

## A Novel Routing Protocol with High Energy Performance in Mobile Special Networks

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**Abstract:** **Problem statement:** Mobile Special Networks do not have a predetermined structure. This type of networks can dynamically reorganize network connection relationships due to change of neighborhoods and the relative positions. **Approach:** There are many problems in creation of a special network such as routing, wireless media, energy consumption and transportability. **Results:** Although these networks primarily had been formed for small group of colleague nodes, nowadays they also have increasing amount of applications in expansive geographical regions. This trend reveals requirement of communication protocols which use energy efficiently and effectively as well as better energy consumption considerations of the hardware. In this study, an improvement of DSR protocol based on energy consumption parameter is explained and a new routing protocol of mobile special networks that is called Group Base DSR (GBDRS) have been proposed. **Conclusion/Recommendations:** It has been shown that energy consumption related communication parameters as pocket loss and route discovery frequency have considerably better values when GBDRS is used in the increasing node movement speed range of 0-30 m sec<sup>-1</sup> and over.

**Key words:** Mobile Ad Hoc network, control systems communication, routing protocols, wireless networks, broadcasting, special networks

### INTRODUCTION

Mobile special networks (MANETs) are group of wireless computers in the form of communication network which do not have predetermined structure. Administration and configuration of these kinds of networks are not dependent on any special user. On the other hand, special networking allows formation of an independent interconnection set of devices. Although there are abundant scenarios for fixed-structure networks, special networks are needed for some cases in military missions, emergency operations, educational classes etc. where network infrastructure varies during the mission both in terms of routing, population and the type of devices. Hence, in the recent years, special networks have been carefully considered and routing appears as the main problem in this kind of networks. There are no basic and fixed stations in their network model while in the model of cellular networks stations are fixed computers which are connected with wire or link with spinal columns of network and they provide wireless media coverage over a geographical area (called cell).

### MATERIALS AND METHODS

**Basics of mobile special networks:** Special wireless network have not any base station and fixed

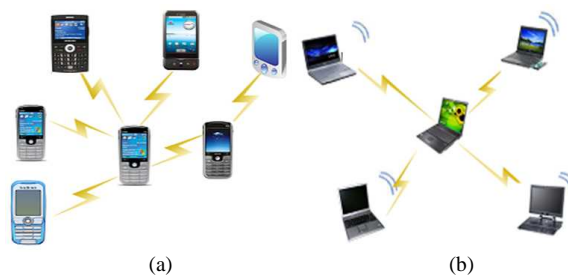


Fig. 1: Heterogeneous special network and special network with mobile host

substructure. Their structures enables automatic and event based updates by back up calculation at any time and in any placed. In such networks, each mobile host acts as a router. For this reason, peer to peer communication as well as peer to remote communication is possible in this kind of network (Kahn *et al.*, 1999; Camp *et al.*, 2002; Johnson and Maltz, 1998; Perkins, 2001; Vincent and Corson, 1999). There are two types of topology for special networks: Heterogeneous mobile devices and mobile host network. The first network has been comprised of different kinds of mobile devices such as PDAs, smart signals and mobile hosts, while, second type of the

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network has been only comprised of mobile hosts. Figure 1 indicates an example of special networks in which (a) shows a heterogeneous network and (b) shows a network with mobile hosts.

It is clear that rate of traffic depends on whether the relation is peer to peer or peer to remote. It is necessary to note that this kind of network can use all formal programs such as telnet, ftp, www, ping etc and one can have client/server programs, colleague calculation and mobile multimedia in these kinds of networks. In summary, some important specifications of special networks can be considered. They are as follows:

- Topology of network may change at any time
- Each node can be mobile
- Capacity of energy of mobile nodes is limited
- A host acts not only as end system but also as an intermediate system
- Width of wireless band is limited for communication
- Quality of channel is variable
- The present components are not centralized and on the other hand, the network has been distributed

Regarding to above listed issues, the following questions are mentioned:

- How should the routing be backed up?
- How is channel access guaranteed?
- How much mobility is acceptable?
- How is energy maintained?
- How can bandwidth be used effectively?

