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Energy Efficiency in Randomized Raodv Routing Protocol of Wireless Networks

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Abstract: In any routing protocol of wireless networks, energy efficiency assumes a paramount significance. In Mobile devices, bandwidth and energy are the primary resource constraints and energy consumption is minimized to achieve an effective transmission between source and destination. The key idea behind our design is to select multipath configuration which incorporates the random choice of paths having a very good routing efficiency and security. In this research, we focus mainly on analyzing the performance of R-RAODV in terms of energy consumption and secured transmission using NS-2 Simulator. Simulation study results show that randomized reverse ad hoc on demand distance vector consumes less energy during data transmission and packet loss is reduced significantly which in term accomplishes a very high basis of remaining energy when compare to the other two routing protocols like AODV and RAODV.

Key words: Multipath, security, transmission, Ad hoc On demand Distance Vector (AODV), Reverse Ad hoc On demand Distance Vector (RAODV)

INTRODUCTION

Energy saving is one of the main objective of wireless network such as MANET, Sensor networks. A mobile Ad-hoc Network have multi hop wireless network, infrastructure less with no centralized administration and also each node in the network acts as a router which is helpful to forward the data. Wireless devices consume more energy but limited energy is available in the devices so energy consumption is one of the important factors in wireless network. Energy consumption is high in a network means the life time of the network is reduced and it is based on the number of packet transmission. The node disjoint multipath routing is used to ensure the safety of information for each packet transforms into several paths to reach the destination. Our main aim is to maximize the network life time and also the security of the network. In this case, the packets are delivered to the destination through the path are selected randomly and the hackers cannot know what are the ways the data packets travels and also distribute the traffic load which means data transfer rate is faster.

Ad hoc On-demand Distance Vector (AODV) (Perkins and Royer, 1999) is one of the examples of on demand routing protocol and it has single route reply along reverse path and also reduce routing overhead in a network. In AODV, when the topology changes or the route is failed in a network, source node again to broadcast the RREQ packet to find the path between the source and destination. So AODV need more power consumption in dynamic topology of the network.

In reverse Ad hoc on-demand distance vector (Kim *et al*., 2006) is also an on demand routing protocol. Source node broadcast the RREQ packet to find the path between the source and destination. Destination node receives the first RREQ packet then it broadcasts the R-RREQ to the source node which collects all the R-RREQ packet information in the routing table. When the link is failed in a network or the topology of the network changes, source node chooses another feasible path in the routing table. RAODV has multiple route reply to the source node and it has less power consumption and also remained energy is high compared to AODV.

All the data packets travel through the same node, those nodes take more power consumption. R-RAODV (Santhi and Parvathavarthini, 2013) is the extension of RAODV protocol. The paths are selected randomly for the security purposes and data packets are traveling through different path to reach the destination node. In this

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protocol, time interval is not set to collect the R-RREQ packet any time in the source node and also energy consumption is not analyzed.

Related review: Brown and coauthors concludes that the on demand routing protocol consumes less energy compare to table driven protocols. De *et al*. (2003), find out the reliable route and also less number of retransmission for lost packet recovery to the routes consumes less energy. Vazifehdan *et al*. (2014) introduce two energy aware routing algorithm for wireless Ad hoc networks. One is reliable minimum energy routing which find the path with minimum energy required for end to end data transmission another one is reliable minimum energy cost routing which helpful to increase the operational life time of the network. Kuo *et al*. (2009) describe dynamic routing in DSDV routing protocol for security purposes. The path between multiple sources to their multiple destinations is stored on a routing table based on the table paths are selected randomly by the source node and then the data packets are sent through this path. Ibrahim *et al*. (2008) construct the minimum power route while guaranteeing the desired Qos using Minimum Power Cooperative algorithm. Lian *et al*. (2009) design the energy efficient algorithm to minimize the total energy consumption and to build a shared multicast spanning tree to all terminal nodes is helpful to minimize the energy consumption.

