

Topology Control in MANET Using RFID Reader

Seyyed Mohammad Ali Tahami*

Arash Dana**

* Central Tehran Branch, Islamic Azad University, Iran , Tehran

** Iran Telecommunication Research Center

Abstract— This paper proposes a new scheme on topology control for mobile ad hoc networks(MANET) using RFID reader. Direction finding radio frequency identification (RFID) reader is developed employing dual and directional antenna for topology control .

A mobile ad-hoc network is a group of mobile wireless nodes working together to form a network.

The bandwidth limitations of the wireless connections and energy of the nodes as well as the continued changes of the network topology in MANET entails severe loss of the network efficiency.

The mobile nodes in MANET move randomly and independently from each other. Therefore, the network topology data in such a condition have a limited expiry time and must be continuously updated. With the increase of the mobile nodes velocity, the updating frequency of the network data is also increased. Any weakness or lack of the central controller in the network would increase the control overhead.

An external controller called “Direction Finding RFID Reader” to which the position of all the nodes has been specified is added to the network as the main node.

Most of the network processing are organized and controlled by the direction finding RFID Reader and sent to the nodes through orders. This causes improvement of the power consumption of each node, besides increasing of the network QoS.

The MANET is therefore controlled by a RFID reader. The topology control, the routing control, and the transmission power control are among the tasks performed by this controller, thereby the QoS is increased.

In the end we have shown the work results through simulation. We achieved considerable results.

Keywords— Direction finding , directional antenna , radio frequency identification(RFID) , RFID Networks

I. INTRODUCTION

A mobile ad-hoc network is a group of mobile wireless nodes working together to form a network.

This network lacks any fixed infrastructure, and is established in a network covering if needed.

A controller is designed for MANET with RFID capability, called “Direction finding RFID Reader”. This controller identifies the nodes position, predicts their movement direction and processes the routing for communication. Finally the controller transmits the orders to the network nodes to establish a communication. The nodes are therefore practically excluded from such processes. The positioning of

the nodes is done through the RSS(Received Signal Strength) technology as well as using the directional antenna.

Among different techniques that provide mobile positioning , using the RSS is regarded as a low cost solution which is applicable in wireless networks.

The origin node distance from the node is defined by the RSS and the node angle in relation to the origin is determined by the directional antenna.

The nodes process the signal received from the RFID transponder, and send their position data back to the RFID transponder. This positioning is performed on especially defined times. In other words, the nodes position is determined by a sample coefficient of the time vector for the RFID reader.

The most popular methods used to estimate the mobile position are received signal strength (RSS), time difference of arrival (TDOA), time of arrival (TOA), direction of arrival(DOA) and angle of arrival (AOA) in light of sight(LOS) and nonline of sight(NLOS) .[1]

The network nodes act as tags in RFID system, so that besides identification of the nodes, the nodes locations are also known by the RFID direction finding reader. RFID reader as the origin or the main node of the network connects with remaining nodes of the network through the closest node, as indicated in fig 1.

Each node antenna receives the signals transmitted from the central controller directional antenna. each node specifies its position in relation with the central controller origin, considering the received signal information from the direction antenna. in addition speed and direction of the node is also specified.

The nodes positional information are then sent directly or indirectly (via the intermediary nodes) to the controller in low volume data packets. As a result, the controller receives all the positional information of all the nodes.

Fig. 1 shows the communication between the nodes and the RFID reader for sending and receiving information.

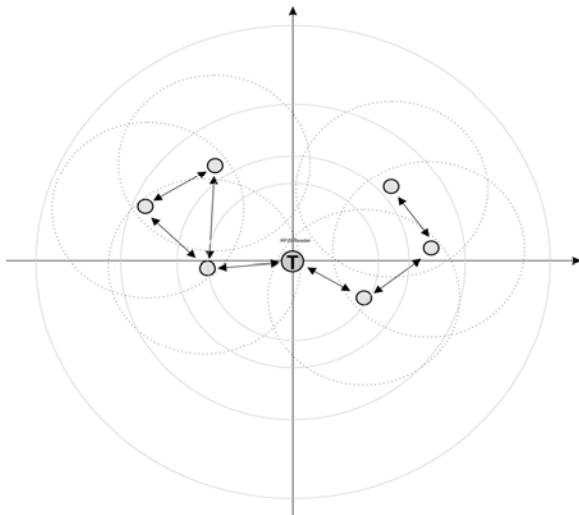


Fig.1. Topology of RFID reader (main node) & regular nodes

In this paper the operations performed for increasing the network QoS by designing the RFID Reader controller are described as follows: positioning and identification of the nodes, predicting the nodes mobilities for precise routing and decreasing the transmission range for optimization of the nodes power, as well as processing of the intelligent algorithm.

