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## ANALYSIS OF FRAMEWORK FOR BUILDING A SMART CITY THROUGH THE IMPLEMENTATION OF A SMART BUS STOP PROJECT

***This article discusses the concept of a "smart city" as a general vector for further socioeconomic development of cities that can lead to a qualitatively new level of life of population along with the improvement of approaches to urban management on Kazakhstan example. The authors discuss the "smart city" concept construction through the implementation of "intelligent transport" and "smart bus stop" projects. The issues of economic efficiency, social significance, the importance of algorithms development for electronic self-service machines ("smart bus stop" element) are discussed. The application of the developed model in electronic self-service machines while implementing the "smart bus stop" project has also been considered.***

***Keywords:*** *"smart city"; "smart bus stop"; city management; routing algorithm; electronic self-service; logistics.*

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## АНАЛІЗ КОНЦЕПЦІЇ ПОБУДОВИ «РОЗУМНОГО МІСТА» ЧЕРЕЗ РЕАЛІЗАЦІЮ ПРОЕКТУ «РОЗУМНА ЗУПИНКА»

***У статті розглянуто поняття «розумне місто» як генеральний вектор подальшого соціально-економічного розвитку міст, здатний сприяти створенню якісно нового рівня життя населення за відповідного вдосконалення підходів до міського управління на прикладі Казахстану. Обговорено питання побудови концепції «розумного міста» через реалізацію проектів «розумний транспорт» і «розумні зупинки». Розглянуто питання застосування моделі в електронних автоматах самообслуговування при реалізації проекту «розумна зупинка».***

***Ключові слова:*** *«розумне місто»; «розумна зупинка»; управління містом; алгоритм маршрутизації; електронне самообслуговування; логістика.*
***Рис. 3. Табл. 1. Літ. 12.***

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## АНАЛИЗ КОНЦЕПЦИИ ПОСТРОЕНИЯ «УМНОГО ГОРОДА» ЧЕРЕЗ РЕАЛИЗАЦИЮ ПРОЕКТА «УМНАЯ ОСТАНОВКА»

***В статье рассмотрено понятие «умный город» как генеральный вектор дальнейшего социально-экономического развития городов, способный содействовать созданию качественно нового уровня жизни населения при соответствующем совершенствовании подходов к городскому управлению на примере Казахстана. Обсужден вопрос построения концепции «умного города» через реализацию проектов «умный транспорт» и «умные остановки». Рассмотрено применение модели в электронных автоматах самообслуживания при реализации проекта «умная остановка».***

***Ключевые слова:*** *«умный город»; «умная остановка»; управление городом; алгоритм маршрутизации; электронное самообслуживание; логистика.*

**Introduction.** At present the concept of creating a "smart city" in Kazakhstan is very crucial, especially in anticipation of EXPO-2017 and while developing tourism and urban infrastructure in general. In order to build "smart cities", the government

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has taken the basic model of European "smart cities" development based on the interaction of 6 characteristics where smart mobility and smart environment are on focus. These characteristics include technologies such as high-tech city and intelligent (smart) machines for residents.

Beside the basic functions of different systems which might be installed while implementing the "smart city" concept, there are global problems which can be solved:

1. Ensuring high quality of life through the use of new technologies, cost-effective, and environmentally friendly urban livelihood systems to provide a platform for innovations and urban development in Kazakhstan.

2. Implementation of smart bus stop and smart transport projects as the main direction of tourism development and improvement of lives of all segments of population with the use of most advanced information and communication technologies and innovations.

3. Implementation of innovative solutions based on "smart technologies".

4. Automatic data collection and storage as for socioeconomic development of a particular city.

Kazakhstan takes measures on new technologies implementation and actualizing industrial and innovative projects in the region within the frame work of the National Program of Forced Industrial and Innovative Development (1.08.2014, #874). In general, it can be stated that today's innovative direction is implemented through the Smart City concept in accordance with the approved plan on technological filling, design of technological solutions in 6 directions, demands formation, financial feasibility study of accepted technological solutions, and project integration into the construction of "EXPO-2017" under the "smart city" principle.

