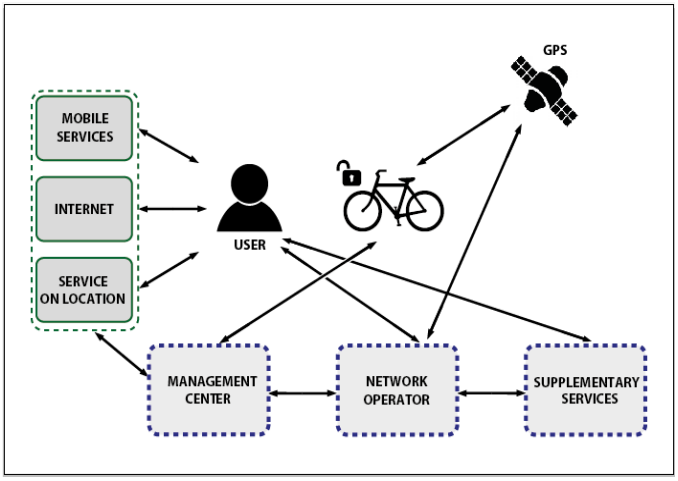

Figure 5. System architecture and communication overview

The system is designed to give users the freedom to find and use any nearby located bicycle using the application on their mobile device (Figure 6).

Using the application system, the user sends a request for creation of a user account. After logging into the system, the user gives a request for locating and finding the nearest bicycle. By opening mobile applications' browser, the user has an insight of all the available bicycles in his location area considering the size of the wanted search area. The system can offer different variants of service due to the selected bicycle and entered parameters of the selected path:

- free of charge for a certain initial period of use,
- more affordable if the destination location is defined by the user,
- more affordable if the offered traveling route is selected by the user,
- more affordable or free of charge if using commercial and retail services,

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- bonus time for the Defects Notification / failure on a bicycle,
- bonus free time for providing information about traffic and the like.

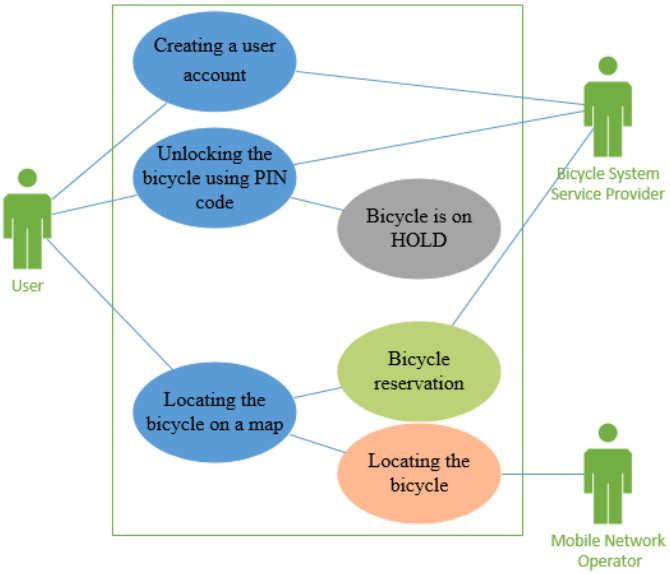

Figure 6. Use-case diagram [12]

The system also can offer optimal solutions for a wanted destination point- a combination of using a number of bicycles or other forms of public transport (city bus, city rail, taxi etc.), and will charge a certain amount only in the case of use after a certain period of time or in the case of unfavorable destination location. The user reserves a selected bike (reservation is waiting in a shorter period), and it takes for the use by unlocking the PIN number provided by the application. The user can make a short stop when it is needed by pressing the "hold" on the bicycle locking system. This ensures that other users of the system can't take over an occupied bicycle over that stopping period.

By the end of the bicycle use, a user logs off from the system and automatically activates the locking system on the bike displaying the bicycle on the free-to-use list. In case the user does not log out of the system and the "hold" option isn't turned on, after a short time, the system will charge a certain amount from the account of the user. This prevents negligently leaving the bikes. If the user started his travel by defining the destination point or he use a particularly favorable travel route, the bike is all the time present in the list of applications with the current position in real time and an estimated time of arrival at the destination. In this way, other users can evaluate the feasibility of waiting for the incoming bike. Reservation of that bike runs until the arrival on the destination position previously defined by the first user.

The provider of the bicycle system service can cooperate with supplementary service providers to offer their customers the use of various services. On the basis of mutual agreement, various kinds of services can be offered, which will be advertised and offered to customers based on their position. Such services can be directly related to travel by cycling, such as information about the traffic conditions or short-term weather forecasts, but they can also be associated with the vast range of services that could be interesting to the user. In addition to services, the object of advertisement can be physical products that can be bought at nearby stores located along the user's travel route. If the customer has choose to use the offer of services or products offered by the system, he achieves certain benefits while traveling by bicycle so that in some cases, travel may be cheaper, and in some cases even free, regardless of time or length of use.

The system monitors the user's position in real time and based on a specific itinerary, entered destination location, as well as predictions based on the current position or route segments, offers such services and products. By continually monitoring the behavior of individual users the system can make a segmentation of users and offer specific services and products that are based either on location or on the established patterns of behavior of the individual user. If a user, for example, is passing through a specific route and buys a specific product each day, the system informs him about such and similar offer of products in the area, and interested merchants can offer discounts in case the user decides to use their services.

V. CONCLUSION

Information and communication technologies have become an important driver of everyday life and economic activity, offering a wide range of tools that can create new opportunities. The majority of people in Europe today use computers and mobile devices as a common everyday activity for a variety of purposes.

By increasing the capabilities of existing systems, as well as through the design and construction of the new global positioning systems, the offer of new information and communication services based on location is constantly growing. The introduction of information and communication services based on the location in the systems of public bicycles greatly reduces the cost of construction and maintenance of such systems considering that the tracking of the location of each bicycle provides the use of system models without stations for bicycles.

Also, the monitoring service of each bicycle in real time creates a dynamic image of cyclists and, therefore, assures better quality management system, as well as additional benefits for users. By upgrading the existing public bicycle service systems with better management and better customer approach, it is possible to identify potential user requirements for new information and communication services and contents.

The integration of new information and communication technologies in the transport system of public bicycles can encourage and increase the use of this form of economic and environmentally friendly transport mode, and thus contribute to the development of sustainable transport.

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