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IEEE EAST-WEST DESIGN AND TEST SYMPOSIUM 2013 COMMITTEE

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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 Traffic Control System

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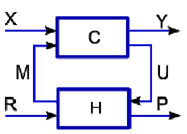
Abstract

A cloud service "Green Wave" (the intellectual road infrastructure) is proposed to monitor and control traffic in real-time through the use of traffic controllers, RFID cars, in order to improve the quality and safety of vehicle movement, as well as for minimization the time and costs when vehicles are moved at the specified routes.

1. Introduction

The processes of separate and non-synchronized development of two components: the real world and cyberspace are now characterized by vector format, focused on creating structured and mutually integrated components of cyber geosystem (CGS). Now CGS evolves by way of building cloud services in cyberspace for monitoring and optimal control of imperfect real-world, based on one-to-one mapping of processes and phenomena [1-9]. CGS can be simplified in two modules: cloud management and executive engine that includes resources and people. In this case, management and executive engines should not be intersected by the material and human resources.

Thus, formally cyber geosystem is represented as two components (engines): Cyberity (monitoring – management) and Humanity (desires), which are interconnected by four signals: Monitoring, Management and Initiation of both engines in order to implement the desires. Analytical form of CH system and its structural equivalent are shown in Fig. 1.



$$S = (C, H, M, U, X, R, Y, P),$$
$$C \cap H = \varnothing;$$
$$\begin{cases} Y(t) = f[(X(t),(R(t),M(t),Y(t-1)]; \\ P(t) = g[X(t),(R(t),U(t),Y(t)]. \end{cases}$$

Fig. 1. Analytical and structural forms of CH-system

Here (C, H, M, U, X, R, Y, P) are respectively: control units (managers and cybers) and execution units (infrastructure, executers and robots); monitor and control signals, inputs of control and execution resources (time - money - materials), outputs for indicating the algorithm status (plan) of the idea implementation and production (service).

Control input is not only a collector of interesting proposals from members of the community, but also a selector, which is able to filter out destructive or impractical ones in terms of limited time and material resources. The structure of this input impacts significantly on the efficiency of the system as a whole, because properly configured first filter makes it possible to collect a large number of constructive ideas through material and moral revitalization of the community. The function of the second filter is high-quality selection of productive ideas by bringing world-class experts from among scientists, economists and marketers. Function of manager is just good management to implement the idea in terms of restrictions on the time, human, financial and material resources.

In the context of creating cyber geosystem the following research directions are relevant and feasible: 1. Technology for distinguishing mobile systems on specialized systems and structured cyberspace of cloud services. 2. Quantum parallelism and specialized multiprocessors. 3. Touch intelligent devices for the real world and high-speed robots for cyberspace. 4. 3D multi-processors, 3D-computational processes and multi-dimensional cyberspace. We are talking about the inevitable transition of computing devices, processes and components in 3D-measurement due to the appearance of three-dimensional transistor FinFET. 5. This will result in the entire computer world to implement a new paradigm – parallel programming of computational structures in three dimensions. 6. Creation of 3D-multiprocessor on a chip is important that will be possible in the next 5 years. It should introduce triangular and tetrahedral structures of interconnections as basic elements for generating computing volumes of micro- and multi-processors, as well as for cyberspace of services. 8. There is actual development of 3D-printers for printing (manufacturing) three-dimensional optimal specialized architectures, which are functionally focused on specific algorithms for solving practical problems.

The evolution of cyber world is divided into the following periods: 1) the 1980s - formation of personal computers; 2) the 1990s - the introduction of Internet technologies in production processes and people's lives; 3) the 2000s - improving the quality of life through the introduction of mobile devices and cloud services, and 4) the 2010s - the creation of a digital infrastructure for monitoring and control of moving objects (air, sea, ground transportation, and robots). Therefore, in the present market feasible problem is the system integration of monitoring-control cloud service and transport RFID blocks as well as digital tools of road infrastructure for optimal on-line vehicle and traffic control in order to address the social, human, economic and environmental problems.