**Latest research and publications analysis.** Smart city, its components and models of its development were investigated by N. Komninos (2002), N. Odendaal (2003), L. Torres et al. (2005), R.G. Hollands (2008), R. Giffinger et al. (2008), A. Caragliu et al. (2009), K. Paskaleva (2009), A. Asin (2013). Different countries have tried to apply various forms of intelligent systems in the fields of transport, medicine, environment engineering, architecture, energy, infrastructure, IT, education, security in order to build smart cities. As the consequence, there is still no methodology or unique list of principles of effective development and realization of this concept. Moreover, many new tasks appear as diverse intelligent systems are proposed. This article discusses the smart city concept construction through the implementation of the "intelligent transport" and "smart bus stop" projects. The key task is finding the solution to the problem of public transport routing and the development of transport schemes for electronic self-service terminals.

**The object of the research** is the construction of smart cities based on the example of intelligent systems application in transport.

**The goal of the article** is to develop an economically effective algorithm for public transport routing, transport scheme, useful and appropriate demonstration of analyzed data on electronic self-service machines on bus stops.

**Key research findings.** One of the main directions in the development of intelligent systems concept is the implementation of smart bus stop project through the changing the current bus stops to the "smart" ones. The authors propose the model of

a new intelligent bus stop with integration of an electronic system. The novelty of the article and of the developed system is the ability to use smart bus stop technology and scale it to any city of Kazakhstan as for a large number of objects and organizations as possible. In general, the current situation at the IT services market in Kazakhstan is very similar to the Western model. The need for services among the population is high enough and still not sufficiently covered. Assessing the market of IT services in Kazakhstan, except Almaty and Astana cities, it can be noted that it is in its infancy and has a great potential for further development.

*Table 1.* **Services in the field of information technologies in the Republic of Kazakhstan,** *mln KZN*

| Name | 2011 | 2012 | 2013 |
|---|---|---|---|
| Services for applications | 1691 | 4289 | 5483 |
| Repair services of computers and peripheral equipment | 6691 | 10462 | 8936 |

Source: Statistics Agency of RK, 2014.

The additional focus of this article is on the importance of algorithms development for electronic self-service machines in terms of vehicle routing, GPS-tracking, analysis of transport data, and demonstration it to the user. The overall development of this system ideally fits into the IT grow thin Kazakhstan.

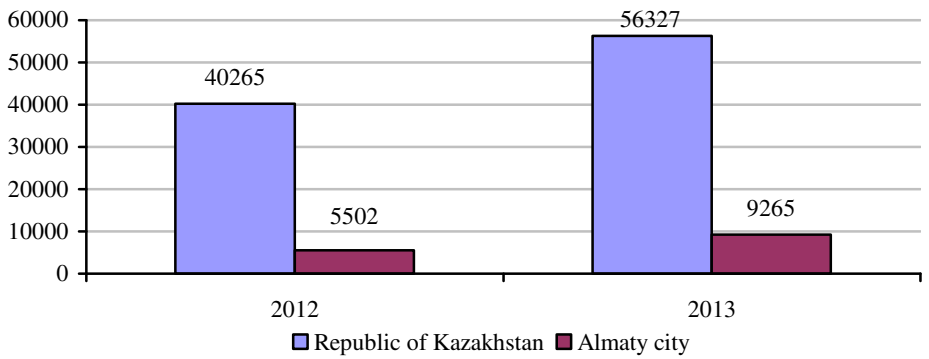


*Figure 1.* **Dynamics of the information services volume in Almaty and Kazakhstan,** *mln KZN* (Statistics Agency of RK, 2014)

Therefore, the tasks of vehicle routing arise in the carriage of goods by commercial or public transport. The aim is to determine the vehicle routing problem and transportation schedules to meet customer orders and minimize operating costs. Typically, the goal is to minimize the duration of a route, its length, cost or the number of vehicles used. Additional requirements must be satisfied for many limitations such as: spaciousness of a vehicle, driving time etc.

