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Kiev, Ukraine, September 26 – 29, 2014

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The main target of the **IEEE East-West Design & Test Symposium** (EWDTS) is to exchange experiences between scientists and technologies of Eastern and Western Europe, as well as North America and other parts of the world, in the field of design, design automation and test of electronic circuits and systems. The symposium is typically held in countries around the Black Sea, the Baltic Sea and Central Asia region. We cordially invite you to participate and submit your contributions to EWDTS'14 which covers (but is not limited to) the following topics:

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The symposium is organized by Kharkov National University of Radio Electronics, National Pedagogical Dragomanov University and Science Academy of Applied Radio Electronics http://anpre.org.ua/ in cooperation with Tallinn University of Technology.

CONTENTS

Smart traffic light in terms of the Cognitive road traffic management system (CTMS) based on the Internet of Things

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Abstract

This work is aimed to describe a cognitive traffic management system (CTMS) based on the Internet of Things approach. Telecommunication technologies, which can be used for the system development and deployment, are analyzed. Smart traffic light integration is proposed as a replacement of the existing traffic lights. The main purpose of such replacement is to optimize traffic management processes which are made by government authorities. Smart traffic light integration excludes mistakes caused by human factor. Proposed approach can be used as a part of e-government system in further.

1. Introduction

From decade to decade global infrastructure projects are connecting the World – transcontinental railways and highways of the USA, the BAM project of the USSR, the Channel Tunnel beneath the English Channel. These projects became a strong development catalyst for the largest economies of the past and present. Laying underwater transatlantic communication cable and the Internet creation has begun development of the global information infrastructure. The latest achievements in wireless technologies opened new prospects for the Internet services development and popularization. The next constructive step was the Cloud computing technologies and services. Nowadays developers are able to scale computing power and storage capacity depending on their needs due to unlimited scaling opportunity of the Cloud technologies.

Increasing mankind needs require the next big step towards information infrastructure development. Fast-moving world needs the infrastructure that allows connecting not only computer devices and systems, but all things which surround people in their everyday life as well. The Internet of Things (IoT) is a new paradigm, which involves intercommunication between different things without human intervention, automated collection, processing and analysis of large amounts of data, generated by the sensors. The IoT makes possible high-accuracy probabilistic behavioral environmental models development. These models allow increasing the levels of everyday life comfort and security due to continuous monitoring of the data obtained from sensors in real time. In the long term IoT will let more effective resource spending owing to Smart cities and e-government concepts implementation optimizing and automating everyday city life management.

Smart traffic light, integrated into the IoT as a part of CTMS, makes possible development of a new generation information infrastructure. The main target of this infrastructure is an effective and optimal road traffic management. Big Data applications allow performing high-accuracy probabilistic analysis. Such analysis increases cognitive features of the system and CTMS is getting more and more autonomous and independent. Human's interventions become as less as possible, as a consequence number of errors, caused by human factor, declines as well.

2. Road traffic in terms of the IoT

Nowadays the Internet of Things is one of the most talked about and developing trends in the information technology industry. Development and implementation

of the IoT requires resolving the number of complex engineering and scientific problems that lie mostly in the areas of computer engineering, computer science, electrical engineering and telecommunications. These problems are being resolved by a special group which consists of engineers and scientists from the world's leading scientific and research communities, such as IEEE and EAI [1-3]. Moreover, R&D departments of the industry's leading companies - Intel, IBM, Apple, Google, Samsung, Dell – are doing research in these fields as well [4].

One of the main problems of the IoT is the Internet coverage. Leading communication companies are working in this direction and looking for the most efficient network technologies (AT&T, CISCO and THALES). Apart from this, progressive IT startups, such as WorldSensing, Aguila technologies, Connit, offer their own solutions which can be implemented as a framework of Smart city. They use proprietary technologies of the companies which offer network solutions dedicated to IoT (SigFox, Guglielmo, DQuid and BitCarrier).

Last but not least problem of the IoT is absence of unified standard. Intel, IBM, Apple and Samsung established working groups to develop a unified standard for the IoT, however this problem has not been completely resolved yet [5-7].

More and more scientific and engineering communities are talking about e-government approach development using the IoT. E-government lets excluding errors, inefficient solutions and even corruption caused by human factor. Road traffic cyber-physical management system CTMS makes transportation and logistics more efficient, leads to much better life quality on the roads due to excluding human factor as well. Transportation authorities have big amounts of statistical data and advanced planning tools. Nevertheless, transportation flows management is being done inefficiently. By means of Big Data processing technologies CTMS can reach the most accurate and up-to-date picture describing real-time situation on the roads. Big data processing and high-accuracy probabilistic analysis technologies open many new business opportunities in the field of freight and public transportation. Real-time public traffic analysis allows to deliver the optimal amount of transport for a given number of passengers during the peak hours and to avoid empty transport movement on the roads. This lets not only saving money, but improving passengers' comfort level.

