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# Restricted Flooding and Directional Routing for Wireless Mobile Adhoc Network

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## ABSTRACT
Mobile Ad hoc Networks (MANET) use a communication technique that can transmit data between nodes without the support of fixed infrastructure.

In MANET, each node has the freedom to join, leave, and move around the network. This movement creates a highly dynamic environment that effects packet routing. Therefore, efficient packet routing is one of the most challenging problems in MANETs. The aim is to find the most suitable path from source to destination, with the ultimate goal being to establish efficient route and efficient message exchange within MANET.

A restricted flooding and directional routing (RFDR) algorithm for MANET is proposed in this paper which eliminates the data transmission delay limitation and increases the number of delivered packets. Quadrant based directional routing is used towards the destination node to restrict flooding of packets in network.

MANET concepts may be used for emergency rescue operation. It is used for social events where the number of mobile users changes frequently and the capacity available for fixed infrastructure is insufficient, military applications & wireless community networks.

## General Terms
Wireless Mobile Ad-hoc Network, Routing algorithms

## Keywords
MANET Routing, directional routing protocol, restricted routing algorithms

## 1. INTRODUCTION
Mobile Ad Hoc Network (MANET) is a peer-to-peer communication technique that can be used to transmit data using a mobile or wireless link without the support of any backbone infrastructure. MANET allows users to maintain connectivity with other users without the use of fixed infrastructure such as base stations, access points or fixed transmission links. In a MANET traffic moves between nodes acting as routers from the source to the destination node. Hence, MANET is a self configuring and autonomous communication system.

The prime features of a MANET are: dynamic topologies; bandwidth constrained; energy constrained operation; and limited physical security.

The key advantages of a MANET are: rapid deployment, operating without central management and control; multi-hop packet relay and low cost.

### 1.1 Conventional MANET model

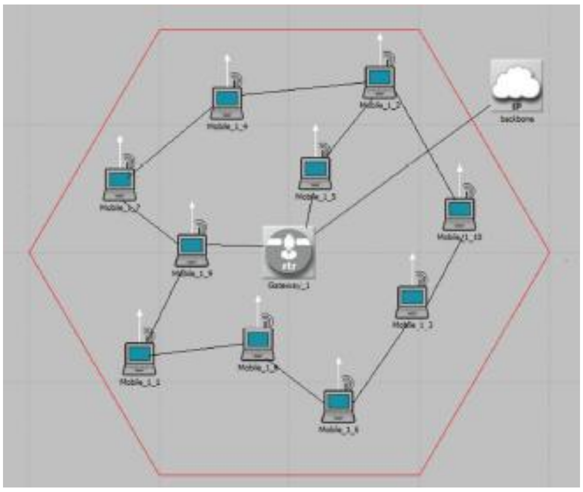

**Fig.1. A Conventional MANET Model**

Fig. one provides an example MANET model where the nodes communicate with each other using intermediate nodes as routers. The interconnection topology shown in Fig. one highlights the flexible nature of the network and how transmission paths may be irregular and determined by the MANET routing. Numerous MANET routing have been proposed, however the opportunity for improved intelligent routing still exists. The aim of future MANET routing includes large data rate, reliability and resiliency and power efficiency. In this paper, an improved MANET routing is presented.

### 1.2 Routing Protocol in MANET
Traditional routing protocol used in wired network cannot be applied directly to wireless and mobile network. Network topology in MANET is very dynamic and ever-changing where nodes are free to join or leave arbitrarily.

Generally, there are two different stages in routing; they are route discovery and data forwarding. In route discovery, route to a destination will be discovered by broadcasting the query. Then, once the route has been established, data forwarding will be initiated and sent via the routes that have been determined. Through broadcasting, all nodes that receive the query will broadcast to all neighbours and hence, large number of control messages is transmitted. It will be further compounded if the nodes move and new route need to be recomputed. Frequent route discovery and in some instances, additional periodic updates will cause more bandwidth being utilized and thus more energy wastage. Hence, to conserve the power consumption, route relaying load, battery life, reduction in the frequency of sending control messages, optimization of size of control headers and efficient route reconfiguration should be considered when developing a routing protocol.

Over the past several years, many routing protocols have been proposed and can be categorized into topology-based [1] and position-based protocols [2].Topology-based routing protocols route packets based on information about the network links while position-based routing protocols uses actual information about the participating nodes to decide on how to route packets.