In the past, vehicles route compilers and controllers operated independently of each other and did not exchange information or did it only partially (Komninos, 2002). Vehicle position on the route line was not known and it was not always possible to establish a connection with a particular driver (Odendaal, 2003). Recent advances in information and communication technologies have significantly improved the quality of communication between drivers and the control center. Now the information on the receipt of new orders or changes in routes can be easily trans-

mitted to drivers which helps to improve the level of service and reduce costs. Moreover, modern navigation systems are capable of providing real-time information about the situation on the road and weather conditions while avoiding traffic jams.

The main purpose of this article follows from the task of developing a intelligent system for public transport in megacities using software and electronic self-service machines. Their main functions are:

- System shows all route numbers of different types of public transport to get information on how to get from a departure point to a destination point.
- System shows different ways of change from one vehicle to another which will be more comfortable to citizens.
- System provides a search function on Almaty tourist attractions and different ways on how to get there using the shortest route.
- System has voice instructions in 3 languages (Kazakh, Russian and English) which makes the system more convenient for all types of citizens.
- System tracks the current location of transport (GPS-tracking).
- System demonstrates the nearest places of clients' interest.

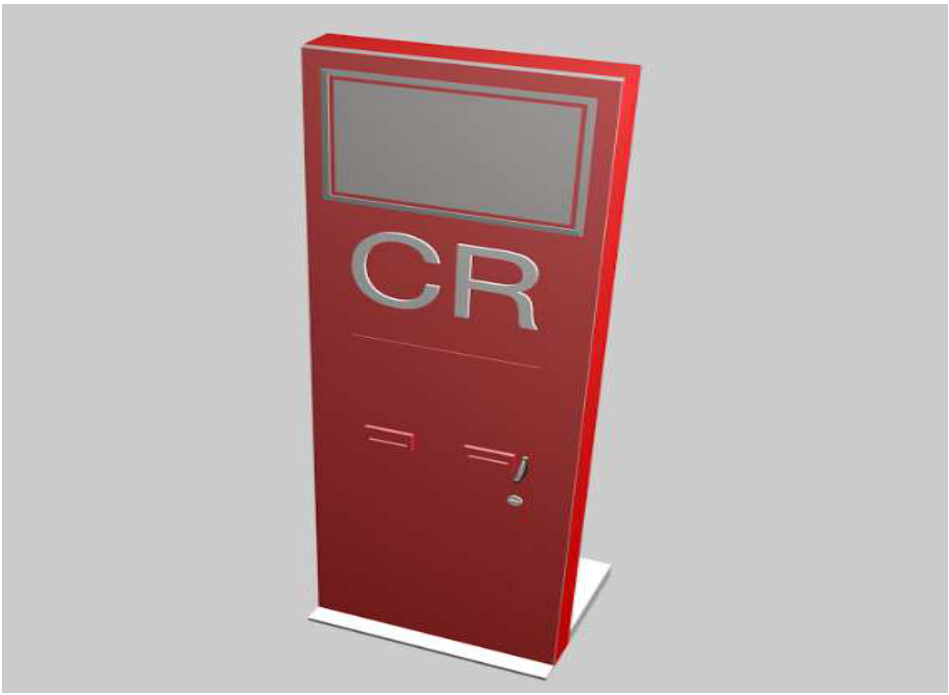


*Figure 2.* **Developed electronic intelligent self-service machine**

According to the results of the survey, it was found out that this service is needed by a huge number of people (foreigners, tourists, and people who do not know the city). Currently there is no such intelligent system in Kazakhstan (without taking into consideration the use of mobile devices). With the help of the developed intelligent system which represents a macrolevel modelling, it is possible to solve the main tasks such as:

- planning of transport infrastructure and public transport in cities;
- graphical processing of the network to facilitate the solution of transport problems and problems with traffic;
- transport networks analysis and evaluation with further optimization;
- forecast of planned activities with the use of public transport and urban road communications;
- provide a smart platform for transport and information systems.

In case of transition to the microlevel and during traffic planning on separate crossroads or group of crossroads and while demonstrating the obtained changes, the designed mathematical model must be used. To simulate transport flows and solve necessary tasks, the formation of data bank was considered including the following parameters:

- a detailed diagram of city streets;
- actual traffic volume and structure of traffic flows;
- vehicle speed (in the free state and with fully loaded street traffic);
- geometric parameters and streets/roads capacity;
- organization of traffic in the streets;
- public transport scheme and timetables;
- public transport bus stops and the time required to stop;
- transport blocks – areas with homogeneous density of population, level of development of industry and trade enterprises, attractive places for recreation etc.
- population, working-age population, the number of jobs and the number of people employed in the service sector (for each unit).