One can say that in special network, routing is a complex problem and its reason is mobility of routings. As a result, links may change frequently and this subject refers to the fact that communication links should be updated continually and its messages should be sent frequently and this control creates traffic. Another problem is that routing tables may not be converged; therefore, some rings may be formed in routing. Problems relating to channel access are due to distribution of access to channels and because there is no base station. In a special mobile system, it is very difficult to prevent from collision of packets and Quality assurance Of Service (QOS).

In fact that everything in special networks mobile leads to formation of multiple ways and levels in communication. Effect of mobility in signal transmission, channel access, routing, multiple sections and applied programs are significantly clear. There are special devices in different forms, but one of their common specifications is the use battery energy and

this energy is limited. Wireless transmission, collision, resubmission and conductive radio waves are all effective on energy consumption. As a result, there is strong need for presence of protocols which uses energy efficiently and effectively as well as technology for better management of energy. But unfortunately, batteries technology does not grow as rapidly as CPU or memory does.

**Dynamic source routing protocol:** Routing protocols in mobile special networks are classified into two classes: Table based and need based. Table based or pre active method is used for linkage alternate updating and can use each one of the methods of distance vector and linkage status which are used in fixed networks. The word "PREACTIVE" means that this method is always working and its aim of permanent reaction on change of linkage. Problem of this method is that when movement is low, additional work is done and is directed towards instability. In need based method or method with reaction, route update is not done alternatively and the routes are found at request of origin. The fact that this method is called a method with reaction means that it reacts clearly for change in linkage which is similar to need based protocols. Therefore, there is possibility of use of caching mechanism. The advantage of this method is that both energy and bandwidth are used effectively.

In comparison with routing protocols of driven table, in this group of protocols, all updated routes are not maintained in each node; instead, routes are constructed if necessary. When an origin node wants to send something to destination, it requests route detection mechanisms for finding a route to the destination. Route remains valid until the destination is accessible (Kahn *et al.*, 1999).

Dynamic Source Routing Protocol (DSR Protocol) is an origin routing protocol and is based on demand. A node maintains cache from the routes including routes from origin and it is aware of them (Bellur *et al.*, 2002; Bharghavan *et al.*, 1994; Long-lived, 1999; Corson and Macker, 2008). The entered data are updated in cache of the route when new information is obtained about current routes. Two main phases of this protocol are detection of route and maintenance and repair of routes. When origin node wants to send a packet to destination node, it investigates its route cache to see whether it has route to destination or not. If there is a valid route to destination, it will use this route for sending its packet. But if this node does not have any route, it will start route detection process through demand packet distribution. Demand packet includes address of origin and destination node and exclusive identification number. Each intermediate node checks whether it has route to destination or not. If not, it will add its own address in this packet and will send it

