Designing of routing algorithms in autonomous distributed data transmission system for mobile computing devices with 'WiFi-Direct' technology

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Abstract. The results of the research of existent routing protocols in wireless networks and their main features are discussed in the paper. Basing on the protocol data, the routing protocols in wireless networks, including search routing algorithms and phone directory exchange algorithms, are designed with the 'WiFi-Direct' technology. Algorithms without IP-protocol were designed, and that enabled one to increase the efficiency of the algorithms while working only with the MAC-addresses of the devices. The developed algorithms are expected to be used in the mobile software engineering with the Android platform taken as base. Easier algorithms and formats of the well-known route protocols, rejection of the IP-protocols enables to use the developed protocols on more primitive mobile devices. Implementation of the protocols to the engineering industry enables to create data transmission networks among working places and mobile robots without any access points.

1. Introduction

Nowadays everybody uses mobile devices for communication, data transmission, audio and video file playing. The users` abilities are limited by the necessity of connecting to the Internet access point. In this view, the topic of creating a possibility to transmit information among users to a long distance without the network connection is getting more and more relevant with time.

'WiFi-Direct' technology enables two and more users to communicate through P2P-connection [1]. However, this technology had been used very seldom for constructing autonomous distributed data transmission system for data transmission of mobile computing devices [2-6]. The use of such techniques in engineering stimulates enlargement of data transmission network for mobile and static robots without access points. Autonomous system enables to build up the route between two users through intermediated nodes with 'WiFi-Direct' technology if direct connection is impossible. The development of the system consists of two principal phases divided into subtasks.

1. Designing of algorithms:
   A) Analysis of existent routing protocols and the comparative analysis
   B) Designing of the route request algorithms and the request structure
   C) Description of the structure of storing the routing cache in nodes
   D) Designing of data transmission algorithms
2. Software engineering
   A) Designing of human-system interface

B) Creation of Use Case diagram
C) Program realization of designed route algorithms
D) Program realization of data transmission algorithms

The paper is a research of the abilities of using protocols for the system realization and the comparative analysis, the description of the structure of storing the routing cache, as well as the design of the route request algorithms and the request structure, basing on the optimal for the system parameters of existence protocols.

2. Analytical review of the wireless route protocols

The wireless route protocols are divided to proactive and reactive. Proactive protocols build up a few tables with complete information about the system and never start data transmission before getting exhaustive information about the network [7].

One of the modern proactive protocols is OLSR (Optimized Link-State Routing) [8], which is based on gathering and dissemination the ordering information inside the network. As a result of the findings each node is able to build up its own network graph, where the points of graph are nodes and the ribs are the lines of communication. With this information every node can calculate ‘optimal’ route to any node of the network.

Reactive protocols form the route at the request [9]. Data transmission starts just after disclosure of the way between the source and the destination node. One of the first reactive route protocols in wireless networks are protocols DSR (Dynamic Source Routing Protocol) and AODV (Ad hoc On-Demand Distance Vector) [10-11].

Protocol DSR accumulates information about the route not in the routing table, but in the request packet. The main protocol mechanisms are building up and serving the route. Mechanisms are used together to identify and maintain the route. After the first identification the packets are sent to all possible directions and the information about the past node is attached to the title. To achieve the goal, the packet must contain a completely formed route between the adjusted nodes. After the repeated reception of the first packet the node deletes the packet.

Protocol AODV builds up the route tables on the each node of the network to minimize the information translation time between nodes and finds the route ways independently from the use of the routes. The first step is building up the route tables on the each node. The table holds the information about the shortest way (metric) to the destination node through the neighbour nodes, which exchange metrics until it stops changing. Only then it’s possible to pass the information to the optimal route. A comparison of the advantages and disadvantages of different protocols is shown in table 1.

Table 1. A comparison of the different protocols

OLSR	**AODV**
Proactive protocol	Reactive protocol
Stores new data about the whole network	Stores data about the active routes which is the reason for the less ordering information processing
It takes less time to find the new route as it is displayed in the route table which always updates	More time is spent to find the new route as there is information only about the active routes

Information in the table 1 shows that reactive protocols are more useful for the mobile devices network. Comparative analysis of the main characteristics of reactive protocols is shown in table 2.

Table 2 shows that protocol DSR is the most appropriate route protocol for network with ‘WiFi-Direct’. However, protocol cannot be used for networks P2P made with WiFi-Direct. That is why, on its base, route algorithms were projected.

