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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

Quantum Computing Approach for Shortest Route Finding

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Abstract

In this paper shortest path finding approach is proposed. This approach is based on graph theory and uses main idea of the quantum computing. Quantum computing approach allows making parallel computations faster. Using this approach in shortest route fining problem helps to find several ways simultaneously and give several alternative solutions which can be chosen according to special metrics and parameters.

1. Introduction

According to Cisco's forecasts, the global Internet traffic will reach 1.3 zettabyte in 2016. It is more than the total traffic over a period from 1984 to 2012. In 2011, 369 exabytes were transferred over IP-based networks around the world. The number of Internet-connected devices will rise to 18.9 billion in 2016, or two-and-a-half for each person on the Earth. In 2011 this figure was equal to 10.3 billion. Today's personal desktop computers consume 95% of overall traffic. In 2016 this value will decrease to 81% due to growth number of mobile devices. The total Internet audience reaches 3.4 billion people, and the average fixed connection speed will increase from 9 to 34 megabits per second. Each user will load through a network about 32.3 gigabytes per month.

Nowadays every modern car is equipped with an onboard embedded computer, which also has access to the World Wide Web. Total number of cars in the world is continuously growing with an incredible pace. Thus in 2009, the center of the global auto industry, WardsAuto, has registered approximately 980 million vehicles. In 2010 this number has exceeded 1 billion. The most automobile countries (car:number of citizens) are the USA (1:1.3), Italy (1:1.45), the United Kingdom, France and Japan (1:1.7) [4]. Thus, analyzing and comparing world's data traffic consumption and the rapid growth of the number of vehicles with on-board computers, it can be concluded that it is addressing the creation of global services for cars will be one of the major challenges in the field of information technology in the near future, namely information analysis and microelectronic systems design.

One of the most difficult driver's tasks is to build the best route on the road map. To date, this problem is not completely solved by existing devices, as they do not take into account the different metrics that affect the time and comfort of the route.

At this moment, quantum calculation approach allows to find several possible results simultaneously. This can greatly increase efficiency of the shortest route finding.

2. Metrics

Component, object, process and phenomenon identification in cyberspace provided by creation an effective metric measuring distances in discrete boolean (logical-vector) space, which is used for high-speed robots-engines development, which determine the derivative and the similarity or difference level between two components or objects.

Discrete vector-logical space (cyberspace) is a set of information processes and phenomena interacting according to specific metrics and described by vectors (matrices) and logical variables. They use computer systems and networks as a carrier.

Metric is a way of the distance measuring between the components in the space of processes or phenomena described by vectors of logical variables. Distance in cyberspace is xor-relation between the pair of vectors signifying the components of a process or phenomenon. This distinguishes it from the Hamming code distance. Distance, derivative (Boolean), change level, difference, similarity are isomorphic. They are

connected with two components or phenomena definition. The components proximity (distance) notion in cyberspace is a measure of their differences. Comparison, measurement, evaluation, recognition, testing, diagnosis, identification procedures are a relationships determining method in that case if at least one object exists.

Cyberspace metrics can be defined by equation:

$$b = \bigoplus_{i=1}^{n} d_i = 0,$$

which creates 0-vector, for XOR of each d_i – distance between non-zero and finite number of points (objects) in loop. Here n is number of the distances between components (vectors) in cyberspace, which creates the loop $D = (d_1,...,d_i,...,d_n)$, d_i is distance vector corresponding to edge of the loop which connects two components (vectors) of the a, b space.

3. Road graph

In order to create a route, we need to represent entire map as a directed graph of roads. Road graph is a set of metrically and topologically related vertexes and edges which represent traffic direction with high accuracy, distance and communication between crossroads. The direction of the edges shows the traffic direction, vertexes or nodes – crossroads. Each edge has a metric-based weight. The metrics are selected on the graph creation step, for example minimum number of left turns, better quality roads, the highest possible speed, the minimum number of traffic lights, etc.

Road graph must be updated each time when optimal route is requested to improve a relevance of the information about the routes. You cannot use the road graph laid during design phase, since the traffic situation is constantly changing and the route that was considered as optimal for one traffic situation may lose relevance to current traffic situation. For example, road can be repaired, car crash may occur, traffic can be blocked during public events, etc. Constantly updated road graph gives possibility to generate the best route at given time, and this route does not lose relevance until next road graph update.

The Road graph update means edges weight update. Complete rebuild the road graph for each request does not make a sense, since the roads position on the map, traffic direction and crossroads remain unchanged for a long enough period of time. Weights update allows you to track every detail of the road network changes and allows using a constant road graph.

4. Quantum approach for shortest path

The problem of finding the shortest path between two points in a weighted graph is an old one. The question of which classical algorithms can be sped up by quantum computing is of course a very interesting one. At present there are only a few general techniques known in the field of quantum computing and finding new problems that are amenable to quantum speedups is a high priority. Quantum approach for finding the lowest weight path has been considered in M. Heiligman's work [1].

