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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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Cloud Infrastructure for Car Service

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Abstract

A set of innovative scientific and technological solutions, including for solving social, human, economic and environmental problems associated with creation and use of a cloud for monitoring and management is developed. All of these technologies and tools are integrated into the automaton model of real-time interaction between monitoring and management clouds, vehicles and road infrastructure. Each car has a virtual model in a cyberspace - an individual cell in the cloud, which is invariant with respect to drivers of vehicles.

1. Introduction

Where does it go real cyber world? Corporate networks, personal computers, as well as individual services (software), go to the "clouds" of a cyberspace, which have an obvious tendency to partition the Internet for specialized services, Fig.1. If today 4 billion users are connected in the Internet (1 zettabytes $= 10^{21} = 2^{70}$ bytes) by means of 50 billion gadgets, in five years each active user will have at least 10 devices for connecting in cyberspace. Use of personal computers without replicating data to all devices becomes impossible. But even simple copying requires more non-productive time for servicing systems and projects, which can reach 50% if several devices or servers with identical functions are available. Unprofessional (bad) service of such equipment creates problems reliable data retention, as well as unauthorized access. Also, there is a problem of remote access to the physical devices when migrating users in the space, and obtaining the necessary services and information from gadgets left at home or in the office is difficult. Economic factor of effective use of purchased applications installed in gadgets and personal computers, force the user to give up their purchase in favor of almost rent free services in the clouds. All of the above is an important argument and undeniable evidence of imminent transition or the outcome of all mankind to cyberspace of virtual networks and computers, located in reliable service clouds. Advantages of the virtual world lie in the fact that the micro-cells and macro-networks in the clouds are invariant with respect to numerous gadgets of each user or corporation. Cloud components solve almost all of the above problems of reliability, safety, service and practically don't have disadvantages. So far as the corporations and users go to the clouds, protection of information and cyber components from unauthorized access, destructive penetrations and viruses is topical and market appealing problem. It is necessary to create a reliable, testable and protected from the penetrations cyberspace infrastructure (virtual PCs and corporate networks), similar to currently available solutions in the real cyber world. Thus, each service being developed in the real world should be placed in the appropriate cloud cell that combines components similar in functionality and utility. The above applies directly to the road service, which has a digital representation in cyberspace for subsequent modeling all processes on the cloud to offer every driver quality conditions of movement, saving time and money.

The goal of the project is improving the quality and safety of traffic through creating intelligent road infrastructure, including clouds of traffic monitoring and quasi-optimal motion control in real-time by using RFID-passports of vehicles, which allow minimizing the time and costs of traffic management and creating innovative scientific and technological solutions of social, humanitarian, economic and environmental problems of the world.

2. System model

Automaton model of cloud and vehicles interaction is shown in Fig. 1, where the cars send on-line their identifiers (personal data), the motion parameters and the current coordinates to the cloud, and in return receive in real-time services of optimal route (by time, cost, and quality) and motion mode to achieve final destination. Integrated analysis of road conditions based on processing operational data from vehicles and infrastructure monitors makes it possible to optimal manage road controllers for switching traffic lights on-line.

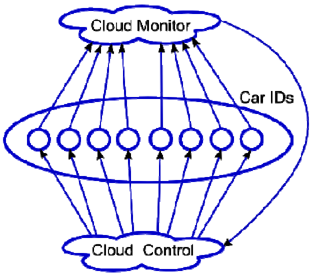

Fig. 1. Structure of vehicle and cloud interaction

The interaction of the real world (car and infrastructure) with a cloud forms two types of relationships defined by the automaton models (Fig. 2): 1) transport infrastructure with a cloud for monitoring and management; 2) a car with a cloud for optimization and providing efficiency of movement. Here the following signals are represented: X_1, Y_1, X_2, Y_2, C, M – input conditions or operands are necessary to ensure the ordered services; the output warning signals, confirming the execution of service operations; input control signals, forming queries for executing services; output variables, which form and identify state of management system; the signals of intelligent driving or road infrastructure; warning signals about execution of operating service. Automata models of road and car management system are represented in the form of variable interaction by the functions of transitions and outputs of the automaton of first kind:

$$CC = \{X, Y, C, M, f, g\},$$
$$\begin{cases} Y(t) = f[(X(t), M(t), Y(t-1)]; \\ C(t) = g[(X(t), M(t), Y(t-1)]. \end{cases}$$

Here, each of the two automata for interacting infrastructure and transport with the cloud has two input variables (services order and state of managed object) and two outputs signals for monitoring the automaton (cloud) state and management of cloud services.