Table 2. Comparative analysis of the main characteristics of reactive protocols

Name	Plural routes	Method of calculating the route	Storing the route	Strategy
AODV	–	The new shortest route	The route table	Complete or partial rewriting of the routes
DSR	+	The shortest or the next in the route table	Route cache	Complete rewriting of the routes

3. Designing of the route search algorithms and forming the clients list

The algorithm updates the route cache regularly. The packet should be informed about the route direction. Thus, information about the route is mentioned in the packet to reach the destination node. Algorithm contains two major mechanisms of the work: the route request mechanism and the route serving mechanism. When opening the route, we can see two possible messages: a route request (RREQ) and a reply to the request (RREP). When the node is about to send a message to a certain destination, it transmits RREQ packet in network. Neighbour node in the broadcasting range gets RREQ-message and adds it to its address, then retransmits it in the network. If PREQ-message does not reach the necessary node, the route is deleted.

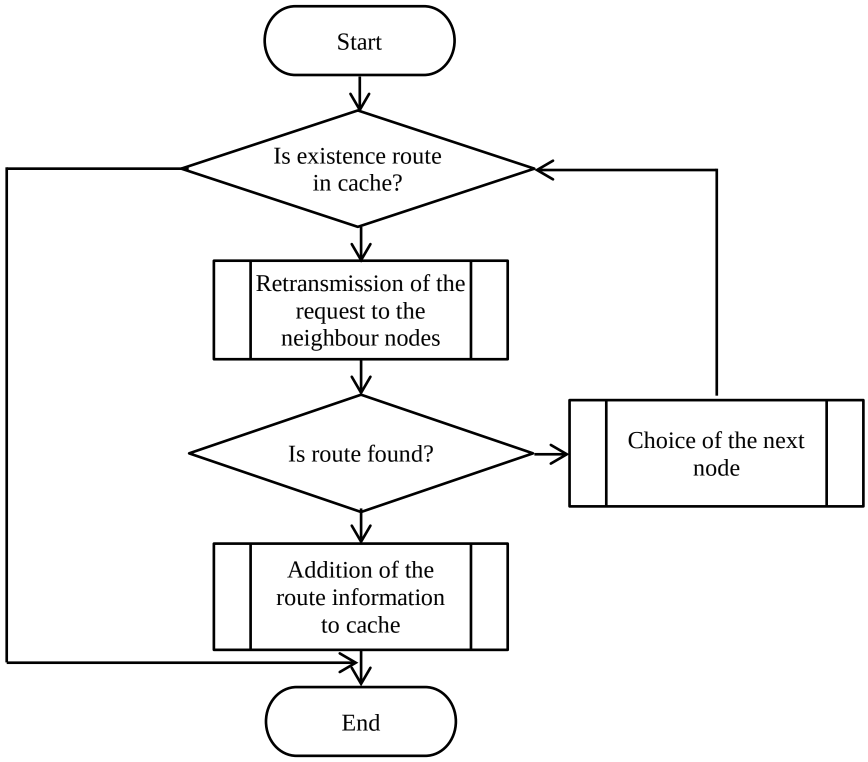

Figure 1. Diagram of route requests.

Every node supports its own route cache, which is stored in memory for the uncovered route. The node will check its route cache for the required destination node until the PREQ-message retransmission. Supporting the route cache on the each node of the network, overhead expenses of the storage, generated while revealing the route, are decreased. If the route is in the routing cache of the intermediate node, it will not retransmit PREQ for the whole network. PREQ-message will be transmitted to the destination node straight away. The first message having reached the destination contains complete information about the route. This node will send PREP packet back to the source, as this route is considered as the shortest one. The source henceforth owns complete information about the route in cache and is able to start the packet transmission. The next function is the packet service. Revealing the route requires two types of messages: message about an error (RERR) and the certification message (ACK). ACK sends a message to the source if the destination node is reached. All intermediate nodes acquire the information about the design route as well. If any errors in the route revealing take place, the source-node gets the message about an error (PRER). It happens if the source-node gets no ACK-message.

In such a way, the source acquires the PERR packet to send the route request again. Having got the RRER message the nodes delete information about the route. The flow diagram of the route request is represented in figure 1.

Fulfilling the routing cache enables to choose the existence optimal route to the destination node or to rewrite it if the previous data is incorrect. If the route isn`t revealed, the request (PREQ) is retransmitted to the neighbour nodes. For the every next node the operation is repeated. After revealing the route the result is written to the routing cache of the source node and the destination node, as well as to all the intermediate nodes.