Topology based protocols can be further divided into proactive, reactive and hybrid routing protocols. The network links are determined long before routing process in proactive protocols, when routing in reactive protocols and a combination of before and when routing in hybrid protocols. In the position-based protocols, location information of the destination are known and used. There are two sub-parts in position-based routing protocols, namely greedy forwarding and limited flooding. In greedy forwarding, nodes selection will be the best progress of it and data packet will be forwarded to these nodes. Ideally, this process is repeated until the packet arrives at the destination. Note there is no route discovery in greedy forwarding. Restricted flooding, on the other hand, will eliminate broadcast storm problem where only nodes in the direction of the destination will participate in the route discovery until the route to destination is found. The participation of nodes in routing will optimize broadcasting in MANET. Restricted flooding will broadcast messages to a selected number of nodes which is usually more than one that are located nearer to the destination. It will significantly reduce energy and the probability of packet collisions of messages rebroadcast by neighbours using the same transmission channel.

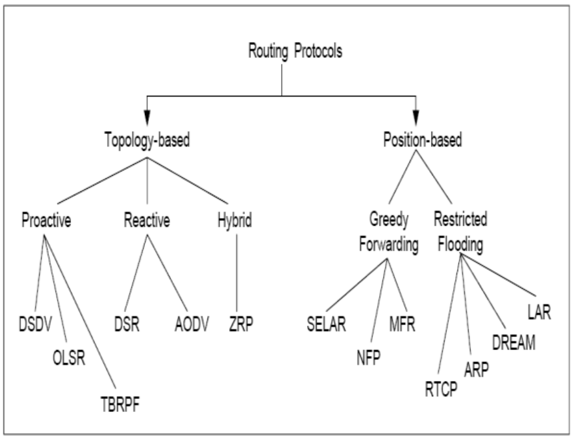


**Fig. 2. Classification of MANET routing protocol**

## 2. RFDR PROTOCOL

Restricted Flooding and Directional Routing (RFDR) is new proposed protocol that restricts the broadcast region will reduce routing packets, packet collisions and lowers the delay with more percentage of packet delivered.

### 2.1 Restricted Flooding (RF)

The main approach in restricted flooding is to restrict the flooding region. Restriction depends on distance, angle and distance covered by the next intermediate node.

All the proposed protocols shown in figure 2 require quite complex mathematical computation of the distance, angle and coverage at all intermediate nodes to determine the nodes' participation. Information of the source and destination are required and must be inserted in the incoming packet. In MANET, route discovery is initiated by total flooding of route request (RREQ) messages that consume a large portion of the already limited bandwidth in MANET.

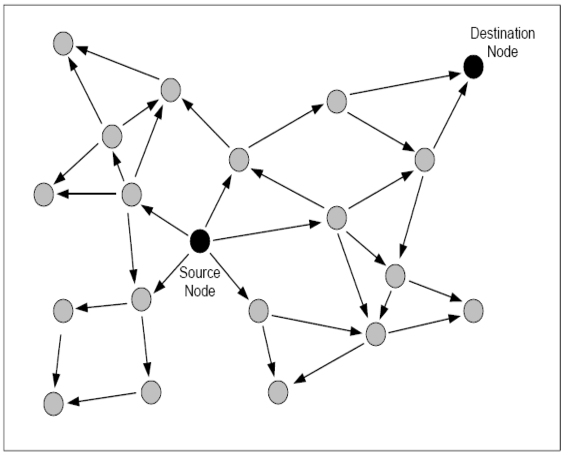


**Fig. 3. Route Request (RREQs) broadcast based on Total Flooding.**

As illustrated in Figure three, route request RREQ is broadcasted to all neighbours whereby frequent broadcast causes network congestion and degrades the performance of routing protocol. As we suggest utilizing restricted flooding mechanism to optimize the route establishment phase of AODVbis. Restricted flooding is broadcasting messages to a selected number of nodes which is more than one that are located in an area in the vicinity of the destination. Location information of the destination can be obtained from any location service while location of the destination can be obtained with the aid of any other self-positioning system proposed for MANET. Then if this information is piggybacked in the reply or query packet, nodes will calculate its location with reference to the source and destination and will then decide to broadcast the query or not. Figure 4 illustrates that the same network topology shown in Figure 3 but with restricted flooding. RREQ packets will be broadcast by nodes located in the request zone which is a quadrant drawn with respect to source node coordinates. Nodes participation is denoted by shaded circles with arrows indicating the direction of broadcast while lesser-toned circles indicate non-participating nodes. With this unique approach of using quadrant as the broadcast region, we proposed Quadrant-Based Directional Routing or RFDR.