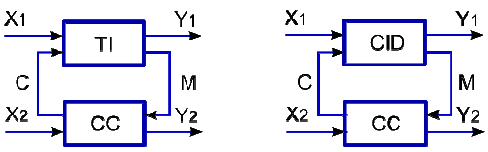

Fig. 2. Interaction of infrastructure, transport and cloud

More detailed representation of the interaction between real, virtual components and the cloud system for transport monitoring and control is shown in Fig. 3 (vehicle computer, road infrastructure, the Internet, smart dust, RFID-tag, satellites of navigation and location, car, electronic map, ID of a car with a transceiver, government services, and communication gadgets with the Internet).

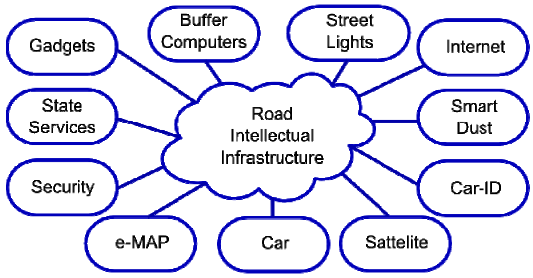

Fig. 3. Intelligent road infrastructure

3. The grounds of research

1) Market appeal. The capitalization of the business project in Ukraine after three years of the exploitation of IRI cloud - $ 100 million.

2) The project is focused on providing services for 7 million drivers in Ukraine and 8000 companies. Analogues of such systems do not exist in the world. There are separate components for creating the infrastructure: electronic maps, satellite location and navigation systems, specialized databases in clouds, tools for monitoring, collecting and protecting information. Availability of reliable cellular communication provides the necessary infrastructure for the project. Tools for navigating and monitoring vehicles are financially accessible to drivers. Software, hardware and network centralized management of traffic across the country, as well as cloud computing technologies are available. The technologies used in the infrastructure of roads and cyberspace are continuously improved, and their cost is reduced. Computer, mobile and internet literacy of people is enhanced. The state government understands the need for creating and use of intellectual infrastructure and cloud service for qualitative and safety road.

1) Project (draft) of the state program "Road Safety" with a planned budget of 5.43 billion hryvnas.

2) Theoretical basics of the project (intelligent and brain-like models, methods and engines for analyzing cyberspace related to discrete optimization of searching, recognition and decision-making) are represented in [1-6].

3) Experience in the development and implementation of embedded RFID and digital systems for road monitoring is described in [7-16, 29, 30].

4) Experience in the development and implementation of software and cloud services for optimizing vehicle routes of Ukrainian corporations in order to minimize the financial and time costs and improve the quality of passenger service is represented in [17-27].

5) The developed distributed road management system in large and major cities is based on highly reliable Siemens computing equipment [37-41].

4. Objectives of research

1) Make an overview and analysis of existing technologies for monitoring and road management, based on interaction of embedded RFID vehicles, cloud services and road infrastructure.

2) Investigate the necessity, possibility and inevitability of creating intelligent cloud service for monitoring and road management that optimizes realization of transport routes by all road users.

3) Create an intelligent road controller for managing traffic, based on programmable logic controller S7-1200 from SIEMENS.

4) Develop metrics and engines to analyze data on the quality and effectiveness of virtual road infrastructure when realizing routes by vehicles.

5) Create intelligent models, methods for synthesis and analysis of virtual infrastructure for evaluating the quality of road traffic, traffic modeling, generation of the optimal route based on the technical, climatic and social factors, the quality of roads, the number of traffic signals, left turns in order to create new and reconstruction of existing road infrastructure.

6) Develop RFID block and equipping transport by tools for access to cloud services, as well as equipping the critical points of road infrastructure by sensors for stationary traffic monitoring.

7) Provide cloud services for transport corporations to improve the quality of passenger service and optimize time and cost within taxi, bus, freight and other transportation companies.