What is the basic of the world cyberspace? – The silicon chip and its analogs. Modern microelectronics enables to create not flat but three-dimensional transistor structures (3D – FinFETs) in 14 nm range, commensurate with the size of the atom. This means the appearance in the near future 3D-System-on-Chip instead of flat structures or system-in-package. The advantages of the chips significantly affect the characteristics of industrial products in terms of: energy consumption, dimensions, performance, cost and quality due to reducing not only the dimension of the components, but also the relationships between them.

Thus there arise problems associated with heat removal from the internal area of 3D-chip, as well as the creation of new technologies for designing, verification, testing, diagnosis and repairing of its components.

Thus, a microworld of cyberspace goes in 3D-measurement not easily. Macroworld remains flat when components, computers, networks, cloud services of cyberspace are combined into the system. Which arguments could be made for the transfer of the macroworld in 3D-space? They are the following: the compactness of information, the performance of searching in cyberspace, and its dimension. The triangular flat structure of the system where all nodes are adjacent has a major drawback in the two dimensions – for encoding three nodes or edges it is necessary three codes, and this means that one code of two-bit vector is not used. Therefore, the creation of a primitive structure, where all nodes are adjacent and their number is four to make full use of the two bits code space, means re-open an amazing 3D-figure - a tetrahedron! It has six edges or distances, xor-sum of which is equal to zero. When descripting the figure two edges are redundant, which can be used to reduce the volume of information up to 66% during storage and transfer of data. Formation of cyberspace through the use of primitive tetrahedra allows optimizing (minimizing) the ratio of the structural complexity of the space to the average distance between two points.

Object of research is technologies for monitoring and management of vehicles integrated with cloud services, based on the use of the existing road infrastructure, RFID, radar and radio navigation.

Subject of research: traffic and road infrastructure of Ukraine and its regions, as well as advanced software and hardware RFID systems for monitoring and road management, based on the use of road controllers, global systems for positioning, navigation (GPS, GPRS), and cloud services in the Internet.

The essence of research is creation of intellectual road infrastructure (IRI) – cloud service "Green Wave" for monitoring infrastructure and management of road in real-time, based on creating virtual road infrastructure (Fig. 2), integrated with road traffic controllers, RFID of vehicles in order to improve the quality and safety of vehicle movement, minimization of time and costs when realization of routes.

2. Criteria for the quality and efficiency of topological structures

In general, to estimate the infrastructure it is necessary to use the integral efficiency criterion of designing or existing intelligent systems for monitoring and traffic management that converges to minimize [1] and consists of three mutually contradictory relative and dimensionless parameters: the error rate of the project L, the time of travel or pass of specified traffic T, the level of software-hardware redundancy H compared to the basic infrastructure (road functionality) H^s defined by monitoring and traffic engine H^a:

$$E = F(L,T,H) = \min[\frac{1}{3}(L+T+H)],$$

$$Y = (1-P)^n;$$

$$L = 1 - Y^{(1-k)} = 1-(1-P)^{n(1-k)};$$

$$T = \frac{(1-k)\times H^s}{H^s + H^a};\ H = \frac{H^a}{H^s + H^a}.$$

The parameter L is a complement to Y; it describes yield (quality of service) and depends on the infrastructure (project) trafficability k, the probability P of the existence of faulty components, and the number of undetected design errors n. Time for passing given traffic flow through the infrastructure is determined by its trafficability (control+monitoring= trafficability) k, multiplied by the structural complexity of the road functionality H^s , divided by the total complexity of the infrastructure $H^s + H^a$. The level of hardware redundancy H is a function of the complexity of the trafficability engine divided by the total complexity of a given infrastructure (road functionality + + infrastructural trafficability engine). Thus trafficability redundancy, namely infrastructure observability, provides predetermined diagnosis depth of traffic jams or collisions in road transport structure. While infrastructure controllability is designed to eliminate conflicts through the use of intelligence cloud services and traffic lights within a predetermined time interval.