II. DIRECTION FINDING RFID READER

A. RFID Reader Central Controller

The controller is considered as the main node and the origin of the MANET, having continuous power supply or high potential energy.

This controller is used for controlling the topology of the network, and is completely different from the wireless access points in fixed infrastructure networks. In other words, the communication is established for the purpose of transmitting the data among the mobile nodes. The controller is tasked with establishing the best communication possible, controlling the nodes' power, controlling the data packets, error recognition management, and accomplishment of other defined algorithms.

Since frequently sampling the behavior and position of the nodes escalates the consumed power of the nodes. the mobility prediction algorithms can be defined on the RFID controller for optimizing the power of the nodes, and sampling the nodes' behavior can be performed using a time sampling coefficient. As a result, the nodes power is further optimized of to a considerable degree.

As the MANET network has a limited energy, continuous sampling of the nodes location is not possible. Hence, we require prediction of the nodes mobility which is done by through the main node or the RFID reader. The velocity and the direction of the nodes are determined in the positioning

moment, thereby, location of each node is predicted in a specific time in the future (fig. 2b).

If the location of all the nodes, the topology and the type of their mobility are specified, the transmission power of the nodes can be optimized by defining an algorithm for the controller. The transmission power of each node is transmitted to any specific node through an order issued by the main node (RFID reader). The fig. 2.c shows the optimization of the node's transmission range by the RFID reader.

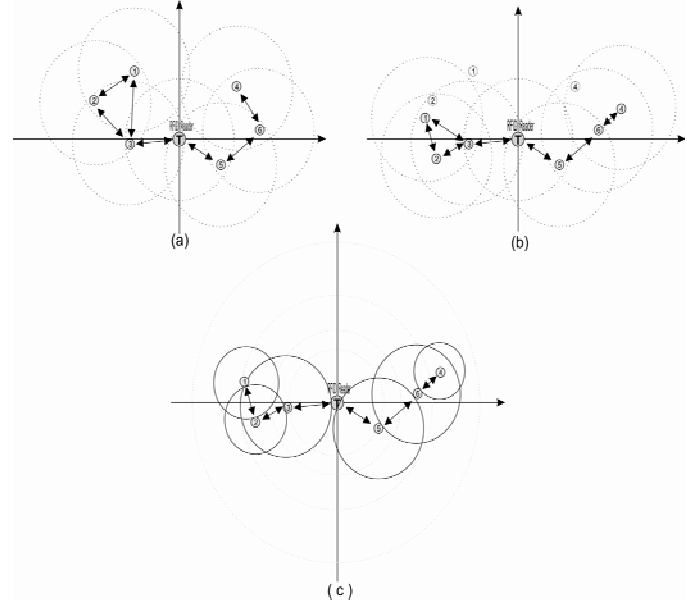


Fig.2 Control topology & transmission power with RFID reader
(a).Initial topology (b).predicted topology with maximum transmission power (c).topology after transmission power adjustment shows the optimization of the node's transmission range by the RFID reader.

In MANET, each node must undertake its share from the network tasks. These processes decrease the stored power of the nodes. However, taking into account the existence of the RFID controller and considering each node as an offline, and having the nodes' behavior information, each node's task can be assigned to the controller. From the said tasks, the routing, packet forwarding, identifying the neighbourhood nodes and cooperating with the neighbourhood nodes can be mentioned.

This RFID reader has been equipped with a designed direction antenna, used for sending special signals to the nodes and ultimately positioning and identifying them. The nodes receive the signal from the transmitter of the RFID controller. Depending on the designed antenna, AOA and RSS, the position of the node is specified in relation with the origin of the RFID signal transmitter. This position is determined by the node itself, and the node sends its positional information to the RFID.

The position angle of the node in relation with the RFID reader is determined by setting the direction antenna on the RFID reader. The purpose of designing this antenna consisting four antenna directions with different signal codes is determining

the direction of the node in relation with the RFID reader direction antenna.

It must be noticed that the signal is sent as a narrow band to all the nodes. This signal determines the position of the nodes and there is no need for transmitting large amount of data in high speeds. So no considerable consuming energy is devoted for transmitting this signal in the RFID reader. However higher reserved energy in the main node is considered than other nodes because of the networks' processes.

These position data specified by the nodes is transmitted to the RFID reader via the established communication (initial routing). So the position of the nodes is known by the RFID reader after signal transmission by the RFID reader.

This RFID reader is equipped with a separate micro controller for routing control programming, transmission power control and topology control. This RFID processes the main routing for data transmission, the transmission power needed by each node for communication and also the topology of the nodes. The instructions are sent to all the nodes through the established communication.

So the best routing is determined in RFID reader according to our requirements. The communication between each node and other nodes is specified for the RFID reader and then the instruction of the processes carried out by the RFID reader controller is sent to the nodes according to the initial communication. Consequently, the ideal communication is formed together with the optimized transmission range of each node.