### 2.2 Quadrant Based Directional Routing

QBDR is a restricted flooding routing that concentrates on a specified zone using location information provided by a location service. It restricts the broadcast region to all nodes in the same quadrant as the source and destination and does not require maintenance of a separate neighbours table at each node as in [3, 4, 5 & 6]. QBDR determines the quadrant of the current node based on the coordinates of source, destination and the current node that will direct the packet towards the destination. Even though [4] uses all these information to determine the distance or area covered, it requires trigonometric computations which will further incur delay if computed in kernel space. Decision to broadcast or discard will be done as the route request RREQ packet is received by the node.

In QBDR, the route request (RREQ) packet which contains the coordinates of the source and destination will be the only information the current node needs to decide to participate in the routing or not. The decision to participate at each node is made immediately as the node receives the RREQ packet and a neighbours table is not required to make the decision.

RFDR will significantly reduce not only energy but also reduce the probability of packet collisions of messages rebroadcast by neighbours using the same transmission channel. This will result in reduced routing overhead especially in a dense network.

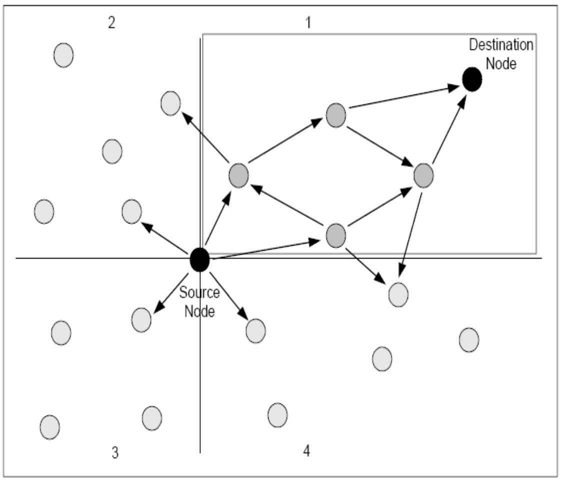


**Fig.4. Route Request (RREQ) broadcast based on Restricted Flooding.**

## 3. NS-2 IMPLEMENTATION OF RFDR

In RFDR operation, the location info of the source and destination nodes is piggybacked within the route request (RREQ) packet and then broadcasted. Upon receiving the RREQ, intermediate nodes can compare employing a straightforward mathematical comparison support the coordinates of source, destination and therefore the current node that directs the packet towards the destination and as illustrated following.

Quadrant of intermediate compared to source?

Quadrant of destination compared to source?

If same, FORWARD

If not, DROP.

Once the choice to broadcast has been created, the intermediate node can insert its location by substitution the source node coordinates and append its address and sequence number at the tip of the RREQ packet. It'll then broadcast the packet. The method will repeat at every intermediate node till it reaches the destination. The replacement of the source node location info with the intermediate node coordinates will create the additional packet directed towards the destination since the comparison now could be supported the previous node. Upon receiving the route request RREQ, destination node can send a route reply message (RREP) back to source via the path taken to reach the destination that was appended within the RREQ because it traverses across the network. There is no need for the route discovery to the source node.

### 3.1 Network Simulation

Network Simulator-2 (Ns-2) has been found to be a wide used tool for simulating internetwork topologies and to check and evaluate numerous networking protocols. It is a discrete event simulator written in C++ and uses Massachusetts Institute of Technology (MIT) Object Tool Command Language (OTcl) as a command and configuration interface. The foremost necessary characteristic of a discrete-event approach is that the elements of an actual network are represented in the software and real events are simulated by the operation of the software.

