KHARKOV NATIONAL UNIVERSITY OF RADIOELECTRONICS

Proceedings of IEEE East-West Design & Test Symposium (EWDTS'2013)

Technically Co-Sponsored by

Rostov-on-Don, Russia, September 27 – 30, 2013

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11th IEEE EAST-WEST DESIGN & TEST SYMPOSIUM (EWDTS 2013)

Rostov-on-Don, Russia, September 27-30, 2013

The main target of the **East-West Design & Test Symposium** (EWDTS) is to exchange experiences between the scientists and technologies of the 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 systems. The symposium aims at attracting scientists especially from countries around the Black Sea, the Baltic states and Central Asia. We cordially invite you to participate and submit your contribution(s) to EWDTS'13 which covers (but is not limited to) the following topics:

- Analog, Mixed-Signal and RF Test
- Analysis and Optimization
- ATPG and High-Level TPG
- Built-In Self Test
- Debug and Diagnosis
- Defect/Fault Tolerance and Reliability
- Design for Testability
- Design Verification and Validation
- EDA Tools for Design and Test
- Embedded Software Performance
- Failure Analysis, Defect and Fault
- FPGA Test
- HDL in test and test languages
- High-level Synthesis
- High-Performance Networks and Systems on a Chip
- Low-power Design
- Memory and Processor Test
- Modeling & Fault Simulation
- Network-on-Chip Design & Test
- Modeling and Synthesis of Embedded Systems
- Object-Oriented System Specification and Design
- On-Line Test
- Power Issues in Testing
- Real Time Embedded Systems
- Reliability of Digital Systems
- Scan-Based Techniques

- Self-Repair and Reconfigurable Architectures
- Signal and Information Processing in Radio and Communication Engineering
- System Level Modeling, Simulation & Test Generation
- Using UML for Embedded System Specification

CAD Session:

- CAD and EDA Tools, Methods and Algorithms
- Design and Process Engineering
- Logic, Schematic and System Synthesis
- Place and Route
- Thermal, Timing and Electrostatic Analysis of SoCs and Systems on Board
- Wireless Systems Synthesis
- Digital Satellite Television

The Symposium will take place in Rostov-on-Don, Russia, one of the biggest scientific and industrial center. Venue of EWDTS 2013 is Don State Technical University – the biggest dynamically developing centre of science, education and culture.

The symposium is organized by Kharkov National University of Radio Electronics and Science Academy of Applied Radio Electronics http://anpre.org.ua/ in cooperation with Don State Technical University and Tallinn University of Technology. It is technically co-sponsored by the IEEE Computer Society Test Technology Technical Council (TTTC) and financially supported by Aldec, Synopsys, DataArt Lab, Tallinn Technical University, Aldec Inc.

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CONTENTS

Smart Road Infrastructure

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Abstract

The idea of creating such a project was the fact that in Ukraine, as well as in many other countries the existing traffic control system does not correspond to the growth rate of the number of vehicles and pedestrians. As a whole lags behind the management of road traffic from the growing number of cars and the changing needs of the people.

The basis of the work included a detailed analysis of the situation, a description of the problems of this area, the identification by means of various algorithms of possible solutions, a theoretical synthesis of similar projects, as well as the introduction of concepts of devices and methodologies to improve and represent radically new way of controlling traffic.

The use of modern IT-technologies, software and hardware to improve and build a new road infrastructure is put as a priority task of the project. This is due to the scientific interests of the project's developers at Kharkiv National University of Radio Electronics, where first notes and discussions on research topic were written.

1. Introduction

1.1 The relevance of research

Currently there are more than 150 projects on automation of traffic. The main disadvantage of them is that these projects are fragmented. There are separate versions of realizations with disabilities. There is no system that combines several technologies and is able to solve multiple global challenges. The new idea behind this project is not only able to solve above existing problems in the traffic control system, but also provides a unique opportunity for all road users, opening the prospect of the development of software and hardware systems for infrastructure development of mega cities. Interest is the use of a radically new way to manage and introduction innovations in the traffic control process. The implementation of a solution to the problem of high demand, as there is an urgent need to change the system of monitoring and traffic control, and there is a growing demand for IT-technologies in built-in car devices. The uniqueness of the project is a combination of modern IT-technology, mathematical models and hardware technology tools into a single integrated system.

1.2 Research goal

The priority goal at stage of creation the system is searching for a close to ideal way to redirect traffic to optimize the capacity of modern roads. A key aspect is building the infrastructure of intelligent interaction of all the nodes of «Smart Roads» system. Primarily system developers' aspirations are aimed at traffic congestion improving, road safety improving and the provision of additional services to facilitate and enhance the usability of the car. The incentive is put as an opportunity to save on fuel costs in the implementation of the system, saving on resources for maintenance of vehicles, reducing idle time in traffic jams and increasing the speed of goods delivery and the speed of emergency services provision.