8) Provide cloud services for the driver in order to improve the quality of travel for a given route and optimize the time and cost.

9) Ensure the collection of traffic information of road infrastructure through the use of «smart dust» (car RFID, traffic lights, video cameras) to monitor traffic.

10) Collect the statistical information (intellectualize global, corporate and personal infrastructure) by accumulating traffic history, changing its parameters in time and space in order to route the quasi-optimal paths for future trips.

11) Create a virtual intelligent cloud infrastructure, which map and simulate movement of vehicles in space and time for service road in real time.

12) Creation of information security and authorized access to personal and corporate data in the cloud. Each user can only see his car in the cloud and anonymous traffic flows. All vehicle identifiers are available only for special transport public services.

5. The benefits of implementing cloud services are the following:

1) For government agencies (the police, traffic police) they include the exact vehicle identification, monitoring the positioning of vehicles in time and space, including theft; significant reduction of accidents, reducing the impact of road traffic accidents, increase of safety and comfort of road users;

2) For transport companies – monitoring locations and movement of vehicles, quasi-optimal transportation of passengers and cargo for minimizing the material and/or time costs;

3) For the driver – providing services associated with generating of quasi-optimal routs and timetable under the negative factors of the existing infrastructure in order to minimize the financial and time costs in real time;

4) For the passenger – providing services to monitor the locations and movement of passenger vehicles on bus stops or transportation terminals through the use of stationary computer display or mobile gadgets to communicate with the corresponding cloud services; visualization on the car screen of critical points of the route for a vehicle in real time through the use of surveillance cameras.

6. Components of cloud road services

"Smart dust" is a set of interconnected autonomous functioning components, which form the microsystem with the transceiver and monitoring tools, designed for collecting information about the environment state. The problems, which are solved by "smart dust":

1. Monitoring environmental conditions (temperature, pressure, humidity, precipitation).

2. Monitoring the movement of transport, frequency of movement, speed, size of moving objects.

3. The interaction between moving objects for positioning, identification of moving objects, transmitting information about objects, moving towards each other, to the management cloud.

4. Creating e-passport of moving object.

5. Preventing theft of vehicles.

6. Ensuring a high level protection of electronic IDs from unauthorized access.

The cost of RFID tag is usually less than 1% of the value of the object identification. Its functionality is to maintain one-to-one correspondence between the label and object during the life cycle of a product.

The real world is in need of advanced and precise monitoring and management of cloud. It has long recognized the need for an absolutely precise radio frequency digital identification of all produce and natural sites on the planet, including humans and animals. The next steps are creating cloud virtual digital models of entities (objects) of the real world for accurate modeling, monitoring and management by all possible relations (natural, social, technical, technological) between them.

7. Problems solved by RFID

1. Identify product (object or subject) in a local or global coordinate system.

2. Save the parameters, which are characterized the basic properties of the object.

3. Accumulate and store the history of the object life cycle.

4. Transfer this information to the management cloud on the authorized request.

5. Receive the confidential information, making it possible to modify the individual properties of the e-passport of the object.

6. Interact with e-passports of other objects in the field of radio-frequency visibility of the object.

7. Transfer information about all interactions of an object with other ones within the radio visibility.

Thus, the object ID is stand-alone digital system-on-chip with low power transceiver, up to 200 meters, which is able to store information about object, modify it by command of control center, and store information about all the interactions with the surrounding environment to transmit the interaction data to management cloud. Other ID modifications are associated with: 1) mobile phone network; 2) satellite systems for receiving and transmitting information.

The advantages of smart dust, based on low-power active RFID transmitter are:

1) Low cost of microsystems, implemented in car electronics.

2) Sufficiently low cost of transponders for digital spectrum monitoring of road infrastructure nodes.

3) High accuracy and speed of reading digital information from moving vehicles, including speed, license plates, data about the driver. License plates are not needed, as well as many of the functions of traffic police.

4) Monitoring and prediction of traffic through the analysis of statistical information in the areas of roads and intersections.

5) The possibility of mutual communication by using microsystems of vehicles moving towards each other, providing information about the traffic on the road sections of the route.

6) Detection of stolen vehicles through global or local monitoring vehicles.

7) Monitoring and alarm of accidents with indicating the exact coordinates of the place and time of the incident.