Zhang *et al*. (2014), reasonably selected path to reduce the network consumption. During the route discovery process, the node can dynamically assign transmission power to nodes along the path. Using discriminating algorithm, the node who has received RREQ message compares its power with the threshold power value and then selects a reasonable route. Zhang and Mouftah (2006) select the energy-efficient route and also minimize the protocol overhead acquired in such paths. Chen *et al*. (2002) proposes a distributed coordination power saving technique for multi hop ad hoc wireless networks to reduce the energy consumption of the network. Taleb and Behzad (2012) do the simulation study to compare the number of hops in selected path along route reply of AODV and RAODV and conclude that RAODV data packets meet fewer hops in chosen path and remind energy is higher than AODV. Feeney (2001) defines a energy consumption model of Ad hoc Network. It uses four states, transmit and receive state is used for transmitting and receiving data, in idle state, interface can transmit receive and sleep state has low power consumption. Gouda and Behera (2012) aim to maximize the lifetime of the network and to improve the performance of the network and also the routing is based on minimum remaining energy.

Das and Dalal (2013) compares the performance of AODV and RAODV and concludes that RAODV consumes less energy consumption compare to AODV. Srinivas and Modiano (2005) using novel polynomial time algorithm finds a pair of minimum energy link disjoint paths and an optimal algorithm that solves the minimum energy k node-disjoint paths problem in polynomial time and conclude that link disjoint paths consumes less energy than node disjoint paths and also incremental energy of additional link-disjoint paths is decreasing. Liu *et al*. (2012) describe the disjoint multipath routing scheme with secret sharing. Deliver sliced packet shares along randomly generated disjoint path by the routing scheme, so the security and energy efficiency can be increased. Madan *et al*. (2009) using a network of cooperating wireless relays to minimize the total energy consumption when the data packets send from source to destination node. Madan *et al*. (2009) focus on the communication energy consumption especially on the data transmission. Design a distributed scheduler that opportunistically schedules data transmission to minimize the energy consumption of a wireless device.

Reddeppa and Raghavam (2007) propose Multipath on demand routing protocol and it reduces the routing overhead and also computes fail safe multiple path. In this protocol, the primary path fails then the sender chooses another available path. Zhang *et al*. (2013) propose a new energy efficient of small world network model and it considers the battery energy of the wireless nodes, the multi hop transmission distance and the geographical distance between the wireless nodes. Ibrahim *et al*. (2008) use Minimum Power Cooperative Routing (MPCR) algorithm which helpful to construct the minimum power routes and then use another algorithm Co operation along the shortest non-Cooperative path (CASNCP) algorithm to find the shortest path route.

Randomized Reverse-AODV protocol (Santhi and Parvathavarthini, 2013) which is based on distributed routing information. It has multipath and to improve the security of data transmission. In this protocol, the data packets are travel through different path to reach the destination node, i.e., dynamic selection of routing path. Source node wants to send the data to the destination node. Source node broadcasts the RREQ packet to their next neighborhood nodes. Neighborhood nodes receives RREQ packet, if it is destination node which broadcast the R-RREQ (Reverse Route Request) packet to the nearest nodes otherwise it forward the RREQ packet to the next neighbor nodes and this process continues finally the destination node receives the first RREQ packet and it prepare and broadcast the R-RREQ packet to the neighbor nodes. Source node receives all the R-RREQ packet information from the neighborhood nodes and stores this information into the routing Table, so time delay is high to collect all the routing path information. Using Randomized algorithm, the paths are selected randomly from the routing table to forward the data packets.

Proposed work: In our present research, the main objective is to reduce the energy consumption, packet loss and security of the network. In AODV, source node finds the path to the destination node and then all the data packets travel through the same path to reach the destination node. It takes more power consumption to transmit the data for every data packets to travel on the same path and also the same problem is being observed in RAODV. In RAODV, source node receives multiple R-RREQ packet information into the routing Table, but it selects the first R-RREQ packet, when all data packets travel through this path only. If the link is failed then the source node chooses another path in the routing table and also every packet travel to the same path. The nodes on the path take more power consumption when the data packets travel through the identical path.

Our main aim is to increase the network life time and to increase the security of the network. In R-RAODV, source node has time limit to collect the R-RREQ information from the destination node and collects the node disjoint paths only and then selects the path randomly in the routing table for data transmission to the destination node. Since, each time the source node selects the different disjoint path to reach the destination node, it takes less power consumption for the data packets to travel through different path to reach the destination node, security is increased and also packet loss is less. No nodes are shared in the node disjoint paths except source and destination node, all the data packets travel through the independent path to reach the destination. No neighbor nodes are common for data packet transmission, so the energy of the node is not distributed and also the data packets are not traveling through the single path to reach the destination. The source node select the node disjoint path randomly in the routing table and also the hackers cannot know about what are the ways the data packet is being transmitted.