The format of the PREQ-request message consists of the following fields: UD (16 byte), Source-node (16 byte), Intermediate nodes (16*N byte), Destination node (16 byte), Hops (8 byte), Time-out (8 byte).

In the Unique Identifier (UD) the unique descriptor of the route request is written to avoid making one and the same requests and their rewriting. The appearance of the bails is fixed by the node declining the packet, if the record with UD is already present in cache. The Hops field enables the node to limit the number of intermediate nodes between the source and the destination. With every next intermediate node the Hops value decreases to zero, then the route revealing will be stopped. Time-Out field shows the time left for the route, after which the route will be deleted. It enables to avoid an endless search of the route and to decrease a chance of a fail in data transmission on account of the revealed route being not actual. MAC-address of the source is written in the field “Source-node”. MAC-address of the destination is written in the field “Destination-node”.

All MAC-addresses of the intermediate nodes are a writer in the field “Intermediate-nodes” in series. N –number of the intermediate nodes can`t be more than 128. PREQ-request is always enlarged by the intermediate nodes until the destination node is reached. Having achieved the destination node, it sends back PREP-reply, which contains complete information about the route and the similar fields.

To avoid a creation of a number of the route requests, which could get less actual with the time, every nodes stores life-cycles of all sent requests in a table. The routing cache of each node includes the next 5 fields: Field 1 – UD of the request (got when initiation of the route request); ‘Main MAC’ (stores its own MAC-address of the source-node); Field 3 – Stores list of MAC-address of the intermediate nodes); Field 4 – ‘Time-out-field’ (stores the left time of the route existing); Field 5 – MAC-address of the destination node.

4. Conclusion

A comparative analysis of the types and kinds was hold after the research of the existing algorithms, peculiarities of each of them were revealed. One of them was taken as the base and adopted to our system.

In the progress of work the next results were achieved:

A) Existing routing protocols were analysed and their comparative analysis was carried out;

B) The route request algorithms and the request structure were designed;

C) The structure of storing the routing cache in nodes is described.

The analysis of algorithms has shown the unique specialities of each of them and decide on situations, where these algorithms are the most effective. Algorithms without IP-protocol were designed, and that enabled an increase of the efficiency of the algorithms while working only with the MAC-addresses of the devices. The route cache storing only the necessary information is described.

References

[1] WiFI Alliance Discover WiFi *(Electronic Materials)* http://www.wi-fi.org/discover-wi-fi/wi-fi-direct

[2] Corson S and Macker J 1999 Mobile Ad hoc Networking (MANET): Routing protocol performance issues and evaluation considerations *(Electronic Materials)* https://www.ietf.org/rfc/rfc2501.txt

[3] Divecha B, Abraham A, Grosan C and Sanyal S 2007 *J. of Digital Information Manag.* **5** 19-24

[4] Kustov D, Sherstneva A and Botygin I 2016 *IOP Conf. Series: Mat. Sci. and Eng.* (IOP Publising) 012037

[5] Imas O, Kaminskaya V and Sherstneva A 2015 *Proc. of 2015 Int. Conf. on Interactive Collaborative Learning* (Florence) pp 511-514

[6] Botygin I, Popov V, Tartakovsky V and Sherstnev V 2015 *Proc. of SPIE - The Int. Society for Optical Eng.* 96800J

[7] Reddy K, Raju V and Venkatadri N 2012 *Int. J. of Video&Ima*ge *Proc. and Network Security IJVIPNS-IJENS (Electronic Materials* vol 12 no 5) http://www.ijens.org/Vol_12_I_05/122005-8484-IJVIPNS-IJENS.pdf

[8] Clausen T and Jacquet P 2003 Optimized link state routing protocol (OLSR) *(Electronic Materials)* https://tools.ietf.org/html/rfc3626

[9] Johnson D, Hu Y and Maltz D 2007 The dynamic source routing protocol (DSR) *(Electronic Materials)* https://tools.ietf.org/html/rfc4728#section-6.2

[10] Perkins C, Belding-Royer E and Das S 2003 Ad hoc on-demand distance vector (AODV) Routing *(Electronic Materials)* https://tools.ietf.org/html/rfc3561

[11] Kaur R, Singh P, Gaba G and Pasricha R 2015 *Indian J. of Science and Technology* IPL0626