Ns-2 is often installed on both Windows and Linux platforms. For RFDR, the simulation work is completed on an Ubantu Linux platform. The compiler employed in RFDR is that the ns-allinone-2.34 version. The underlying protocol is AODVbis that has the path accumulation feature [7]. The Dynamic MANET On-demand – University of Murcia (DYMOUM) [8] is predicated on DYMO that is a web draft dated June 2005. DYMO allows reactive, multi-hop routing between participating node that want to communicate. The fundamental operation of DYMO is similar to AODVbis which are route discovery and route management and the differences are in the new packet format, generic packet handling, unsupported element handling and optional path accumulation. There are three types of elements that are outlined in DYMO. They are RE (Routing Element), RERR and UERR (Unsupported-element Error) and RE can be further divided into RREQ and Route Reply (RREP). From the description given, DYMO can be used as the underlying protocol in this work. DYMO is reactive and implements route discovery and path accumulation. Even though it uses a generic element structure but basically has the needed RREQ, RREP and RERR packets as in the AODVbis routing protocol. Any modification work ought to be wiped out the C++ hierarchy.

### 3.2 Route request packet format

To modify the RREQ packet, the source and destination coordinates are declared as a double precision integer.

For declaration of extra fields in RREQ packet following code is included after following code u_int8_t res2: 2;

in *typedef struct RE* of *"dymo_re.h" file .*

```
u_int8_t  dst_x;
u_int8_t  dst_y;
u_int8_t  src_x;
u_int8_t  src_y;
```

In the DYMOUM source file, when a new RREQ is generated by the source node, the **NS_CLASS** *re_create_rreq (...)* procedure will create the RREQ packet. The RREQ packet requires location information of the source node; therefore the following syntax will extract the source coordinates from the ns-2 environment which is searched by using the node address.

In file *"dymo_re.c"* in procedure RE ***NS_CLASS** *re_create_rreq(….)*,after code *RE *re;*, included following code for extracting location information of source node.

```
Node
*node=Node::get_node_by_address(re_node_addr.s_addr);
((MobileNode *)node)->getLoc(&x,&y,&z);
```

and after code re->target_seqnum= htonl(target_seqnum); following code has included.

```
re-> dst_x= dst_x;
re-> dst_y= dst_y;
re-> src_x= x;
re-> src_y= y;
```

Following header files included in "*dymo_re.h"* for linking of node and mobile node in dymoum.

```
#include <Node.h>
#include <MobileNode.h>
```

To extract the destination coordinates, a declaration of the following were made at the beginning of the source file that permits calling for those information using Tool command language hooks in the ns-2 platform. Description of the declaration for Tcl hooks will be described in the following section above the **NS_CLASS** *re_create_rreq ()* procedure .

```
extern int  dst_x, dst_y;
```

## 3.3 Link with Tool Command Language

Ns-2 consists of 2 hierarchies: compiled C++ hierarchy and therefore the OTcl that make use of objects in C++ through OTcl linkages that have a one-to-one correspondence to each other. The objects that have already been linked are "*no_path_acc_*", "*reissue_rreq*", "*s_bit*" and "hello_ival". So to link the coordinates of the destination node that will be declared in the tcl script within the OTcl environment, links for both objects have to be created and the declarations are as shown in below code for binding of tcl object to C++ hierarchy. This *ns-2.34/dymoum-0.3/ns/dymo_um.cc* file in that procedure is

```
NS_CLASS DYMOUM(nsaddr_t id) : Agent(PT_DYMOUM),qtimer_(this),initialized_(0),pq_len(0)
{
        bind_bool("no_path_acc_", &no_path_acc);
        bind_bool("reissue_rreq_", &reissue_rreq);
        bind_bool("s_bit_", &s_bit);
        bind("hello_ival_", &hello_ival);
        /*Following code is added for TCL links*/
        bind_bool("dstx", &dst_x);
        bind_bool("dsty", &dst_y);
        …
        ….
}
```

The variables for *dst_x* and *dst_y* in the header file *dymo_um.h* to enable referencing by *dymo_um.cc* have been declared.

To enable calling DYMOUM from the tcl script, the agent DYMOUM (Agent/DYMOUM), *dst_x* and *dst_y* in the *ns-default.tcl* file in ns-2 library are inserted.