However, it is necessary to solve a few problems which lie in the fields of information technology and data science to achieve this goal [8, 9]. Firstly, business analytics has to develop business process, aimed to collect such information, which could be used for business profitability improvement, operations optimization and increasing the level of user's satisfaction. Close interaction with existing systems will identify a set of data and collection methods required for modeling a real-time system.

Statistical analysis of the collected data and CTMS modelling will help to determine or predict possible scripts on the roads. It is necessary to develop a process of reporting and visualization that will solve problems and make quick and effective decisions on an intuitive level, based on the provided reports for a clearer presentation of the results.

Not only information about the situation on the roads and current statistics can be used in further. CTMS will use online traffic statistics, weather indicators, geospatial information, sales statistics in different parts of settlements and other sorts of information that can help to make the most accurate forecast.

The future of probabilistic analysis in the transportations sector cannot be overemphasized. Nowadays, initial amount of data about the traffic situation already exists and can be analyzed and applied aiming to new services creation. It is necessary to create a process that will select relevant data and then, make an accurate prediction in real-time, using Big Data technologies.

3. CTMS infrastructure

An integral part of the Internet of Things is inter-machine interaction – M2M – a set of technologies and approaches aimed to provide communication between machines and devices. Many companies on the Smart City market provide proprietary platforms, frameworks and hardware solutions for such type of systems – Connit, Aguila Technologies and others. There are several companies that have their own patents and working projects in the field of Smart Cities. One of these companies is WorldSensing – a company working in the field of Smart Cities. WorldSensing has implemented several well-functioning projects. One of the projects of the company is aimed to build a smart parking – WorldSensing FastPrk (fig. 1).

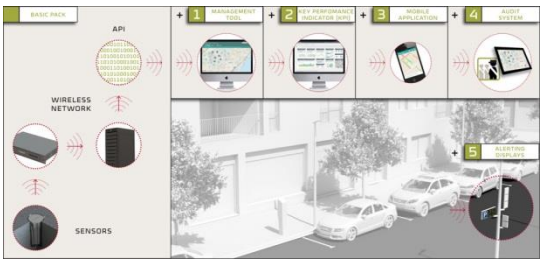

Figure 1. FastPrk smart parking system

FastPrk is a smart parking system, which gives a driver possibility to find a free parking space fairly quickly. Apart from this, city authorities obtain a possibility to arrange limited parking space more efficiently and get more money from drivers. Informing the driver is carried out either by using a mobile app, or by displaying information on the interactive screens. City authorities have 24/7 access to the system and receive data regarding occupation of parking space, as well as information about payment for parking places. The sensors operate in Sub-GHz frequency range with a maximum radius of action of 500 meters.

Global traffic management system such as CTMS requires environment which provide the Internet connectivity to all vehicles on the road. This can be achieved by synchronizing your mobile phone with the vehicle. Such approach gives an opportunity to uniquely identify the driver by means of a mobile number. Two major companies work in this direction to achieve such connectivity – Apple and Google. In 2014 two embedded platforms for communication, navigation and entertainment were announced – Apple iOS CarPlay (March) and Google Android Auto (June). These systems do not have fundamental differences and use microprocessor based operating system Blackberry QNX. The only difference is a set of services provided by Apple and Google. In order to start the system, you must connect your smartphone (Android or iOS, respectively) via USB cable to the car. After that, the driver obtains access to the provider's services through applications tailored for the automotive operating system.

Dedicated automotive OS development and industrial production of vehicles operating under their control, allows assuming that in the near future all vehicles will be connected to the Internet. Global systems development, aimed to optimize traffic, road lighting and other services related to road traffic the car becomes possible.

Roadsolver & Citysolver – the solutions proposed by WoldSensing and BitCarrier companies. These intellectual traffic monitoring systems for cities (CitySolver) and highways (RoadSolver) are aimed to optimize traffic on the roads and provide real-time assistance to the drivers. Realization of these projects is a huge pace towards Smart City infrastructure development, which satisfies needs of a city and provides people with up-to-date information about the situation on the roads by means of information and telecommunication technologies. Projects implementation requires dedicated network deployment in the city and along the highways outside.

Weak spot of CTMS is communication standard used to provide M2M connectivity. Rapid development of the Internet of Things requires creation wireless heterogeneous networks operating in different frequency ranges and different standards - ZigBEE, WiFi, LTE (3G, 4G, 5G), Bluetooth. Each of these types of networks has its advantages and disadvantages within the concept of the Internet of Things. The main parameters of the networks that affect the Internet of Things are range, bandwidth and power consumption. In various applications, the priority of these parameters is different, so none of the listed communication technologies is suitable for all applications of the Internet of Things.

Important part of the Internet of Things infrastructure is the collection, processing and data analysis – Big Data, Open Data and Cloud computing [10]. Big Data approach allows analyzing huge volumes of unstructured data. Big data allows doing high-accuracy probabilistic forecasts, which can be used in various fields. Open Data is a concept where certain data are opened to use in machine-readable format. Open Data is open or free of copyright restrictions. Cloud computing in the aspects of the Internet of Things is infinitely scalable platform for processing and storing information from the sensors. Cloud computing technologies open new possibilities of processing large volumes of data in real-time, transforming the system and adjusting to the current environment.