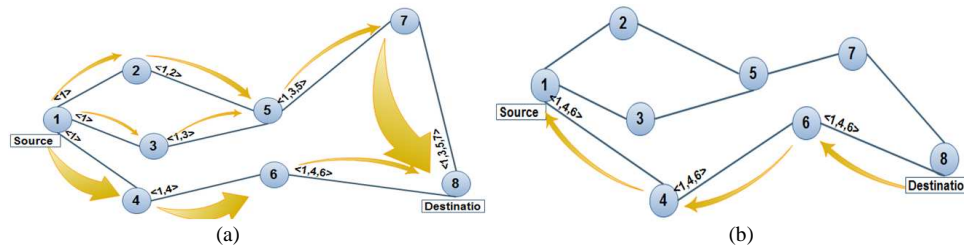


Fig. 2: An instance of route detection in DSR

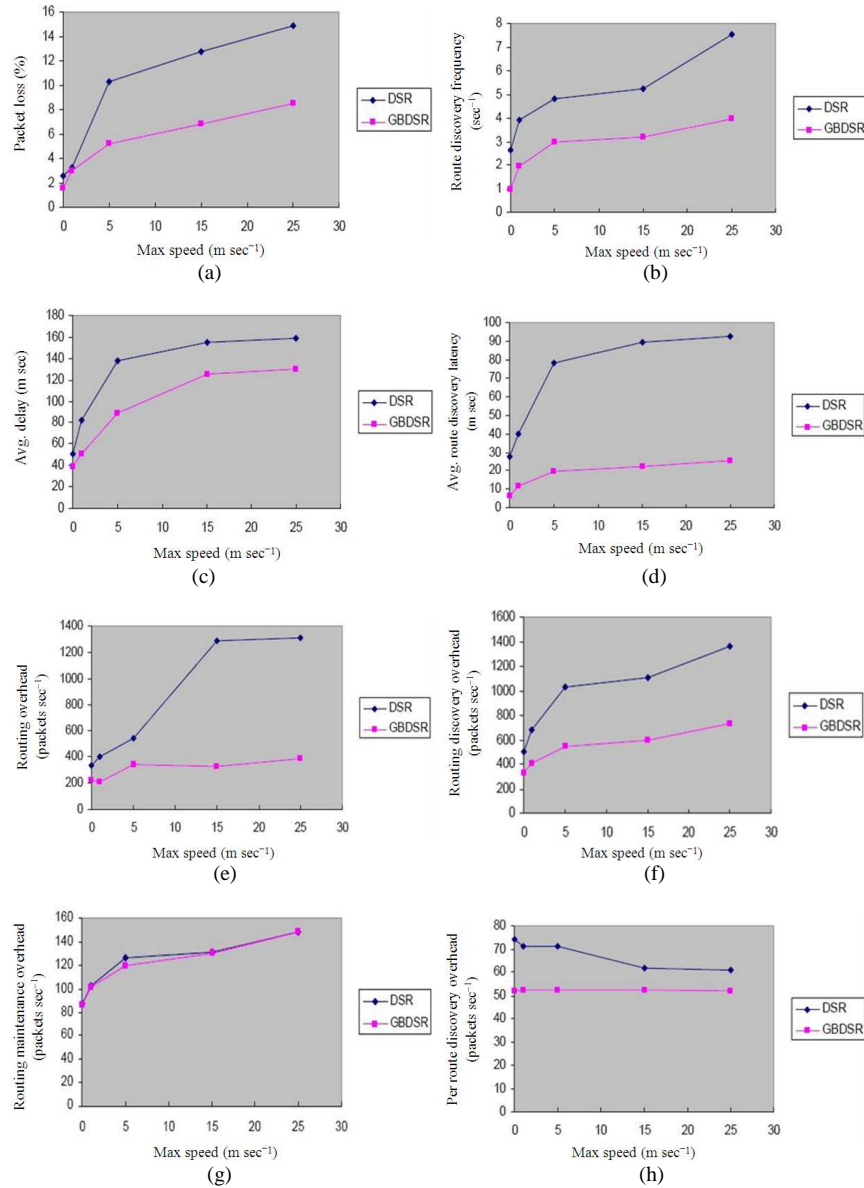


Fig. 3: Performance comparison of the DSR and GBDSR at different movement MANET speeds for (a) Packet loss trend between DSR and GBDSR (b) Route Discovery frequency (c) Average delay between DSR and GBDSR (d) Average route discovery latency (e) Routing overhead between DSR and GBDSR (f) Route discovery overhead (g) Route maintenance overhead (h) per route discovery overhead

to its neighbors. In order to limit the number of publication of route demands, a node process route demands packet only when it has not seen it before that is its address has not been available in section route record. A route reply is produced when destination node or an intermediate node with current information about destination node receives route demand packet. Route record section of route demand packet which reaches a node includes sequence of hops passing from origin node to this node. Figure 2, Section (a) shows how route demand packet is distributed in the route and indicates its route record section. If reply of each route is produced by destination node, this node places route record section of route demand packet in route reply. In another state, if an intermediate node wants to produce route reply, it will place its cached route to destination in route record section of route demand packet. Figure 2, section (b) indicates the state in which destination node itself has sent route reply.

In order to send route reply packet, the replying node should have a route to origin node. If it has a route to origin in its route cache, it can use it. The reverse route given in route record section can be used when symmetric links are supported. If symmetric links are not supported, node can perform detection of route to the origin and carry route reply in route demand packet.

**Improvement of DSR protocol by using group distribution:** GBDSR is development of DSR on the basis of multiple distributions. DSR and GBDSR are both routing protocols for especial network in such a manner that PSR is used in single distribution traffic and GBPSR is used in multiple distribution traffic.