8) Lock the car engine in case of car theft through the access code of the owner.

8. Corporate transportation management system

The system is already being used for optimal planning routs to deliver goods to reduce time and cost due to: 1) reduce the cost of fuel; 2) the optimal distribution of orders between cars; 3) forecasting the supply of goods to reduce the storage costs; 4) saving staff time or reducing staff; 5) reduce the number of vehicles for a given volume of traffic; 6) monitoring and operational management of the vehicles when delivering goods in real time.

The market appeal of cloud service of transport logistics is determined by the following: wholesalers, regional distributors of food and industrial goods (bakeries, dairies, meat processing plants, brewing plants, industries, transport companies, retailers, logistics service providers, freight forwarding companies, vending companies, ambulance, cash services, courier services, online shopping, cleaning companies) – more than 7,500 companies in Ukraine only.

Logistics technology is in follows. Transportation of goods is a complex, multi-criteria problem that includes a large number of parameters determining the effectiveness of performance of the contract with the customer, and thus profits. Transportation problem is NP-complete, where the number of cases is in the exponential function of the number of input values. The exact solution can be obtained by complete enumeration of all possible variants. For real business problems quasi-optimal methods are used, which do not provide the exact solution, and hence the maximum possible cost savings. It is proposed the optimal method for solving the transport problem based on the original algorithm that significantly reduces the time. It becomes acceptable for the analysis of most practical situations on maps of the region [28].

Business models are: 1) the sale of licenses to use the software with post-paid service maintenance; 2) the sale of services in accordance with the subscription fee for using the road cloud.

9. Organization of the communications "cloud – car" and "cloud – infrastructure"

The most important aspect of technological (technical) IRI implementation is organization of communications between four system components (Fig. 4), integrated with the cloud: Cloud Servers for creating a cloud of long-term storage of distributed data and services; Buffer Computers for collecting data from infrastructure monitors and delivering management services to road controllers; C-RFID – computer blocks for radio frequency identifying vehicles; I-CMC – infrastructure controllers for traffic monitoring and control based on radio frequency identification of vehicles.

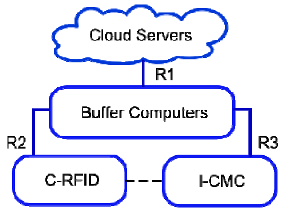

Fig. 4. The structure of communications between IRI components

The structure of communication integration of four IRI components is represented by the transactions: (R1*R2) = (SC,BC,C-RFID) is delivery of cloud services to the customers; (R1*R3) = (SC,BC,I-CMC) is delivery of control signals to the road controllers. The route of the first type uses the traditional technologies GPRS, HSPA, Wi-Fi, WiMAX based on Internet. For the transaction of second type additional scientific and technical research is needed when creating a scalable prototype, because the transaction are important and high requirements are imposed to reliability, security and protectability.

It is assumed that the block C-RFID will store an individual vehicle code (CID), the electronic code of residence registration (NID), and the code of the driver (DID), who uses the vehicle at the current time. Reading the triad of codes (CND-ID) is performed by radio devices, which will be located on all the traffic lights, bridges, tunnels, level crossings and other points of the road network, significant from the standpoint of traffic management, including the critical control points. The structure of the C-RFID unit is shown in Fig. 5, where the modules (CND-ID, CT, SP, ALB, M, D, CU) mean: universal car code, transceiver, protection module, arithmetic and logic unit, memory module, display and control module.

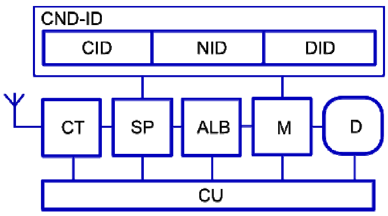

Fig. 5. Structure of C-RFID unit

10. Structure of car unit CAR-ID

The proposed concept of CAR-ID is based on the principles used in the air traffic control system ADS-B [31,32,33]. The essence of CAR-ID is that the transponder of the vehicle periodically transmits a broadcast message, which includes the identification information and data on the coordinates and speed of the vehicle, receiving from the built-in GPS receiver. In addition, the controller CAR-ID generates protocol of vehicle dynamics, receiving information from the acceleration sensor.