Node disjoint paths are helpful to distribute energy consumption, traffic load and to avoid the intrusion rate of malicious node. In this work, we focus on the energy efficiency of Randomized RAODV. It has less energy

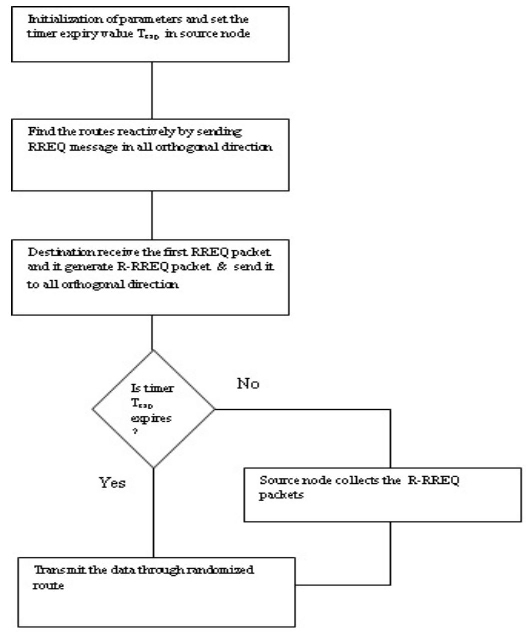

Fig. 1: Working model

consumption compared to AODV and RAODV and also remained energy is high after transmitting the data packets in Randomized RAODV. The energy spent for transmitting n bit packets is given by:

$$E(n) = nEle \quad (1)$$

Where: E_{le} is energy loss depends on encoding and digital modulation. Energy consumption of the nodes in a network can be obtained by the number of data packets traveling through the node and it leads to decrease the life time of the network. The working model is represented in the Fig. 1. In this Fig. 1, source node initializes the parameters and set the timer expiry value in $T_{exp.}$ It receives all R-RREQ packets from the destination node before the timer value expired. So source node collects only the feasible paths i.e., less number of hop count path.

We focus on transmitting the data packets along the routes distributed in the whole network to enhance the security of the network. All the data packets are travels through the single path means energy is wasted and also the hackers can easily find out the path for either drop the packet or misuse the packet. Our aim is to maximize the network life time and security of the network that is minimizing the probability of intruders. Energy consumption of node i denoted as E_i. Maximize the network lifetime can be expressed as:

$$\max life = Ei \quad (2)$$

In this research, source node select the disjoint path in randomized manner for data packet transmission to the destination node, So, the energy is distributed in the node disjoint paths. Probability of packet interception is less in node disjoint path because each path is independent in a network. In a given source destination pair(s,t), the possible node disjoint paths for packet deliveries between s and t is represented by:

$$PH\ s,t = \{ P1, P2, P3 \&. Pn\} \quad (3)$$

Source node select the path randomly in the set $PH_{s,t}$ (i.e,) rand ($PH_{s,t}$). The source node s selects the node disjoint path P_1 to transmit the data packet to the destination node t. In the next possible paths, the source node selects the following ways:

$$Pk = \{ P1, P2, P3 \&. Pn\} - P1 \quad (4)$$

Source node randomly selects any one of the path from the list P_k. k paths are node disjoint path and the source node s has k outgoing edge:

$$\sum(p) = T_r(s) + \sum_{x \in p, x = s} T_r(x) \quad (5)$$

Tr (s) is the transmission power of the source node. k node disjoint paths require k outgoing edges from the source. In this work, the source node s can select the path randomly in the multiple disjoint paths. Disjoint multiple paths can be maintained from source to destination. The transmission energy for network is minimum for k node disjoint paths between the source and destination. Total link distance the data packets travel from s to t is represented by:

$$TL = \sum_{i=1}^{n} l_i \quad (6)$$

Total energy of the chosen link path is represented by:

$$E = \sum_{i=1ton} e_i \quad (7)$$

Consider the delivery of a packet with the destination t. The process randomly picks up a neighboring node in the collecting list of paths to the destination node and then the previously selected path is avoided to send the next packet. It does not have a fixed route for data transmission (Fig. 2).