1.3 Research target

To determine the range of problems and finding competitive implementations on the problems of research we should to make an analytical review of existing models of transport monitoring in different countries. It should be analyze the methods and technologies based on literature / internet sources to identify the advantages and disadvantages in different systems. Search and compare the practical applications of IT-technologies in the field of traffic management will help to define the task of the project. Formulating the requirements that are necessary to achieve that goal, and, based on the theoretical algorithms, we can develop a scheme of the system and start the software implementation. Bringing to the prototype stage will mean the successful implementation of the planned tasks.

2. Infrastructure components

For a description of the tasks realization it is necessary to determine components of the system and its structure, and the necessary tools for implementation. The proposed project consists of a system of interaction between the vehicle on-board unit, traffic control points ("smart lights") and cloud service in Internet.

2.1 The model of the system

Globally «Smart Roads» system can be represented as follows. It consists of several key elements.

- All cars passing in the territory of the system (state, city, and region) have certain tag, which is an electronic passport of the vehicle.
- For areas of the road, where the traffic lights and electronic signs with arrows, it is proposed to implement with additional equipment within the complex "Smart lights", which includes sensors that scan in real time marks of passing vehicles, as well as an antenna for multi-channel data transfer to the cloud service.
- Central data collection and processing server received the data from a cloud service, and by analyzing the information, provides it online to the map system in Internet, as well as support feedback with "Smart lights" traffic control system. There will be a large number of such servers; they will form an array of distributed data processing system. Thus, it is assumed that the computational load is evenly distributed between the servers.

2.2 Innovations

1. Smart traffic lights switched depending on the traffic, but not in terms of timings as in the existing road traffic systems.
2. Maps for devices work in real time and displayed online situation.
3. Using multi-channel data transfer.

Let us consider in details each of the technologies.

2.3 «Smart light» solution

The primary regulator of traffic in the current system of Ukraine is the control by traffic signals, signs and road marking in accordance with road traffic rules.

If we exclude the static form of control, the traffic light is the only regulator of the flow of cars and pedestrians, which is able to change dynamically the readings of light devices. However, this method has some serious problems and is becoming outdated.

It is found that the traffic intensity of the vehicles may vary depending on the time of day, period of year, different sections of the road, holidays or weekends, changing road conditions, weather conditions, having an accident on the road sections, the difference is even according to the city (the capital region, the border town, the resort).

The classical scheme of traditional traffic light can be described as follows: there is a light device with a microcontroller that has a hard-coded logic of switching states of light indicators. There are different configurations of traffic lights. Sometimes they work in manual mode, and also there may have additional indicators, sections, but the overall sense is similar.

Usually, the mathematical scheme of traditional traffic light based on switching states in a predetermined time interval. But is it always good to have a constant "timings" in the system? It is a philosophical question.

We live in an era of dynamic world where changes on the stock exchange in one country may cause a sharp jump in the exchange rate in another country, and even a sequence of financial or human manipulations in a third country. Successful and proper execution of the project by architect will help to implement it faster and make more profit. "Bugs" in the programmer's code causes failures in project release time because of needs to debug and also causes the delay in getting the product to market. Just one mistake of «MacDrive» manager in McDonald's is able to create a query of 5 cars and make difficult the movement at the parking.

The obvious one is the transition from the constant control to a more rational and sustainable dynamic solution in the management of the traffic flow.

2.4 Efficiency justification

The advantages of using a system of "Smart light" clearly demonstrate the examples in real life.

In such a big city like Moscow there are a lot of crossroads, where the time of the green light less than 12 seconds. Ordinary people, especially older people and children, do not have enough time to cross the road in such a short time. At the same time, in the city like London, drivers complain about excessively large time interval of red light in areas where priority for pedestrians is bigger than it requires. In the cities of Italy, France, Greece, where historically the streets are narrow and intricate it needs to apply the opposite

method of traffic management, than in the U.S., where streets are often at 90 degrees angles to each other. In Ukraine, including Kharkov and Kiev, for example, there are no any underground parking, so cars, left on the roadside, especially during the daytime, reduce the effective place of the roadway, complicating the traffic in cities, which is already aggravated by unsustainable and poorly coordinated traffic lights work.

Almost everywhere the width of the roadway, the total length of the crosswalk with street islands, the presence of hospitals or schools nearby, underpasses and bridges and a lot of other factors are not taken into account.

Thinking about the situation pushes to changes, the result of which is increasing need of using different ways of traffic lights switching. Scientific and technical progress of the 21st century is already able to resolve some of problems.

