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Development of Routing Algorithm for Self-Organizing Radio Networks

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***Abstract*-**An improved routing algorithm is proposed for self-organizing radio networks. The distinctive features of the algorithm are as follows:

- Reduction of redundancy of control signal flow in the network by means of transfer of the Function Route-Selection (Continuation) of all relaying nodes; and
- Fast adaptation and self-recovering of network along the alternative route in case of failure of active relaying nodes.

The proposed algorithm has proved better characteristics in terms of parameters in comparison with the known algorithms. The Self-Organized Routing Algorithm (SORA) is intended for mobile wireless self-organizing communication networks, where nodes have identical status. Functions of base stations are distributed among all participants of informational interaction. The SORA algorithm is intelligent; it enables a node to independently make a decision on participation in the building of a route and/or its restoration.

Keywords- *Algorithm, Self-organizing Radio Networks, Routing, Relay, Communication Node, Decision Making*

I. INTRODUCTION

When designing and building a self-organizing communication networks, difficulties arise in organization of network operation under 'unpredictable movement of nodes' condition; at the same time, delivery of a message shall be ensured in any direction (i.e. connectivity of network shall be ensured with regard for retransmission). This article suggests that such problem should be solved by modeling and assessment of radio communication of nodes during network transformation and developing a more efficient routing algorithm.

II. ANALYSIS OF PUBLICATIONS

World famous scientists in the field of telecommunications - Gupta and Kumar - made their estimates regarding the maximum capacity for a fixed episodic self-organized network. High mobility of up-to-date communication facilities, the active variability of the topology of local and other networks require the development of new approaches to their analysis, creation of new design tools and new algorithms for stable operation. There is a worldwide trend towards deploying such networks and using them for military purposes and emergency situations, when regular telecommunications cannot operate as usual.

III. PROBLEM STATEMENT

To improve the connectivity and quality of service in a mobile self-organizing network, it is important that the following tasks be solved:

• To determine the most effective ways for improving connectivity in the mobile self-organizing networks; and

• To develop an effective routing algorithm in a self-organizing network with elements of self-adaptation and self-configuration under 'unpredictable movement of nodes' condition.

With a view to perform the message transfer functions from one node to another in self-organizing radio network, the "re-transfer" relaying mode shall be used. Routing in self-organizing radio networks consists of two important stages:

• Finding the optimal route; and

• Maintaining the route during the session.

IV. THE PURPOSE OF THE ARTICLE

Network "connectivity" is responsible for a route maintenance solution. The optimal route may be found after the connectivity has been ensured. But, even if connectivity is ensured in the network at the initial stage, due to the movability of nodes and limited resources of receivers, the established connections are likely "to break" easily, so a route will have to be built several times in order to transmit a large message in the network.

To select the most complete option of the routing algorithm, the following parameters should be distinguished:

1. At network level: sufficient performance or residual capacity (bit/s), end-to-end latency (delay), buffer capacity in a node, delay discrepancy, packet loss rate, power consumption per packet (J), and route lifetime (s),

2. At channel (MAC) level: MAC delay, stability of the connection (connection) - the estimated lifetime of connection; communication reliability - packet delivery rate (%), and relative movability/stability of nodes,

3. At physical level: signal-to-noise ratio (SIR), bit error rate (BER), and battery residual or cost metric.

In the self-organizing radio network with an unknown topology, the 'on-request (demand) method' is considered the best route search method. This method allows building a route in the network without constant polling, which reduces the load on the network. With a view to find a route with packet broadcasting, it is necessary that a number of complex tasks, associated with the avalanche-like distribution of packets over the network [2, 3], should be solved. This type of route finding fills the network with a large number of packets, and if methods of reducing the number of packets are not applied, the network will quickly reach its 'critical mass' of traffic, which leads to its inoperability. Figure 1 shows the flow of requests that ends up with an avalanche of broadcast traffic. Due to the properties of data transmission environment in the radio network, packets reach every node only in the area with stable radio reception. In order to reduce the amount of administrative traffic in the network, the repeater selection task should be delegated directly to the intermediate nodes (Fig. 1).

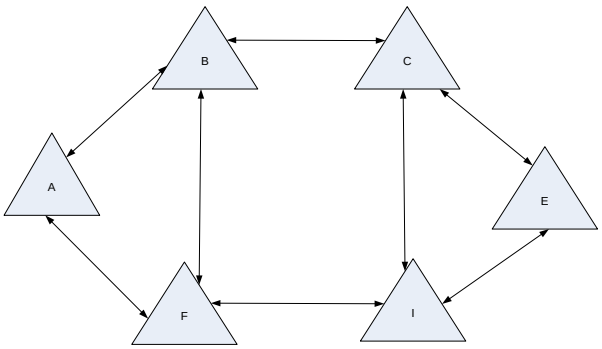

Figure 1. Request during building a route in the radio network

The main feature of self-organizing radio networks is the variability of topology, the change of communication line parameters, the unpredictable dynamics of nodes and connections between them.