Definition a communication standard for the Internet of things can be reduced to the determination of three interrelated parameters - power consumption, bitrate and range. After system requirements definition, it is possible to determine the most effective technology for certain conditions.

4. Smart Traffic light

In 2014, Nick Fablo (Portland) presented a new idea of intersections. Main objective of the project is to increase safety of cyclists on the roads. In addition to special engineering constructions, the project involves usage of dedicated traffic lights for cyclists. In the case of a standard system of traffic lights, this approach faces increasing vehicle downtime. It is necessary to use smart technologies and special algorithms that take into account the flow of cars and bikes and depending on the situation on the road manage traffic. Approach of the Smart Traffic light will reduce the negative impact of the nervous tension for cyclists and motorists as well.

Connecting all the cars to the network and combining them into a single system will optimize traffic through intelligent control of intersections. Smart Traffic lights system takes into account the workload of the road and switch traffic light signal depending on the number of vehicles. This will prevent

needless delays at intersections in that case if one of the roads is less loaded than the other. It makes possible to calculate the total emissions of carbon dioxide, which can be one of the switch parameters of the traffic light. As a result, this approach will completely get rid of the physical traffic lights on the roads, saving a huge amount of budget money on electricity bills, maintenance and updating the existing infrastructure of physical traffic lights.

Smart Traffic light (STL) is the main controlling part of CTMS infrastructure. STL is a stationary microcomputer with a transceiver connected to CTMS cloud server. At the same time, STL operates as a repeater in CTMS wireless network, which is used to interact with car computers. STL state is available for monitoring in the CTMS cloud service. Provided information is displayed on the screens of all vehicles crossing the intersection and those who are in the area of its competence. STL can be controlled remotely by special emergency services. STL scans and processes all requests from the vehicles in real-time. It also provides appropriate control signals that are functionally dependent on the traffic situation on the sides of the intersection. All the STL of the city form an STL network technological layer which controls road traffic in autonomous or/and semiautonomous state. STL control method uses the maximum Boolean derivative on the lines of motion, graphics triangular accumulation $N^{\bullet} = k \cdot t + b$ and passing $N^{\circ} = -k \cdot t + b$ vehicles through the intersection – bottleneck of the road infrastructure. Scan period equals to 1 second. Derivative calculation or update aimed to form the control STL signal is synchronous with the specified period. STL switching is delayed if all sides of intersection are full for minimizing conflicts on all lines of traffic flows. STL switching cycle has a minimum period equals to the crossing time. The maximum period is limited by the occurrence (presence) of crossing orders from the vehicles.

Measurement results obtained using the Big Data technologies can be used to improve the efficiency of the system, its autonomy and accuracy, due to analysis of the dependence of the density of traffic flows from different aspects and sources, including social networks and smartphones applications.

Thus, CTMS is characterized by cloud interrelated components: infrastructure, monitoring and traffic management (fig. 2). The main controlling part of CTMS is the STL, which allows to: 1) optimize the traffic time, cost and quality to address the social, humanitarian, economic, criminal, insurance and environmental needs; 2) reduce existing road infrastructure and save: materials for the manufacturing of road signs and traffic lights, energy, money for installation and servicing the traffic lights, reduce operating costs through development traffic lights in the virtual environment of the planet.

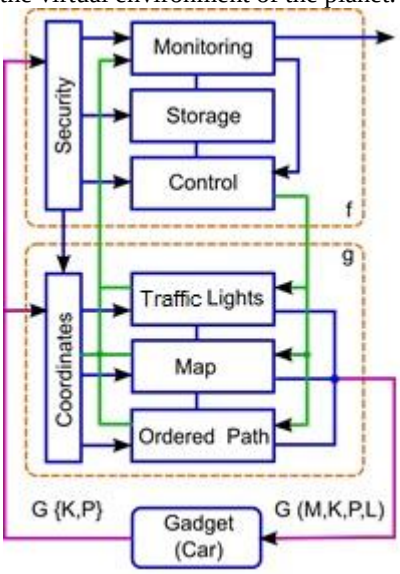

Figure 2. CTMS structure

5. Conclusions

Traffic management system – CTMS – has been proposed in this paper. The main part of the system is Smart traffic light – virtual analog of existing physical traffic light. The system generates control signals based on the information obtained during the analysis of data obtained from cars and road sensors, as well as alternative sources of user data, such as social networks, the results of opinion polls and others. The logic of the Smart traffic light changes periodically, which can increase the efficiency of the control system through the analysis of relevant information obtained in real time. CTMS is a part of e-government model, which excludes operating errors caused by the human factor. CTMS implementation enables the most efficient distribution of budgetary funds by automating the traffic management system and is a step towards the development of a global e-government concept.

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