The "Smart light" solution in conjunction with systems of the infrastructure of «Smart Roads», will provide a lot of things, including the following:

– improving pedestrian safety by more correct functioning of traffic lights (getting rid of the problem of people's road transition at a red light, reducing casualties);

– improving the drivers' comfort by intelligently designed centralized control of traffic lights and reducing the idle time of cars;

– improving the efficiency of the mathematical apparatus of the traffic light's microcontroller (using a variable logic of lights switching);

– heuristic analysis of congestion applying and redistribution of car flows to reduce traffic jams in cities;

– increasing the capacity of vehicles by using intelligent control within «Smart Roads»;

– permanent traffic monitoring to provide actual information to the map service and to users of mobile devices and also to display online road traffic situation through the cloud service system.

2.5 RFID Tag scanning

Equipment cars or other vehicles (buses, trucks) with RFID tags will allow defining them as moving objects at traffic control points, to monitor the capacity of the road.

Such a solution of detecting vehicles can provide a connection with "Smart light" as quickly as possible in comparison with other methods, and is the cheapest to implement product for car owners. In examples below you can see the use of these radio-tags in the systems of gates control and in the parking lots.

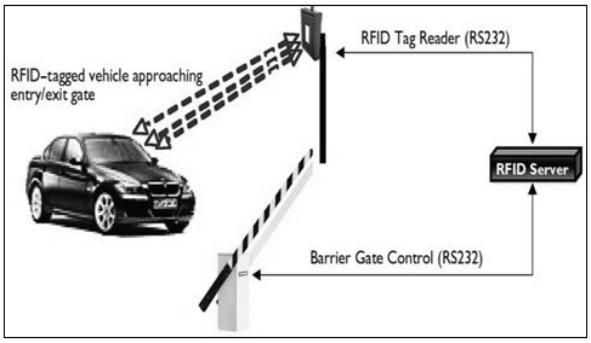

Figure 1. ID tags in front of barrier

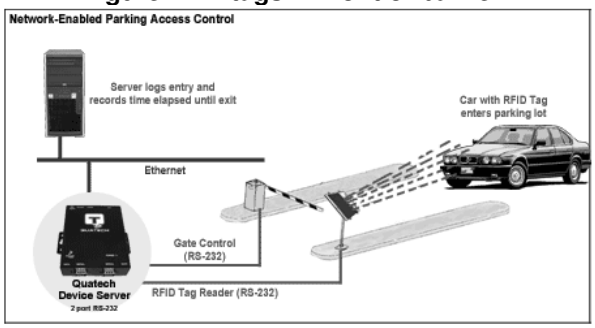

Figure 2. RFID at parking lot

2.6 «Multi-Link» system

Providing the communication and transfer of data from the point of traffic control to cloud service «Smart Roads Cloud» - this is a priority task in the building of intelligent and fully automated system «Smart Roads».

The developed system «Multi-Link» is based on three supporting factors such as:

1. Speed
2. Stability
3. Cost

One of the main criterion in urban environments - is the speed of information exchange. Another important factor, especially on routes outside the city, is stability and reliability of the link. The final cost of using the system should be as low as possible. The combination of these three criteria – is the purpose of the system «Multi-Link».

Let's analyze "stability" aspect. What could be more reliable than a Swiss bank? Only the system of communication used at ATMs in Switzerland. The author offers don't waste time for reinventing the wheel, but modify and introduce such a scheme due to the complex «Smart Roads».

There are 3 channels in the scheme, such as:

- Wired (as more reliable)
- Wi-Fi / WiMAX (as the fastest)
- Mobile Cellular (for availability in the coverage area)

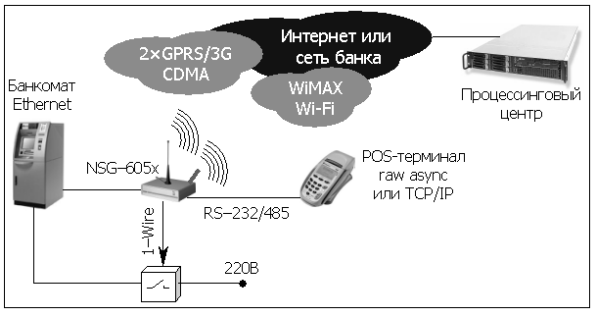

Figure 3. Using multi-channel link in ATM

As a result, by programming the system to choose the optimum channel it could be done a permanent line of communication almost anywhere.

Let's input some of definitions, which describe the functionality of the "Smart Roads".

Criterion of system efficiency (CSE).

CSE – is the ratio of the number of routes with optimal congestion and all routes in the specified interval of the road. In ideal case CSE is close to 1 or 100%.

$$C_{SE} = \frac{Q(R_{optimal})}{Q(R_{all})} \quad (1)$$

Optimal route (R optimal) – this is the route that does not have cars, or load does not exceed the specified limit (< 50 %).

Critical route (R critical) – this is the route that have full load of cars (100 %), or load more than the specified limit (> 50 %).