In AODV and RAODV all the data packets are travel through the single path means traffic load is high, fast energy consumption of the nodes and also violate the network security. This protocol helps to distribute the traffic load across the network and balanced energy consumption of the network. The traffic load is distributed in a network leads to decrease the transmission delay.

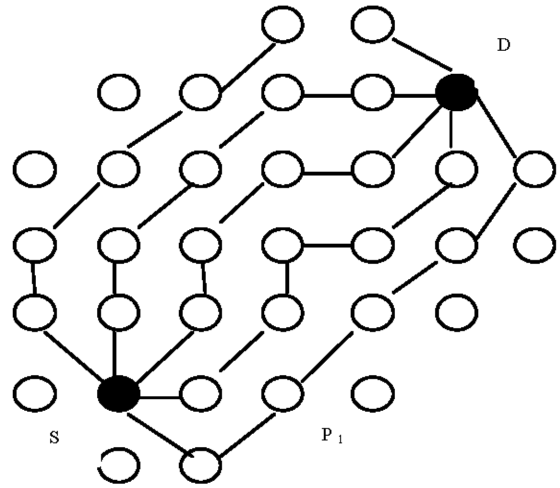

Fig. 2: Example of k node disjoint paths

The energy consumption of each node can be determined by the number of data packets transferred to and received from the neighbor nodes. Average energy consumption of nodes on active paths can be expressed by:

$$E = \frac{M}{p_n}(E_{trans} + E_{receive}) \quad (8)$$

Where, M is the total packets. E_{trans} and E_{receiv} are the amount of energy required to transmit and receive a packet. P_n is the number of paths of transmitting packets. The probability of nth path is represented by the following and p is the number of randomly selected path.

$$Prob_n = \sum_{i=1}^{p} E_j \quad (9)$$

This scheme is used to avoid unnecessary energy consumption of the nodes on the mobile disjoint paths and also avoid the missing of Route Reply packet from the destination node. Source node selects the node disjoint path randomly, so packet loss is less, security and network life time is increased and also avoids the drop of route reply packet. This one is used to distribute energy and traffic load in node disjoint paths, decrease the intrusion rate of malicious node.

MATERIALS AND METHODS

Simulations are useful to evaluate the performance of randomized RAODV based on the parameter like energy

Table 1: Simulation parameters

Parameters	Values
Simulator	ns-2.34
Protocols	AODV, RAODV,RRAODV
Number of nodes	40,60,80,100,120,140
Simulation area	1000m X 1000m
MAC layer	IEEE 802.11
Radio Transmission range	250m
Movement model	RWP (Random way point model)
Traffic type	CBR
Mobility	10ms
Propagation	Two ray ground
Agent	UDP agent
Data Payload	512tes/packet5

consumption and packet loss. In this part stipulate the simulation environment and then discuss the result of the simulation. Table 1.

RESULTS

Detailed performance analysis of AODV, RAODV and Randomized RAODV using the parameter like energy consumption and packet loss. Two different scenarios are helpful to evaluate the energy consumption and packet loss. First scenario is varying the number of nodes but speed is constant and the second one is varying speed but node is constant. Scenario 1, Network with varying number of nodes:

In scenario 1, AODV, RAODV and Randomized RAODV are analyzed using the parameter energy consumption using varying the number of nodes (40, 60, 80, 100, 120 and 140) and the speed of the nodes is constant ($20m^{-1}s$).

Energy consumption: Figure 3 shows the energy consumption of AODV, RAODV and Randomized RAODV. Randomized RAODV has better energy consumption compared to AODV and RAODV when the minimum number of nodes and maximum number of nodes. AODV consumes more energy utilization when the number of node varies because of all the data packets travel through the same path. After the analysis, Randomized RAODV has 68% over AODV and 54% over RAODV. The number of nodes is 80 and 100 Randomized RAODV has less energy consumed to transmit the data.