Sending a message is realized through two channels - wireless and\or optical. Messages are received by vehicles or fixed stations, which are located in the area of optical or radio coverage. Stationary stations are networked and located in places where there is a power (light signals). When receiving a message, CAR-ID checks for it in the "history" and in the absence add it to the memory of controller. When getting into the zone of the stationary monitor (station) rewriting all the information accumulated since the previous reading from the memory controller to the memory of the station is performed. The information packets are formed and periodically sent to the "cloud".

To ensure high noise immunity, structural stealth of signal and eliminate impact of noise on other radio equipment CAR-ID direct spread spectrum DSSS are used [34]. The unit can operate in the unlicensed ISM band with an output of 0 - 4dBm. This is sufficient to ensure the radio visibility up to 100 meters when using omnidirectional antennas.

All information transmitted via open channels, is pre-encoded. To eliminate collisions in the block the method Slotted – ALOHA is applied [35]. If necessary, the entire information stored by controller for a day, can be read by the police or other fiscal services by using a special reader. Thus, a distributed intelligent wireless network based on RFID unit is created (Fig. 6), the advantage of which is the presence of distributed storage devices and rapid information exchange [36].

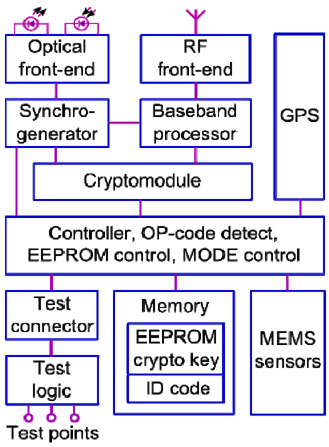

Fig. 6. Structure of CAR-ID unit

The structure of CAR-ID unit contains the following modules: Optical front-end is optical interface; RF front-end is RF interface; Synchrogenerator is frequency generator; Baseband processor is designed for processing signals after demodulation; GPS is positioning module; Cryptomodule is encryption module; Controller, OP-code detect, EEPROM control, Mode control are unit management system; Test connector is switch for unit testing; Test logic (Test points) is module for test management and programming; Memory (EEPROM crypto key, ID code) is memory card for storing data and proprietary information; MEMS sensors are module of sensors.

11. Road management and monitoring

Modern cities have a complex road infrastructure, where road management is carried out through the traffic lights by using traffic management systems (TMS), which include hundreds of traffic lights. Here, under the traffic lights we will understand TMS subsystem that provides monitoring and control of traffic on the separate section of the road network. The central part of the subsystem (see Fig. 7) is specialized traffic controllers (TC) with built-in switched power circuits, which are designed to control the traffic lights. Modern TCs, like the German controllers SITRAFFIC C800 [37], is able to inquire up to 84 vehicle detectors of inductive type and control 48 groups of signals of the total capacity 4 kW in real time with maximum permissible cycle in 300 seconds. C800VX controller supports up to 120 of these modules in management segment, each segment is able to function independently and integrated into TMS network based on wireless technologies (GPRS, WiMAX); it is centrally managed from the traffic control center (TCC) [38].

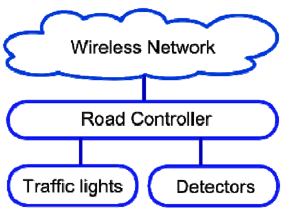

Fig. 7. The general structure of traffic light object

On present trends of road infrastructure expansion, it is clear that the use of such solutions is possible subject to high reliability of such systems. It is known that if TMS structure is extended (the number of traffic lights controlled by the system is increased) the reliability will be decreased [39]. Therefore, developing more reliable TMS structures including advanced distributed automation technology is topical scientific and industrial problem. Cheaper and much more flexible variant of TMS organization on such principle was proposed in [40], where the authors propose to improve the quality of traffic through distributed automating key processes and creating a system of distributed traffic control. They found that to improve the reliability of the system along with providing information and control functions of the traffic control center (TCC), TMS should be organized according the principle of centralization-decentralization. In this case, the buffer computer of IRI (Fig. 16) executes functions of database server and provides connectivity to peripheral workstations, as well as it manages multiple TCs, segmented (10 - 20 traffic lights per segment) on geographical basis. This TMS architecture allows positioning TCC anywhere in the city and organizing mobile TCC; as well as if the central part of the system is failed it will provide the coordinated functioning all TCs at the object. All of above problems are solved at low cost for organization, implementation of communication and maintaining acceptable performance, reliability and speed of information transfer. This control structure is implementation of the component I-CMC (see Fig. 8) and can be represented as a matrix, elements of which are traffic controllers (R-PLC), and the columns correspond to the segments of the road network, controlled by segment servers (RSS), which in turn are controlled by the buffer computer of IRI.