## 3.4 Processing on Route Request RREQ

Processing of RREQ consists of two events. They are Generating RREQ when the current node has data to send and initiates the route discovery for a certain destination and Receiving RREQ that is implemented at the intermediate nodes that receives the query broadcast. In the same *dymo_re.c* file previously mentioned, in the function **NS_CLASS re_process(),**variables such as temporary fields to store coordinates of current node and value of quadrant are declared. Then, the syntax to search for the current node coordinates and store these information in *mynode_x* and *mynode_y* will be made as shown in following code syntax.

```
/* Declare variable type for x and y coordinate field in packet received */
double mynode_x,mynode_y;
int quaddest=0,quadsrc=0;
double x=0,y=0,z=0;
/*get info of current node using address from ns*/
Node *node=Node::get_node_by_address(ip_src.s_addr);/*current node address*/
printf("Process current node=%d\n",ip_src.s_addr)
((MobileNode *)node)->getLoc(&x, &y, &z);
/*put the coordinates into mynode_x and mynode_y */
mynode_x=x;mynode_y=y;
/*For Quaderant*/
if((re->dst_x>=re->src_x)&&(re->dst_y>=re->src_y))quaddest=1;
if((re->dst_x>=re->src_x)&&(re->dst_y<re->src_y))quaddest=4;
if((re->dst_x<re->src_x)&&(re->dst_y>=re->src_y))quaddest=2;
if((re->dst_x<re->src_x)&&(re->dst_y<re->src_y))quaddest=3;
printf("Quadrant of destination is compared to previous node is %3d\n",quaddest);
if((mynode_x>=re->src_x)&&(mynode_y>=re->src_y))quaddest=1;
if((mynode_x>=re->src_x)&&(mynode_y<re->src_y))quaddest=4;
if((mynode_x<re->src_x)&&(mynode_y>=re->src_y))quaddest=2;
if((mynode_x<re->src_x)&&(mynode_y<re->src_y))quaddest=3;
printf("My Quadrant compared to previous node is %3d\n",quadsrc);
if(quaddest !=quadsrc)
{
printf("I am not in the same quadrant as destination. So drop packect.\n");
return;
```

```
}
else
{
printf("I am in the same quadrant as destination. So FORWARD packect.\n");
}
```

# 4. PERFORMANCE OF RFDR

The study to gauge the performance of RFDR in a very massive and densely network were conducted and results show that RFDR with reduced collisions, and fewer contention of bandwidth, less routing overhead and consequently, power consumption is inherent and reflects that this new routing is implementable and economical.

## 4.1 Network model for simulation

Figure five shows a network model of forty nine nodes that forms a seven by seven grid model. For location of nodes, the network model has been drawn in Cartesian coordinate system. The S for source and D for destination is the notation for source and destination nodes respectively and destination node is at the top right edge of the seven by seven grid.

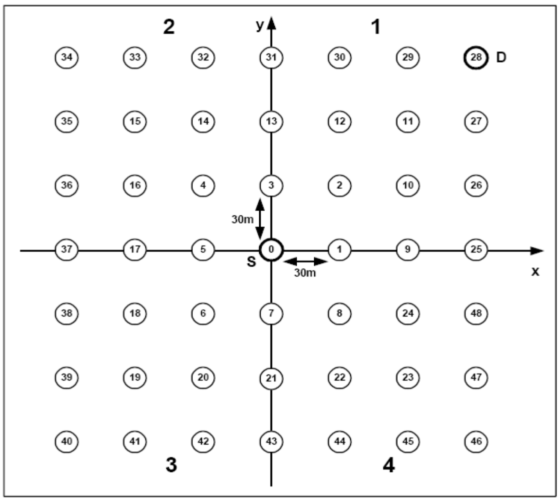


**Fig.5. Simulation Network Model of 49 nodes**

## 4.2 Performance parameters

Three protocols were simulated and they are BREATH [10], AODVbis that is a total flooding protocol and RFDR which is clustered based on restricted flooding. BREATH is clustered based protocol.

The performance metric used are as follows:

1). *Routing overhead* - The number of routing packets transmitted per data packet received at the destination.

2). *Effective energy consumption per data packet received* - The total energy consumption in the network for every data packet successfully received by the destination. This is the metric on the effectiveness of energy consumption when routing data packets.

## 4.3 Simulation Result

### *4.3.1.1 Effect of Varying Simulation Time*

The simulation time was varied from 100s to 800s in steps of 100s. The quantity of routing packets that are broadcast and the corresponding data packet received at the destination in the network are counted for all three BREATH, AODVbis and RFDR routing protocol. Table 1 shows the normalized routing overhead graphs for all three protocols. As the simulation time increases to 800s, all three protocols show reduced routing packets and leveled to a constant as it approaches 800s. The average normalized routing overhead in BREATH & AODVbis is 330 packets while in RFDR, the average routing overhead is 125 packets per data packet received. It is discovered that 155% more routing packets are transmitted in BREATH & AODVbis compared to RFDR due the higher number of node participations in the network in BREATH & AODVbis.