(Rall) – the total number of routes in the interval of the road.

Availability of alternative ways to travel from point "A" to point «B» shows that the specified interval of the road has more than one optimal route (R optimal), and it increases CSE.

The capacity of the route (CR) – is the quantity of cars, which are passing through traffic control point per time unit.

$$C_R = \frac{Q(A)}{T} \quad (2)$$

{A – automobile, T – time unit}.

This parameter is closely related with R optimal and uses for car flows balancing, which needs for reducing the load of roads. Bigger road capacity is better.

Data transfer speed is critical parameter, that's why the system consists of 3 different channels, but not of one.

This gives an advantage in stability and covers almost all of possible communication errors.

V_{ch1} – wireless channel

V_{ch2} – CDMA/GPRS/3G channel

V_{ch3} – Ethernet channel

An example below shows a failure of one of the channel link.

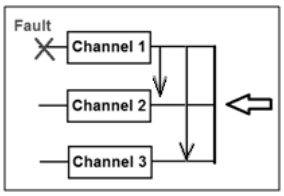

Figure 4. Channel switching in error case

Connection stability parameter depends on availability of free data transmission channels and the maximum supported data rate.

"Smart Roads" system load is defined as the ratio between the servers that perform the monitoring, transmission and data processing procedures and the total number of servers running on the system at the current time.

To balance the workload of servers, all the information tasks are redistributed between the nodes of the system, thus achieving a better efficiency of using software and hardware resources.

3 Innovations

3.1 Advantages of the system

1. Standards compliance

Traffic management in the new scheme does not violate the existing road rules, and harmoniously fit into the speed limits and other control criteria in compliance with all standards described by the legislative framework of the country.

«Smart Roads» system improves and complements the existing system by more convenient services with modern functionality.

2. Easy to implement

The infrastructure for the system will use existing traffic control points, which means that the infrastructure is halfway ready (electric power supply as well). We can also use stationary points of the video fixation using radars like "Harpoon" and "Vityaz", which is already installed on the public roads in Ukraine. It needs only to add the new compact equipment for data transfer and connect it to the network. Server side development is possible in every police patrol service point and in the cloud service.

3. Benefits for users

The system is based on the principles of service availability. The price and installation cost of RFID

tags will be low. Sales and support functions will be done by inspection services or third-party company.

Providing a map service to users of mobile systems, as well as owners of car navigators is carried out on a competitive fee basis or by monthly subscription.

The opportunities of reducing the time in traffic jams, as well as timely arrival of the taxi workers will be accepted positively. There are also feedbacks gathering in Internet.

4. Motivation for government agencies

First of all it is the modernization of the system and brings it to the international standards level.

It is recommended to create the agency for centralized maintenance of «Smart Roads». Optimization of workload of the traffic police services will improve monitoring efficiency.

Attracting profit by using the new features described above (monetization of map service, ease of payment for parking lots and toll roads) is also good motivation.

5. System safety

A key argument "against" in applying photo-video vehicle identification was that potential users do not wish to be identified.

Many people are worried about the information of their cars that may be transferred or used for other purposes. There is also possibility of hacker attacks on the identifiers database and stolen cars database.

The use of RFID tags in proposed «Smart Roads» system eliminates problems about privacy and will not violate any law of the country regarding to the invasion of private life of a person.

3.2 Future research

Upon successful implementation the «Smart Roads» project it is also planned to deploy a system of interaction with the emergency services to provide quicker detection and localization of road accidents, to provide fast assistance for victims in cases of emergencies.

In order to improve traffic control devices it is proposed an innovative device, such as the monitor with an interactive interface.

There is ability of creating infrastructure to scale, depending on the changing cities conditions and the numbers of vehicles, and also ability to the territorial extension and addition of new "nodes" of cloud system.

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Camera-ready was prepared in Kharkov National University of Radio Electronics
Lenin Ave, 14, KNURE, Kharkov, 61166, Ukraine

Approved for publication: 11.09.2013. Format 60×841/8.
Relative printer's sheets: 52. Circulation: 200 copies.
Published by SPD FL Stepanov V.V.
Ukraine, 61168, Kharkov, Ak. Pavlova st., 311

Матеріали симпозіуму «Схід-Захід Проектування та Діагностування – 2013»
Макет підготовлено у Харківському національному університеті радіоелектроніки
Редактори: Володимир Хаханов, Світлана Чумаченко, Євгенія Литвинова
Пр. Леніна, 14, ХНУРЕ, Харків, 61166, Україна

Підписано до публікації: 11.09.2013. Формат 60×84$^{1}/_{8}$.
Умов. друк. Арк. 52. Тираж: 200 прим.
Видано: СПД ФЛ Степанов В.В.
Вул. Ак. Павлова, 311, Харків, 61168, Україна