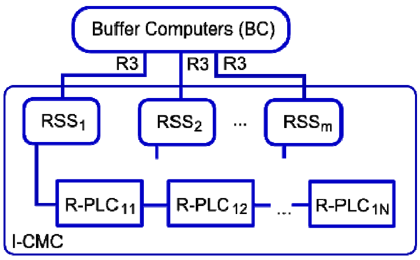

Fig. 8. Structure of I-CMC unit

Here RSS component is highly reliable industrial computer, component R-PLC is based on PLC SIMATIC S7-1200, which is one of the newest controllers from SIEMENS for programming engineering process [41]. Controller S7-1200 is able to solve the problems of automatic control, motion control and can be used in engineering, enterprise management systems, and in many other areas. It is multifunctional and has relatively low cost. Compact modular design combined with high computing power allows the use of SIMATIC S7-1200 for a wide range of automation problems. The advantages of PLC S7-1200 are: 1) high reliability, the mean time before failure of more than 30 years; 2) the ability to dynamically load the software to the controller when it is running; 3) service directly at the place of object location; 4) high performance about 10^5 instructions per second under a clock cycle time 15 ns; 5) high accuracy of cyclic commands; 6) programming language STEP-7 Basic with integrated fuzzy logic.

12. Conclusion

Cloud on-line monitoring RFID tags of vehicles eliminates the license plates from the accounting system and has the following benefits: 1) exclusion of the direct participation of the traffic police in commit traffic violations (speeding, travel to prohibit traffic lights, improper maneuvering); 2) saving thousands of tones of metal to produce numbers and simplify registration of cars when buying from a few days to a few minutes; 3) automated completing written reports about an accident without the traffic police by means of digital monitoring digital map of the incident that has been copied from the cloud; 4) considerably (×2-×5) reducing the staff of the traffic police, because the history of car movement and its traffic violations is completely transparent for the cloud, which will make it possible to automatically pay the penalties for violations in accordance with country laws; 5) completely eliminate corruption in relation between the driver and traffic police due to inability to erase information about the violation in the cloud; 6) virtually eliminate criminals in car theft, thanks to use built-in car RFID block that provides on-line twenty-four-hour observability of vehicles, on condition that a car is not physically destroyed; 7) simplify the legalization of driver by adding the driver's license to the list of authorized persons of car RFID block via "Bluetooth", which eliminates necessity of special papers and power of attorney for others; 8) reducing in several times the number of accidents and considerably improving the quality of life for drivers and passengers due to total monitoring of violations and the certainty of punishment for them; 9) decreasing by 30% automotive carbon emissions by reducing the idle time at intersections and selecting the optimum mode of transport and routes of movement; 10) ensuring high market appeal of cloud services through selling the services to companies and individuals that guarantees high profits – from hundreds of millions up to tens of billions of dollars – which is scalable depending on the area of service coverage: cities, states, countries, entire world. In the presence of 10 million cars in the country and if the value of one RFID tag equal to $ 100, the cost of equipping the entire fleet is equal to 1 billion dollars. The cost of creating a scalable IRI prototype is $ 10 million dollars plus the overhead of technical support and maintenance of infrastructure – $ 10 million dollars a year. The annual cost of sales for cloud service is not more than $ 100 dollars for each car. This amounts to nearly $ 2 billion dollars in profits after three years of the cloud maintenance. Payback period IRI is 1.5 years. 11) Near future. The real world is in need of advanced and precise monitoring and management of cloud. The problem can be solved only by using radio frequency digital identification of all produce and natural sites on the planet, including humans and animals. The next steps are creating cloud virtual digital models of entities (objects) of the real world and all possible relations (natural, social, technical, technological) between them to create services for precise digital modeling, monitoring and management of processes and phenomena in the world.

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