NS2 includes standard implementation for DSR protocol on which basis GDPSR protocol has been implemented, however, but this implementation of GBDSR includes two essential limitations:

- Only members of the group can send data for multiple distribution group
- Multiple distribution data packets are the same single distribution packets. As result, bandwidth is not used fully effectively

New version of GBDSR allows each node located in the network to send data packets for other nodes and multiple distribution data packets are turned into public distribution data packets during distribution across tree of multiple distribution groups Fig. 3.

In total, several acts have been improved in this new protocol and led to improvement of DSR protocol.

**GBDSR improved protocol:** Each distribution group (hereinafter called group) has a unique address and one can name other specifications attributed to it as follows:

- Each group has been organized on the basis of a tree structure
- Each group has been composed of a series of members and several route finders which are not part of group members but are connected in tree structure to members of group
- All members of group and route finders are called members of tree and entire tree is called group

The first member of the group which has been formed in the group is called Group Leader and this member is responsible for preservation of communication of this tree with another tree which does this study by broadcasting Group-Hello (GRPH) message across entire network alternatively. Each node in network can keep 3 Tables. The first of them is unicast (single receiver) route table in which the subsequent hop is recorded for the routes, which is destination of another node of the network. The second table is multicast route table including a list of the subsequent hops for tree structure of each group. Each row shows a tree structure of group.

All nodes which are in a group have equal rows in their table specifying information of group leader, group members and routers. The 3 Table is group leader table, including address of multicast group with address of its group leader and the subsequent hop toward group leader.

**Detection and maintenance of route to a special node:** Detection and maintenance of the route are main duties of DSR protocol. Detection and maintenance of the route are main responsibility of DSR protocol which has been also implemented in NS2 and GBDSR, two important notes about this fact are as follows:

- Only MAC layer is used in recognition of broken links in active route but in GBDSR whether this active route is to a special node or to multicast tree, only one hop named Neighbor-Hello is used for recognition of link breakage in tree
- Implementation of DSR in NS2, is broken link local restoration but in GBDSR, this restoration is ignored and in case of breakage of a link, instead of its local restoration origin node finds a new route

**Detection and maintenance of route to a tree:** As said before, in GBDSR, each node can have multicast, therefore, this case should be studied that if origin node

is not member of a tree, how data reaches each member of tree. For this purpose, a two-stage method has been selected. In this stage, there is a route from origin node to a member of tree, therefore, when this member receives packet, casts it among all members of tree. For this purpose, route detection and maintenance mechanism are used. During sending multicast data packet, each node checks whether it is placed in the tree or no, if node is not member of tree, unicast route table seeks itself for finding the subsequent hop to this address. If information is available in this field, it will send packet for that hop, otherwise, it will send a clear RREP packet for origin node. In this case, origin node starts detecting a new route to multicast address. If a node is member of a tree, it can be send packets on the basis of available information.

**Maintenance of multicast tree:** Maintenance of multicast tree is more complex than that of unicast route. This maintenance includes group-hello cast, maintenance of neighbor connection, selection of group leader, cancellation of membership and merge of tree.

**Probability method:** One way of probable maintenance during implementation, is tree maintenance in added GBDSR method. Main idea of this method is that it predicts time of active link breakage in a tree before link breakage and then a new connection prevents from link breakage and removal of data packets.

## RESULTS AND DISCUSSION

For implementation of GBDSR, many different simulations have been performed and we have conditions of simulation environment and results obtained from as follows:

- Area of simulation: 1500×300 sq m
- Number of nodes: 50
- Time of simulation: 900s
- Number of simulation frequency: 7 times
- Physical layer/ MAC: IEEE 802.11, in 2 Mbps and 250 m transmission interval
- Movement model: Random model without stop time and speed of nodes movement 0, 1, 5, 15 and 25 m sec<sup>-1</sup>
- Each sender sends two data packets each 256 bites long per second
- Each receiver is a multicast group member but each sender is not group member unless all 50 nodes are receivers and members of group

- Each receiver belongs to a group at the beginning of simulation and senders starts sending data after 30 sec all senders stop sending data after 900s

- Type of traffic used in the simulation: Only multicast

Two measure criteria of GBDSR are PPR and latency as follows:

- PDR is packet receiving rate which is obtained through total number of sent packets × the number of receivers.
- Latency of is reaction period of average delay for transmission of data from the sender to the receiver

The following figures show results obtained from this simulation and equivalent results for DSR protocol.