Quality criteria of the road topology are associated with static analysis of graph structure with the E arcs and n nodes. Feature of the first one is to calculate the absolute value, not reduced to the unit interval that is determined by the cost of connections multiplied by the quality of transactions between all pairs of nodes:

$$Q_1 = \frac{E}{n} \times \sum_{i=1}^{n} \min_{j} (p_{ij}).$$

3. Functions and criteria of trafficability in the road infrastructure

Metric for evaluating infrastructure of monitoring and control is based on the concept of trafficability, consisting of two criteria: the controllability and observability, which make it possible to evaluate the system as a whole, and the quality of vehicle movement on a given route (on-line, real-time traffic monitoring). Existing standards of testable design of computer systems and networks (IEEE 11.49, IEEE 1500) can be adapted to the design, testing and verification of road infrastructure in order to further its effective operation.

Considerable redundancy of road infrastructure suggests effective using it in order to improve the trafficability. For this purpose the (oriented) traffic graph (TG) is used, which provides to user information about the relationships of roads and intersections. For integral evaluating the trafficability of FG the following criteria are entered:

$$Q = \frac{Z(S)}{Z(S) + Z(F) + Z(B) + Z(A)} \times \frac{1}{n} \sum_{i=1}^{n} (U_i \times N_i);$$

$$U_i = \frac{1}{T} \sum_{j=1}^{x_i} T_j^i \times \frac{1}{d_i^x \vee t_i^x}; N_i = \frac{1}{T} \sum_{j=1}^{y_i} T_j^i \times \frac{1}{d_i^y \vee t_i^y}.$$

where n is a number of graph nodes. Controllability and observability is a metric for estimating the trafficability of the road infrastructure. Controllability of a node (intersection) is characterized by functional dependence on the structural depth d_i^x of node location relative to the point of departure or the length of the conjunctive term t_i^x. Observability of the node has a similar dependence $d_i^y \vee t_i^y$ relative to the point of arrival. To calculate the trafficability one of the parameters can be used $d_i^x, t_i^x (d_i^y, t_i^y)$. Evaluations of controllability and observability are also dependent on the percentage of the number of incoming edges $\frac{1}{T} \sum_{j=1}^{x_i} T_j^i$ (outcoming edges $\frac{1}{T} \sum_{j=1}^{y_i} T_j^i$) of the node to the total number of edges T, where x_i is a number of edges, which form access to the input node; (y_i) is a number edges for which the node is a source. The trafficability Q depends on the controllability U, observability (N), as well as the cost of implementation (Z) of infrastructure components: metric of functional coverage (F), testbench (B), assertion engine (A), functionality (S). Controllability (observability) is a function of the number of edges incoming the node (outcoming the node) of the graph, the structural depth of the nodes (intersections) - the distance from the point of departure (arrival).

This trafficability criterion can also be used to evaluate the quality of a flow-chart or traffic management infrastructure. Here the nodes are considered, on which the input conditions and the position of the nodes with respect to the beginning or end of the planned route are loaded with. The number of conditions or incoming edges at each node, combined by operation Or, impact on the trafficability of the graph in terms of controllability. Observability is calculated similarly; the structural depth and power of output edges, provided by the operations And, Or, affect on it. Thus, the trafficability of the node of a directed graph can be represented by a logical function, defined as a conjunctive normal form (CNF). In this case, controllability and observability are determined by Quine estimate of computational complexity of CNF. In general, the logical functions of controllability and observability of the current node are determined by conjunction of disjunctive terms (first line):

$$1) U_r^f = \bigwedge_{i=1}^{n_r^x} (\bigvee_{j=1}^{x_i} T_{rij}^x); N_r^f = \bigwedge_{i=1}^{n_r^y} (\bigvee_{j=1}^{y_i} T_{rij}^y);$$

$$2) U_r^f = \bigvee_{i=1}^{x_r} (\bigwedge_{j=1}^{n_i^x} T_{ij}^x); N_r^f = \bigvee_{i=1}^{y_r} (\bigwedge_{j=1}^{n_i^y} T_{ij}^y).$$