In the classical case, the total work for the algorithm is max $(O(kn^2), O(n^2))=O(n^2)$ which is minimized by taking k=1, therefore

$$W_{classical}=O(n^2)$$

In the quantum case, the situation is a bit different. The total work on the first step is just the maximum of the work on next two steps, since the work on the first step is always dominated by these other work factors. The total work is therefore

$$\max\ (O(k^{\frac{1}{2}}n^{\frac{3}{2}}), O(k^{\frac{-1}{2}}n^2))$$

and to minimize this, the parameter k should be chosen to make these two work factors the same. Setting $k^{1/2} n^{3/2}=k^{-1/2}n^2$ gives $k=n^{1/2}$ and therefore

$$W_{quantum}=O(^{n7/4})$$

This indeed is an improvement over the classical work factor of n^2.

5. Choosing the best path

Quantum approach allows finding several alternative solutions of shortest path problem. Then we need to choose one of the found path using metrics and parameters. Every metric and parameter of the optimal path should be presented as a vector. The aim of the vector-logical quality criteria is to significantly improve calculating performance of the interaction between components (vectors) by using only vector operations performed simultaneously of all discharges. We can make it with help of logical merging [2]:

$$Q = d(m, A) \vee m(m \in A) \vee m(A \in m) =$$
$$= (m \oplus A) \vee (A \wedge \overline{m \wedge \bar{A}}) \vee (m \wedge \overline{m \wedge \bar{A}}) =$$
$$= (m \oplus A) \vee [A \wedge (\bar{m} \vee \bar{A})] \vee [m \wedge (\bar{m} \vee \bar{A})] =$$
$$= (m \oplus A) \vee [(A \wedge \bar{m}) \vee (A \wedge \bar{A}) \vee (m \wedge \bar{m}) \vee (m \wedge \bar{A})] =$$
$$= [(A \wedge \bar{m}) \vee (m \wedge \bar{A})] \vee [(A \wedge \bar{m}) \vee (A \wedge \bar{A}) \vee (m \wedge \bar{m}) \vee (m \wedge \bar{A})] =$$
$$= (A \wedge \bar{m}) \vee (m \wedge \bar{A}) \vee (A \wedge \bar{m}) \vee (A \wedge \bar{A}) \vee (m \wedge \bar{m}) \vee (m \wedge \bar{A}) =$$
$$= m \oplus A.$$

Better solution searching model with a minimal number of '1' is shown on the figure. It includes following operations:

1) Initially, every coordinate of the result vector Q is filled by '1' value (the worst solution). Operation SLC (left shift) is performed simultaneously to compress '1' in the current vector Q_i.

2) Compare two vectors: Q and Q_i, from decision list.

3) Vector operation AND is implemented $Q \wedge Q_i$ and the result is compared with vector Q. This makes possible to modify it if the vector Q_i has a minimal number of '1' values.

4) The best solution finding procedure is repeated n times.

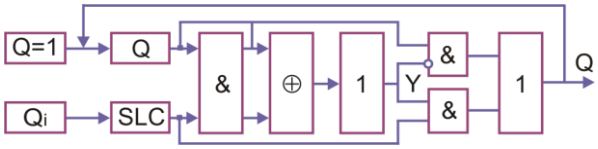

Figure 1. Solution model

$$Q = \overline{Q(\vee((Q \wedge Q_i) \oplus Q))} \vee Q_i(\vee((Q \wedge Q_i) \oplus Q));$$
$$Y = \vee((Q \wedge Q_i) \oplus Q);$$
$$Q = Q\bar{Y} \vee Q_i Y.$$

In this case OR-reduction operator (after XOR element) generates a one-bit binary decision based on OR logic operation on the n bits of the quality criterion. For two binary vectors (quality criteria) selection the best one procedure is presented below:

$Q_1(m, A) = (6,12)$	1 1 1 1 1 1 . . . . .
$Q_2(m, A) = (8,12)$	1 1 1 1 1 1 1 1 . . . .
$Q_1(m, A) \wedge Q_2(m, A)$	1 1 1 1 1 1 . . . . .
$Q_1(m, A) \oplus Q_1(m, A) \wedge Q_2(m, A)$	. . . . .
$Q(m, A) = Q_1(m, A)$	1 1 1 1 1 1 . . . . .

Numerical estimates are presented as explanatory information for a user Thus, quality vector logical criterion of objects interaction in cyberspace allows obtaining with a high speed parallel logic an estimate of search, pattern recognition and decision-making operations [3], which are particularly important for fast finding shortest path and selection the best one from several proposed solutions.

6. Conclusions

In this paper has been proposed new approach for shortest path search. It means using quantum algorithms and calculation approaches for getting several paths simultaneously using quantum algorithm. Vector logical operations are used for choosing one path from several solutions due to high performance of hardware in case of vector logical operations. Combination of these approaches gives the opportunity to find shortest path with high performance in short time.

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