## CONCLUSION

Spatial speed of communication nodes is one of the key factors for design and performance of mobile Ad Hoc networks. In this study, simulation has been performed with traffic load of 20 origins and maximum speed of 20 m sec<sup>-1</sup>. All protocols deliver high percentage of the produced packets when movement of nodes is low (for example in case of high stop time) and this value reaches 100% when movement of nodes reaches zero, especially DSR which delivers more than 95% of the packets in each rate of movement. DSR that is on demand protocol has the lowest parasite and its parasite changes in parallel with changes of movement rate and completely depends on it. DSR protocol, which is the most important protocol for routing special network, has been-property improved with use of multicast property. Regarding to simulation results which have been obtained for DSR protocol and its improved protocol i.e., GBDSR, it is observed that new algorithm has improved characteristic values in all aspects rather than base DSR. New version of GBDSR allows each node located in the network to send data packets for other nodes and multiple distribution data packets are turned into public distribution data packets. Overall, several actions have been improved in new protocol. This led to improvement in DSR protocol. Access time has importance for mobile control and automation systems where physical response time is critical. Energy efficiency is one of the design objectives for the mobile applications where main energy source is not generative as in the case of Ad Hoc sensor nodes. Energy consumption of the RF transmitters in wireless digital communication is also dependent on active data transmission time percentage, total switching rate and the required link budget related

to dynamic power level. For this reason, routing protocol characteristics become important especially for energy consumption of the mobile special networks where the resource is limited by the volume. It was shown by the simulations that improved characteristics of GBDSR provides 5 and 10% less (almost 50% of the DSR) packet loss and reduced amount of route discovery data packets down to 30% in the speed range between 5-30 m sec<sup>-1</sup>. These figures are directly effective on energy consumption. In the continuing part of the study we work on implementation of an embedded test routing software for minimization of the energy consumption in case that the dynamic characteristics of the RF transmitters in physical layer is known.

### REFERENCES

- Bellur, B., R. Ogier, F. Templin and M. Lewis, 2002. Topology Broadcast based on Reverse-Path Forwarding (TBRPF). TBRPF. <http://www.sri.com/esd/projects/tbrpf/>
- Bharghavan, V., A. Demers, S. Shenker and L. Zhang, 1994. MACAW: A media access protocol for wireless LAN's. Proceeding of the SIGCOMM '94 Conference on Communications Architectures, Protocols and Applications, (CCAPA'94), ACM New York, USA., pp: 212-225. DOI: 10.1145/190314.190334
- Camp, T., J. Boleng and V. Davies, 2002. A survey of mobility models for ad hoc network research. *Wireless Communi. Mob. Comput.*, 2: 483-502. DOI: 10.1002/wcm.72
- Johnson, D. and D. Maltz, 1998. Dynamic source routing in ad hoc wireless networks. In: *Mobile Computing*, Imelinsky, T. and H. Korth, (Eds.). Kluwer Academic Publishers, USA., pp: 153-181.
- Kahn, J.M., R.H. Kutz and K.S.J. Pister, 1999. Mobile networking for smart dust. Proceeding of the ACM/IEEE International Conference on Mobile Computing and Networking, (ICMCN'99), University of California, Berkeley, pp: 1-21.
- Long-lived, C.K.T., 1999. Ad hoc routing based on the concept of associativity. Wikimedia Foundation, Inc., [http://en.wikipedia.org/wiki/List\\_of\\_ad\\_hoc\\_routing\\_protocols](http://en.wikipedia.org/wiki/List_of_ad_hoc_routing_protocols)
- Perkins, C.E., 2001. *Ad Hoc Networking*. 1st Edn., Addison-Wesley, USA., pp: 370. ISBN: 0201309769
- Corson, S. and J. Macker, 2008. *Routing Protocol Performance Issues and Evaluation Considerations The Internet Society*. <http://xml.resource.org/public/rfc/html/rfc2501.html>
- Vincent, D.P. and M.S. Corson, 1999. A highly adaptive distributed routing algorithm for mobile wireless networks. Proceeding of the Conference of the IEEE Computer and Communications Societies, INFOCOM'97, IEEE Computer Society Washington, USA., pp: 1405-1413.