Here the controllability function U_r^f (observability function N_r^f) is determined by the conjunction of all the nodes-precursors n_r^x (successors n_r^y), wherein each of them has x_i incoming (outcoming y_i) edges, combined by disjunction. Power of disjunctive terms corresponds to the number of edges, incoming the node, and the number of conjunctions is the structural depth of the component position in the graph. The conjunctive form is transformed into DNF – the second line in the previous expression, where the number of terms for controllability (observability) function $x_r(y_r)$ is equal to all possible paths for forming the state of the node, and the length of the controllability (observability) term $n_i^x(n_i^y)$ is the condition of the node reachability –structural depth from the inputs (outputs). There exists the standard solution, when the criteria of controllability and observability of the current node of the transaction graph are calculated based on the model in the form of logic functions of controllability and observability (U_i, N_i) and integrated estimation of the trafficability (Q) when using the algebraic form of graph representation. Formula for calculating mentioned estimates are as follows:

$$U_i = \frac{1}{t_{max}^x \times n_t^x} \times \sum_{i=1}^{n_t^x} \sum_{j=1}^{k_i^x} (t_{max}^x - \left|t_{ij}^x\right| + 1);$$

$$N_i = \frac{1}{t_{max}^y \times n_t^y} \times \sum_{i=1}^{n_t^y} \sum_{j=1}^{k_i^y} (t_{max}^y - \left|t_{ij}^y\right| + 1);$$

$$Q = \frac{1}{n} \sum_{i=1}^{n} (U_i \times N_i),$$

where $t_{max}^x, n_t^x, k_i^x, \left|t_{ij}^x\right|$ – conjunctive term of the maximum length for the determination of the controllability criterion; the number of terms in the logic function of controllability; the number of letters (variables or arcs) in the current function term; power of the term. Similar symbols are used in the calculation of the observability criterion – $t_{max}^y, n_t^y, k_i^y, \left|t_{ij}^y\right|$ for each graph node.

For a fragment of the graph structure shown in Fig. 2 transformation of conjunctive form into the disjunctive model respect to the nodes $V_1 - V_3$ according the rules above allows obtaining the following logical controllability functions:

$$U^f(V_1) = T_1 \vee T_2 \vee T_3;$$

$$U^f(V_2) = (T_1 \vee T_2 \vee T_3)T_5 \vee T_4 \vee T_6 = T_1T_5 \vee T_2T_5 \vee T_3T_5 \vee T_4 \vee T_6;$$

$$U^f(V_3) = (T_1 \vee T_2 \vee T_3)T_5T_8 \vee (T_4 \vee T_6)T_8 \vee (T_7 \vee T_9) =$$
$$= T_1T_5T_8 \vee T_2T_5T_8 \vee T_3T_5T_8 \vee T_4T_8 \vee T_6T_8 \vee T_7 \vee T_9.$$

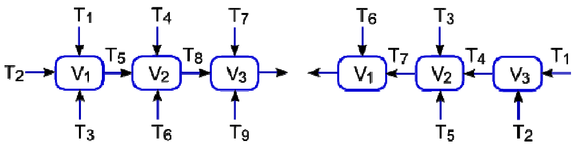


Fig. 2. Fragments of the graphs for calculating the controllability and observability

The following expression defines the procedures for calculating estimates and allows determining the controllability of the component V_3:

$$U(V_3) = \frac{1}{t_{max}^x \times n_t^x} \times \sum_{i=1}^{n_t^x} \sum_{j=1}^{k_i^x} (t_{max}^x - \left|t_{ij}^x\right| + 1) =$$
$$= \frac{1}{3 \times 7} \times (1+1+1+2+2+3+3) = 0{,}61.$$