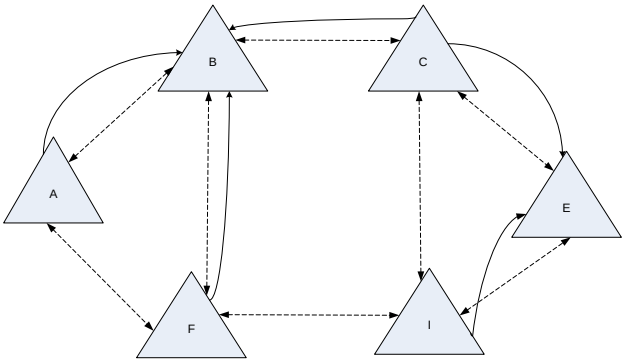

Figure 2. Interaction of nodes in the request-response mode

The picture below displays the features of the proposed routing option. Unlike the protocols that include the building of several path options ('spreading' or 'flooding' term is often used to describe this) and the estimate of costs, in the proposed (self-organized) routing option, each relaying node, depending on the initial program and conditions, 'decides for itself' on relay of message to the neighbors or not. This decision, for example, may depend on the discharge of battery in the related device. The 'epidemic-spread' algorithms might be considered similar to the routing ones. The advance of an epidemic among members of any society (team) is modeled with the 'epidemic spread' algorithms being applied. Transfer of information includes intermediate storage, whenever it is not possible to immediately transfer the information to an addressee [1, 6]. The developed SORA has a slightly different principle of 'epidemic spread': depending on its state, a node either 'picks up a disease' or not.

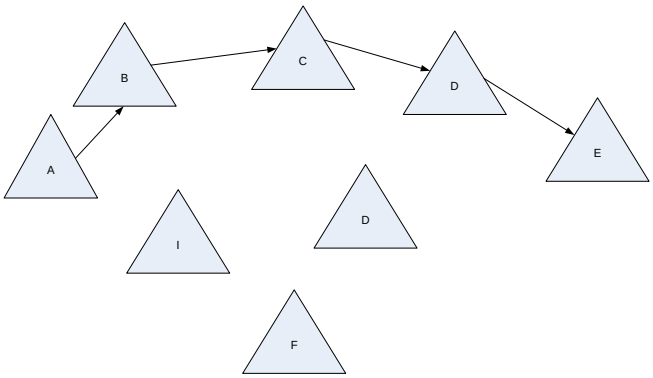

Figure 3. Development of one way

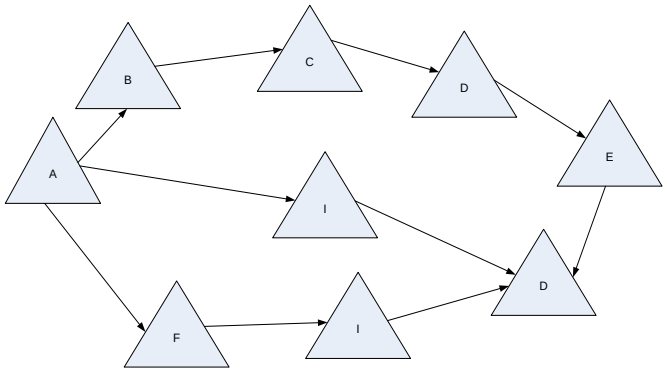

Figure 4. Development of several ways

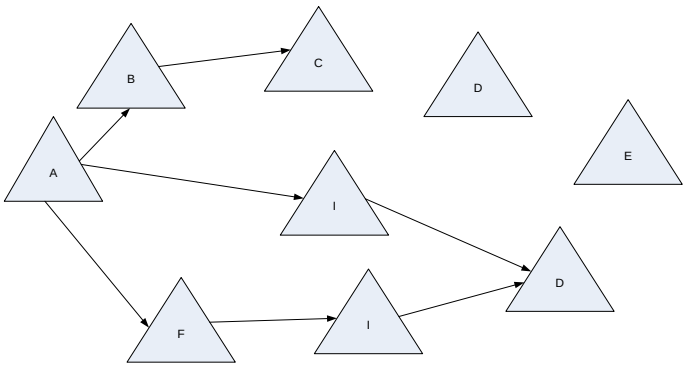

Figure 5. Self-organization of network

Description of a standard routing algorithm operation is presented below for comparison

A subscriber, who receives a packet from the air, performs the following actions:

1. Checks a type of packet: informational / administrative;

2. Checks a recipient's address: friend or foe;

3. Checks a request for a route: a route is available / not available;

4. Checks for duplicate: yes / no;

5. Checks a packet for relay: yes / no;

6. Checks if packets are from a user;

7. Removes packets (duplicate, refusal to participate, other reasons);

8. Checks the packet relaying protocol: yes / no / request to build a route (a route request may be periodic);

9. Checks the algorithm for building a route: yes / no;

10. Broadcasts.

Brief description of how the SORA algorithm works:

A subscriber-receiver of a packet from the air performs the following actions:

1. Checks a recipient's address - friend or foe;

2. Checks a packet - request to build a route / to move along a route / duplicate;

3. Checks for a duplicate - delete / for the user;

4. Checks if packets are from the user;

5. Removes packets (duplicate, refusal to participate, other reasons);

6. Makes a decision on participation in the route - yes / no;

7. Checks the relay - yes / no;

8. Broadcasts.

Let's take a closer look at the SORA:

• The SORA algorithm is intended for mobile wireless self-organizing communication networks, where nodes have identical status. Functions of base stations are distributed among all participants in the informational interaction. The SORA algorithm is intelligent; it enables a node to independently make a decision on participation in the route building process and/or restoration of the rout. This feature enables to control the traffic driven through the node.

• The algorithm is used to find the optimal route between a calling party and a called party within the self-organizing network. The peculiarity and uniqueness of the algorithm lies in the fact that it does not build routing tables in the node, and subscribers do not have information about the location of each network participant. Along with this, the algorithm enables finding the optimal route between participants in the connection.

• To prevent errors associated with node movability, the SORA algorithm uses the ability to select options for route updating and maintaining. One of the options is based on breaking-up and building of routes after a certain time. This approach enables building an actual route, since a route is built in the current topology at a given time. The difficulty of this approach lies in the flooding of route building packets.

• Another option for ensuring connectivity is the local route restoration method. On the path of information distribution along the selected route, there are always nodes available that do not participate in the route, at the same time they receive information from neighboring nodes. So, the nearest nodes receive and process received packets and based on received information, the data, required for maintaining the route, are calculated. If a route is broken, the nearest nodes restore the broken-up route.

• The algorithm starts building a new route from the breaking point in the breaking section. Route recovery is based on the main algorithm; a route is being built using data from the previous route.

• A request to build a route triggers a packet distribution translation. An addressee accepts packets from all routes and selects the primary and secondary routes. The primary route carries data, while an alternate route carries route support packets.

The SORA algorithm ensuring connectivity and also solves tasks that adapt this algorithm to constantly changing conditions:

1) Changing of the number of nodes.

The number of nodes affects only the network bandwidth and load. The algorithm is built in such a way as not to depend on the number of nodes.

2) Network load, packet loss.

The routing algorithm evenly balances the load across the network. For this purpose, various states of the node are used to assess the capability of a node. Delivery of packet to the following node is monitored owing to the properties of transmission environment.

The network is built in accordance with the CAM protocol. When it is necessary to send packets to several nodes, it forms various sessions enabling to share information among different nodes. In the case of transferring information from a group of nodes to one node, the identifier of connection allows the receiving node to share information.

The SORA algorithm, intended to ensure network connectivity, eliminates disadvantages of routing protocols, which are inherent in the known algorithms. Listed below: disadvantages and corrective measures:

1) Network congestion due to constant data transmission.

An acknowledgement mechanism involves sending acknowledgement packets. This doubles the number of packets on the air. For the purpose of acknowledgement, the algorithm uses the dipole antenna properties to propagate signals in all directions, which makes it possible to refuse the acknowledgement packets or reduce their number.

2) Very low level of reliability and protection, since the data is distributed over the air.

These problems have not yet been considered, as data protection can be provided by application.

3) Each node independently decides whether to participate in the route or not as well as to receive/send packets along several routes.

This leads to excessive delays. In the SORA algorithm, after a route has been built, the nodes compare only the required fields and do not make calculations. This reduces the time for processing and decision-making on participation in the route. A decision on participation in the route is made at the stage of building the route and depends on the current state of node; it is not changed in the course of the route. The SORA method does not use targeted data transmission, only information is checked (whether a node is relaying a packet or not).

4) Each node "shall open a large packet", which takes longer than opening "small" administrative packets.

There is no need to examine the entire packet in order to process it; it is enough to check the values in the certain fields and compare them with the other values. The difference between small and large packets is: the occupied memory and the time of propagation on the air. During the time when the last bit of the packet is being received, a decision about relay can be made.

V. CONCLUSIONS

It has been proven that a self-organized routing algorithm meets the requirements for network adaptation, self-configuration and network recovery. The positive feature of the algorithm is the reduced administrative traffic.

Reduction of administrative traffic is achieved by combining the information and administrative flows.

It has been found out that the proposed algorithm is more efficient and has advantages over the standard protocols such as: AODV, DSR and OLSR in terms of a set of parameters such as end-to-end delay, network bandwidth and media access latency.

The developed routing algorithm for self-organizing radio networks exceeds the main information exchange protocols in terms of the 'network congestion with administrative traffic' parameter by 15%. This is a perfectly acceptable result proving the advantages of the developed algorithm.

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