Packet loss: Packet loss = Number of packet send Number of packet received. Packet loss means the total number of packets sent by the source node minus the number of packets received by the destination node. Figure 4 shows packet loss of each protocol. Energy consumption is also based on the minimum number of packet loss, Packet loss is less means the energy consumption of the network is also less. It is observed that the packet loss on an average in randomized RAODV is 81.5% better than AODV and around 74% better than

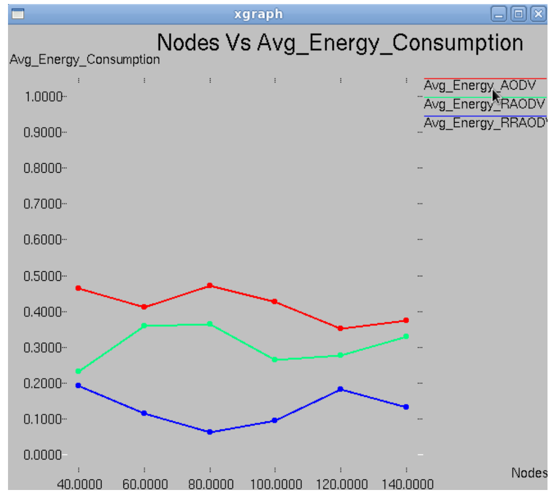

Fig. 3: Energy consumption VS number of nodes

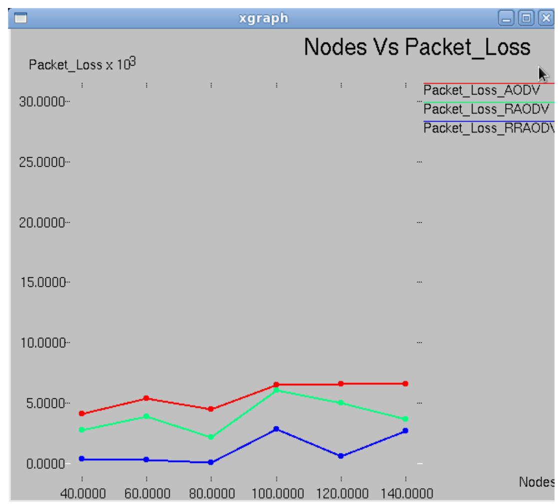

Fig. 4: Packet loss vs number of nodes

RAODV. Since, the paths are selected randomly in a routing table and all the packets are not travels through the same path.

Figure 5 shows the average remained energy of AODV, RAODV and Randomized Reverse AODV when number of node varies. Compare to the result, Randomized RAODV has more remaining energy after the data packets transfer compare to AODV and RAODV. Remaining energy is very low in AODV compare to RAODV. Randomized RAODV has more remaining energy when the number of node is 80. Figure 3 shows the average remained energy of AODV, RAODV and Randomized Reverse AODV when node speed varies and Figure 4 shows the energy difference when node speed varies. Scenario 2 Network with varying Speed of nodes: In

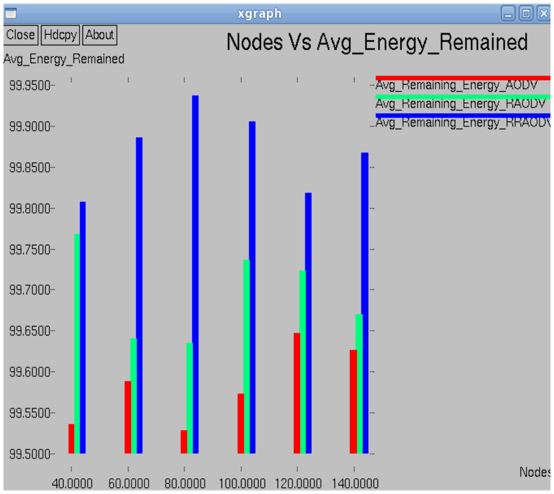

Fig. 5: Average energy remained, when number of nodes varies

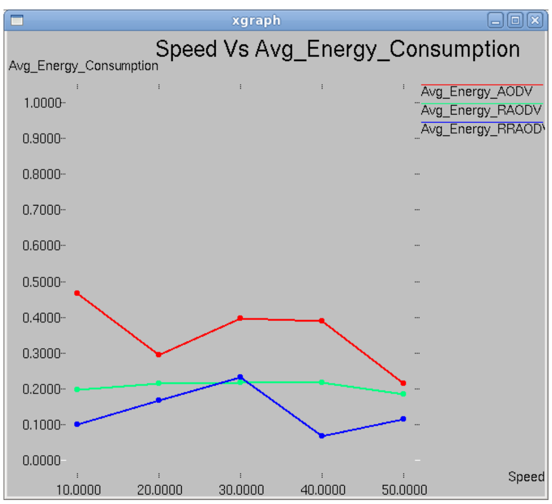

Fig. 6: Energy consumption vs speed

scenario 2, AODV, RAODV and Randomized RAODV are analyzed based on the parameter like energy consumption using varying the speed of nodes (10, 20, 30, 40 and 50 m^{-1}sec) with the number of nodes is constant (60).