For second graph fragment shown in Fig. 8, the transformation of the conjunctive form into disjunctive structure allows determining the logic function and the numerical value of the observability for the node V_1:

$$N^f(V_1) = T_6 \vee T_7(T_3 \vee T_5 \vee T_4(T_1 \vee T_2)) = T_6 \vee T_7T_3 \vee T_7T_5 \vee T_7T_4T_1 \vee T_7T_4T_2;$$

$$N^f(V_2) = T_3 \vee T_5 \vee T_4(T_1 \vee T_2) = T_3 \vee T_5 \vee T_4T_1 \vee T_4T_2; V_3 = T_1 \vee T_2.$$

$$N(V_1) = \frac{1}{t_{max}^y \times n_t^y} \times \sum_{i=1}^{n_t^y} \sum_{j=1}^{k_i^y} (t_{max}^y - \left|t_{ij}^y\right| + 1) =$$
$$= \frac{1}{3 \times 5} \times (3+2+2+1+1) = \frac{9}{15} = 0{,}6.$$

For the case when the edges of the graph are the weighted b_{ij}^x (b_{ij}^y) by the numerical values of traffic in the lanes between the nodes (multi-edges), formulae for counting trafficability are much more complicated:

$$U_i = \frac{\sum_{i=1}^{n_t^x} \prod_{j=1}^{k_i^x} b_{ij}^x (t_{max}^x - \left|t_{ij}^x\right| + 1)}{t_{max}^x \times (\sum_{i=1}^{n_t^x} \prod_{j=1}^{k_i^x} b_{ij}^x)}; \quad N_i = \frac{\sum_{i=1}^{n_t^y} \prod_{j=1}^{k_i^y} b_{ij}^y (t_{max}^y - \left|t_{ij}^y\right| + 1)}{t_{max}^y \times (\sum_{i=1}^{n_t^y} \prod_{j=1}^{k_i^y} b_{ij}^y)}$$

The synthesized logic functions of traffic model define all the possible ways of management, both in time and in space, which can be considered as a new form of analytical descriptions of infrastructure trafficability. The criteria of controllability (observability) for all components of the graph model can be determined by DNF. Two variants (scripts) for calculating the infrastructure can be considered: 1) Considering only the graph model, where the weight of each edge is 1, regardless of the traffic flow; 2) All graph edges are marked by the real number of transport transactions, which occur between two nodes of the graph. Estimates of trafficability for the described variants can use the first scenario, or have a more complex and accurate model of vehicle transactions distributed in time on the set of graph components.

The result of calculating controllability (observability) for all graph nodes makes it possible to obtain a schedule that allows determining the critical points for the installation of necessary control (traffic lights) and surveillance (monitors) points. After determining the controllability and observability of graph nodes calculating the generalized trafficability criterion of the infrastructure is performed. It characterizes the quality of the draft version, what is very significant when comparing several alternative solutions.

4. Conclusion

It is difficult to forecast social, technological and technical positive effects of the revolutionary transformation of the existing world related to implementation cloud road services. In the limit, in 10-15 years, we should expect a service for automatically routing vehicles. However, on the way to full automation some obvious innovative scientific and technological solutions of social, humanitarian, economic and environmental problems associated with the emergence of cloud monitoring and management, are represented below.

Scientific novelty lies in the system integration of three components: cloud for monitoring and management, RFID blocks of vehicles, and road infrastructure tools for monitoring and management, which makes it possible to automate optimal control of transport and traffic in real-time for social, humanitarian, economic and environmental issues.

Practical value of research is defined by following services:

1) On-line switching traffic lights to provide free traffic on the route for special machines or tuples (children, important government officials, ambulance, fire department, military convoys, dangerous goods).

2) Optimal on-line control of traffic lights on the roads and intersections with accurate digital monitoring traffic through the use of RFID-tags of cars, enabling to minimize the movement time of all road users.

3) Planning the best route to achieve one or more destinations by a car in time and space, that allows reducing time and cost for a given quality of comfort (time of day and year, road surfacing, left turns, weather, traffic jams, repairs).

4) Intellectual history of car movement, based on car virtual model in cyberspace in the form of an individual cell of the cloud, which is invariant with respect to vehicle drivers. It allows tracking any vehicle movement in the past, and to predict the desired routes and future travels without the driver.

5) Service for intelligent managing traffic light controller, when switch signals are generated depending on the availability (quantity) of vehicles, which send the requests from car RFID blocks (C-RFIDs).

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