**Table 1.Effect of varying simulation time**

| Simulation Time(s) | Routing Overhead(No. Of Packets) | | |
|---|---|---|---|
| | BREATH Protocol | AODVbis Protocol | RFDR Protocol |
| 200 | 600 | 610 | 140 |
| 300 | 410 | 415 | 120 |
| 400 | 360 | 380 | 100 |
| 500 | 270 | 280 | 110 |
| 600 | 265 | 280 | 112 |
| 700 | 280 | 290 | 120 |
| 800 | 275 | 280 | 117 |

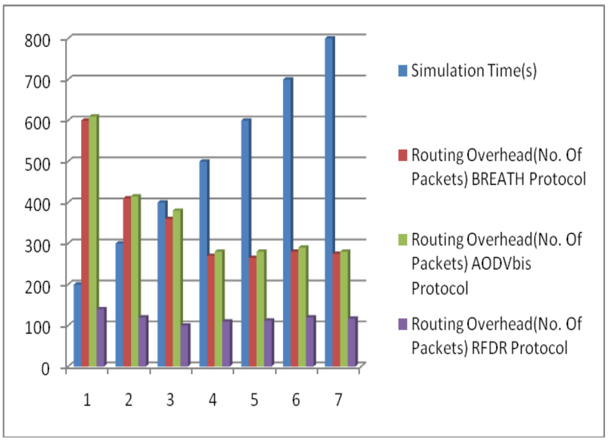


**Fig.6. Effect of varying simulation time**

### *4.3.1.2 Effect of Varying Packet Rate*

All three BREATH, AODVbis and RFDR are simulated in the forty nine nodes topology for a simulation time of four hundred seconds because the performance of both protocols remains constant. The transmission rate was varied in steps of thirty two kbits/s with initial rate of sixteen kbits/s to a maximum of one hundred forty four kbits/s. Table 2 shows the average normalized routing overhead for both protocols which increases as the transmission rate increases. The graph in figure 7 for BREATH & AODVbis shows large fluctuations as the transmission rate increases. BREATH & AODVbis sends out an average of 250 normalized routing packets compared to RFDR which sends out only 110 packets. The large fluctuations in BREATH & AODVbis are due to the total flooding algorithm and hence the routes taken vary for different transmission rate. However, the values in RFDR remain consistent throughout due to the directed flooding based on quadrant.

**Table 2.Effect of varying transmission rate**

| Transmission rate(bits/Sec) | Routing Overhead (No. Of packets) | | |
|---|---|---|---|
| | BREATH Protocol | AODVbis Protocol | RFDR Protocol |
| 16k | 280 | 300 | 120 |
| 48k | 142 | 150 | 90 |
| 80k | 222 | 220 | 110 |
| 112k | 196 | 200 | 112 |
| 144k | 410 | 400 | 100 |

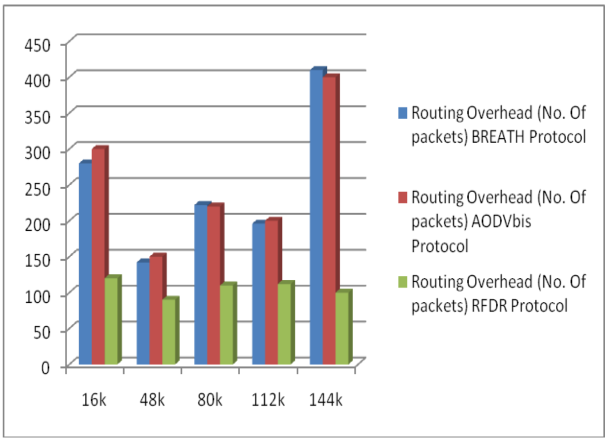


**Fig.7. Effect of varying transmission rate**

## 5. CONCLUSION

This paper has given the performance of RFDR that is a restricted flooding algorithm that uses location information of the source, destination and the intermediate node to work out the broadcasting decision. Nodes that are in the restricted broadcast region will broadcast while other nodes which are out of this region will ignore the route request packet.

The restricted flooding and directional routing reduces the quantity of participating nodes because the route request traverses within the network towards the destination node and thus reduced routing overhead and power consumption are achieved in new RFDR protocol.

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