Energy consumption: Figure 6 shows the energy consumption of AODV, RAODV and Randomized RAODV with respect to speed. When the speed of the node is increased, Randomized RAODV has better energy consumption compared to AODV and RAODV. AODV energy consumption is high compare to RAODV and Randomized RAODV and it consumes more energy when the speed is less but it consumes less energy when the speed is high. In Speed of 30 m/sec^{-1}, less energy variation between RAODV and Randomized RAODV,

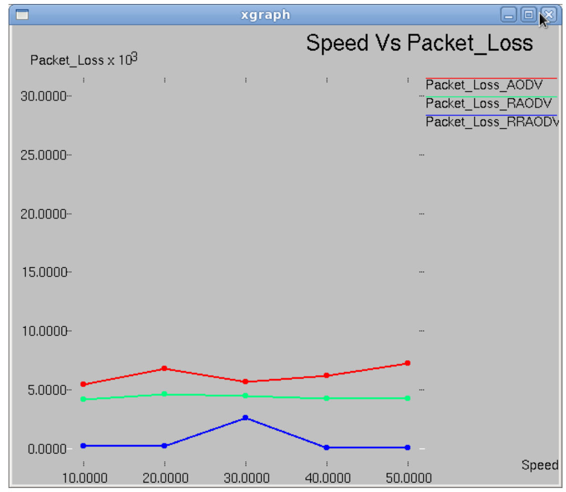

Fig. 7: Packet loss vs speed

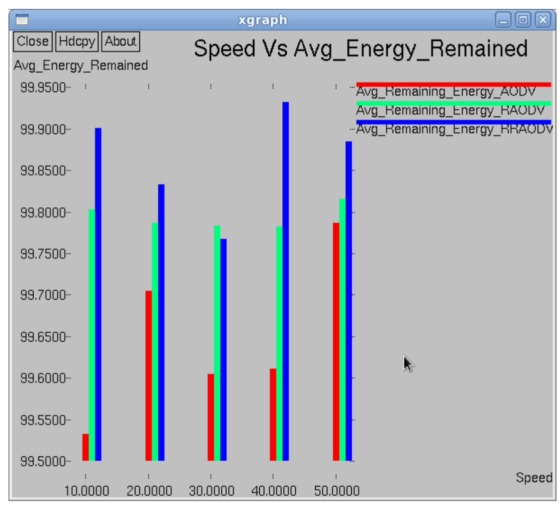

Fig. 8: Average energy remained when node speed varies

RAODV has 0.21% but Randomized RAODV has 0.23%. Other Speed of the network like 10, 20 40 and 50m/sec^{-1}, energy consumption of Randomized RAODV is higher than RAODV.

Packet loss: Figure 7 shows packet loss of each protocol. When the speed of the node is varied from 10m/s-50m/s, packet loss in RRAODV is reduced by 89% over AODV and by nearly 86% over RAODV.

Figure 8 shows the remained energy available after the transmission when the speed varies compare to AODV, RAODV and Randomized RAODV. In speed 40m/sec^{-1}, Randomized RAODV has more energy remained. AODV has very less energy is remained when the speed is 10m/s and RAODV has more remained energy compare to AODV and Randomized RAODV when the speed is 30m sec^{-1}. When the speed is 40 and 50m sec^{-1},

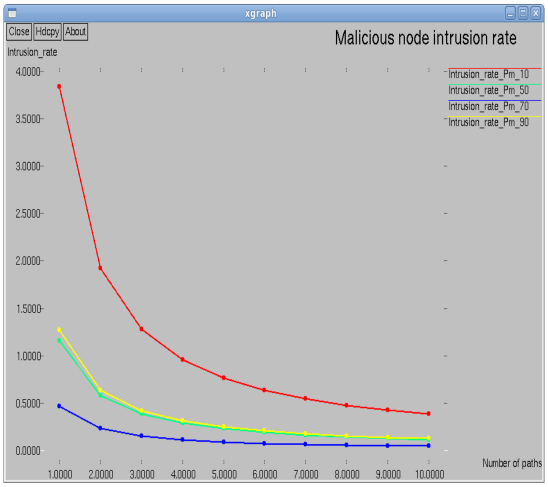

Fig. 9: Intrusion rate of malicious node

Randomized RAODV has high energy remained compare to AODV and RAODV. Less amount of energy is needed for data transmission between the source and destination, so the remaining energy will be high in Randomized RAODV.