*Figure 3.* **Public transport routes of Almaty city (Kazakhstan)**

While implementing the intelligent system of electronic terminal, all data of the transport network was stored as the database based on SQL. The first step in creating a transport scheme is the insertion of city maps in accordance with the project description (Torres et al., 2005). It will serve as the background image applied to the transport network of the city. After that, it should be assigned to the transport system with a name, maximum and minimum speed. To simplify the sketch, streets are appointed to different types of segments classified by their functions and other parameters. The name is assigned to each type and specifies the following characteristics: maximum vehicle speed, lane allowed for movement, the total number of lanes etc. All these parameters can be set separately for each direction.

Creation of a transport scheme begins with the application of nodal points that characterize changes in geometric parameters of the street, speed, capacity, and the availability of stopping areas (Hollands, 2008). Grouped nodes are connected by segments of the appropriate type. Each segment is assigned by the name and made by detailed adjustments of its parameters (speed, lane, transport systems etc.)

The next step is the placement of stopping areas, the appointment of public transport routes and scheduling of motion. When calculating the schedules program, it is necessary to focus on the duration of the bus stop, start and end time of a route etc. (Giffinger et al., 2008).

One of the most important stages which effects the accuracy of the subsequent results is the division of area into transport blocks. For each block we appoint the center of gravity and communication – virtual segments which conduct entry and exit of private vehicles in the streets of the center of gravity in order to set communications parameters such as the resolution of the transport system and the share of private vehicles moving in this direction. Also the required links show the movement of passengers from the stopping areas to the center of gravity.

On the next step the system considers organization of vehicles' movement. Here we need to take into account several things: the limitation of individual modes of transport, a complete ban of turns at intersections of streets/roads, the organization of traffic flows at intersections at one or more levels, one-way traffic etc.

Bank of the road network parameters is designed to calculate the intelligent system's investment matrices on time of trips for population. Costs can also be expressed in terms of money or by using arbitrary parameters. Using these received matrices of costs and statistics on the population of the city, the matrix of correspondences of individual and public transport is constituted (Caragliu et al., 2009). For this purpose, a program module is used even if the number of blocks does not exceed 30, the calculation can be performed using the simple software.

The main statistical data necessary to create received matrices of correspondence are:

- population of each selected block;
- working-age population;
- the number of jobs;
- the number of people employed in the service sector.

The received matrix of correspondences of individual and public transport is substituted into the software of the intelligent system to produce the distribution of

population movements and individual transport. The result of this distribution is represented as diagrams.

To obtain more stable calculation results matrices of time are needed (until the system does not come to equilibrium). The final step in providing the accuracy of traffic distribution, the adjustments of model parameters as well as manual adjustment of traffic values according to field observations are needed. The program for the visualization of this transport scheme makes it possible to make segments on a variety of information such as traffic, speed etc. There is also a possibility to classify segments by different characteristics, components, stops and other attributes, thereby separating them from the total sample.

The main advantage of this smart system is the ability to forecast the organization of vehicles' movement (Paskaleva, 2009; Asin, 2013). It allows simulating the development of transport network with reconstruction or construction of new streets, intersections at different levels, changes in traffic organization, construction of new districts, planning consequences of emergency situations etc.

**Conclusions.** While responding to challenges of rapid urbanization and growing traffic, the development of smart transport systems has attracted much attention recently. Many promising initiatives have emerged over the last years. Despite these initiatives, there is still a lack of understanding about an appropriate definition of smart transport system. Therefore, the authors tried to propose the developed model of a "smart bus stop" project through the implementation of electronic self-service machines which would provide unique services and functions.

Based on the analytical study, this project would have a positive socioeconomic impact providing socially significant services. Information service provided will improve access to transport services, reduce service time for customers and save their time. This proves the attractiveness and usefulness of the model and the proposed smart bus stop system.

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