Security: This protocol is helpful to reduce the intrusion rate of malicious nodes. Source node randomly select the node disjoint paths in a routing table to send the data packets to the destination node. Node disjoint path has more secured because no intermediate node is shared between the source and destination and also the paths are selected randomly, so hackers cannot know about what are the ways the data packets travels. Intrusion rate is reduced when the network has multiple node disjoint paths and it is represented in Fig. 9

DISCUSSION

Performance analysis of AODV, RAODV and Randomized RAODV is specified in Table 2. In scenario 1, the performance of AODV, RAODV and Randomized RAODV is analyzed based on the number of nodes. AODV consumes nearly 0.4 % , RAODV consumes around 0.3% but Randomized RAODV consumes 0.1%. After the analysis, Randomized RAODV consumes less energy compare to AODV and RAODV. In the packet loss, Randomized RAODV has 81.5% over AODV and 74% over RAODV. Packet loss is very much reduced in Randomized RAODV. In Scenario 2, the performance of AODV, RAODV and Randomized RAODV is analyzed based on the speed. Randomized RAODV consumes less energy for data transmission based on the speed of the network and it requires less energy for transmission of data packets. Packet loss is reduced in Randomized RAODV compare to AODV and RAODV.

Table 2: Performance analysis of AODV, RAODV and randomized RAODV with constant speed and varying number of nodes

Speed = 20 m/sec^{-1} (Constant)

Energy Consumption (Joules) VS No. of Nodes Number of nodes

No. of nodes	AODV	RAODV	R-RAODV	Average Efficiency of R- RAODV
40	0.464286	0.232215	0.192424	68.33%
60	0.412196	0.359024	0.114417	over
80	0.471775	0.364384	0.0630186	AODV
100	0.426482	0.263163	0.0944576	54.33%
120	0.3527	0.276516	0.181658	over
140	0.374029	0.329739	0.132637	RAODV
Packet Loss (Bytes/s) VS No. of Nodes 40				
40	4118	2760	357	81.5%
60	5382	3887	312	over
80	4451	2151	74	AODV
100	6503	6026	2859	
120	6576	5045	603	74% over
140	6550	3700	2701	RAODV

Table 3: Performance analysis of AODV, RAODV and randomized RAODV With constant node and varying speeds

No of node = 60 (Constant)

Energy consumption (Joules) vs speed (m/sec^{-1})

Speed	AODV	RAODV	R- RAODV	Average efficiency of R- RAODV
10	0.467429	0.197316	0.0991271	58.4%
20	0.29514	0.213816	0.167049	over
30	0.395632	0.216107	0.232433	AODV
40	0.389425	0.217178	0.067847	37.4%
50	0.213721	0.184116	0.114941	over
				RAODV
Packet Loss (Bytes/s) VS Speed (m/s^{-1})10				
10	5457	4153	193	89% over
20	6790	4670	202	AODV
30	5655	4484	2619	85.8%
40	6207	4249	75	over
50	7247	4282	75	RAODV

The performance analysis of AODV, RAODV and Randomized RODV with respect to speed is represented in the Table 3. Based on the Analysis, Randomized RAODV has 58% over AODV and 37% over RAODV.

CONCLUSION

Energy efficient routing is an efficient method for reducing energy cost of data transmission in wireless networks. In Randomized RAODV, the paths are selected randomly for data transmission between the sender and receiver. It achieves less control packet overhead, packet loss and also failure of the links is less, in these reasons energy consumption is low in Randomized RAODV. The result of the simulation work is based on the metric for energy consumption, packet loss and it has the better performance for minimum energy consumption, packet loss is less and also remaining energy is high in Randomized RAODV.

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RECOMMENDATIONS

Our future work will focus on this protocol is to improve the security of data transmission and also applied the fuzzy logic method to choose the feasible paths to monitor the performance of Randomized RAODV.

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