The central node is capable of programming. For routing therefore, different types of routing protocols can be defined on the central node according to our requirement. In this type of design, the node itself does not completely operate as a router, but the routing is offline done by the RFID controller.

B. RFID Reader Directional Antenna

The node distance is gained from the origin using the RSS technology[4][5][6]. Also for determining the direction or the position angle of the nodes in relation with the origin, the AOA, DOA, LOS, NLOS methods in [9][8][7] is used.

In this paper, an antenna with special application is designed for determining the direction of the nodes position in relation with the controller's origin. The accurate angle of the node in relation to the origin can be determined using this antenna.

This antenna is composed of four direction antennas having a specific code, each positioned with 90° angle in relation with each other. The signal transmitted by each of these antennas features a specific code that is defined for all the nodes. The signal strength is identical for the signals transmitted from all the four direction antennas.

When a node receives a signal from a direction antenna, recognizes its direction in relation with the RFID reader through separate the received power from each of the antennas. Of course through considering the total power of the received signal from the direction antenna by processing the RSS protocols, It also recognizes its distance from the RFID controller. Finally the node sends the position data

(including the angle and the distance of the node from the origin) to the RFID controller. So the position of the node in the RFID reader controller coordinate plane is determined. Accordingly, the position of all the nodes is specified in the central controller coordinates.

Fig. 3 shows the simulation of this antenna. The antennas have been positioned in 0°, 90°, 180° and 270° degrees and transmit signals with a certain code. Any node positioned in between these angles and through receiving a signal from the antennas and separated the signal value received from each antenna recognizes its position in this space.

Upon receiving the signal in a short and defined time slice, the speed and direction of the node mobility is also specified.

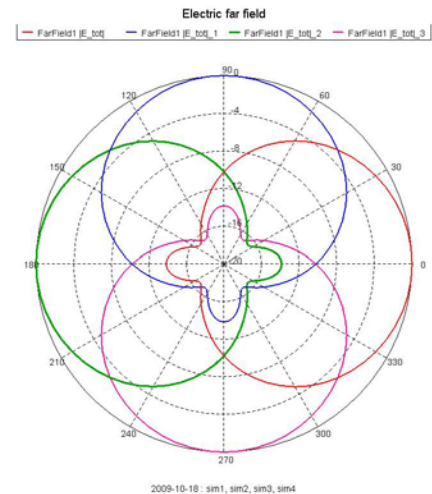


Fig.3 The controller directional antenna simulation results in four antennas with 0°, 90°, 180° and 270° angles.

The RFID controller transmitted signal by the direction antenna is of high range, narrow band type. This signal is used for positioning of the nodes and is not designed for transmitting high volume data.

A dual antenna can be set on the nodes for determining the direction of the node in relation with itself. It is also used for more precision of the mobility prediction. [2][3]

Collision exists in nature of the wireless environments, so that the packet loss possibility due to transmitting errors is higher than the wired environments. In [10] the suppressing methods of the collision we have utilized in this design are discussed about, and also using the anti-collision protocols in this design results in higher quality of the network.

III. QUALITY OF SERVICE & ROUTING

A. Quality of service (QoS)

Since the packet loss rate causes the loss QoS of the network, using the topology controller in MANET prevents from loss of the data packets.

While the network topology is RFID reader controlled by the control management, initially the link is formed and subsequently the data is sent. So if no link is formed, no packet

is transmitted and no packet is lost. Accordingly the packet loss rate is decreased.

When using the intermediate nodes for creating communication and data transmission between two nodes, if the mobility or velocity of the intermediate nodes is increased to a high degree, each node with high mobility is not used for creating links. No link is formed in case of lack of less mobility nodes, hence, no data packet is transmitted at all.

Meanwhile a node is about to interrupt its connection with the network, the RFID controller does not issue any order for creating a link to that specific node for transmitting data packets to it. In that case, no node sends information towards a node being upon the threshold of interrupting from the network.

Also if the intermediate nodes are used for communicating between two nodes, there is the risk of loss of data packets in case the nodes' buffer capacity is filled up. When a nodes' capacity is filling up, the same node sends the filling up warning, so that a new routing is selected for transmitting data packets. The packet loss is decreased in this case.

In a MANET network, the error recognition is complicated due to distributing the network management among different nodes. However, utilizing this controller in the topology of the mobile network centralize the the network management to a more degree, resulting in lesser errors and lesser error recognition in the MANET, and ultimately higher QoS.

The simulation results provides for comparing this network with uncontrolled networks.

B. Routing

As the behavior of each node may be considered as being offline, any routing protocol can be defined on the RFID controller considering the requirements and usage in the network.

There is no pre defined routers in the MANET for transmitting the data. In fact, any node acts as an independent router, so that the node after receiving the data packet find its neighbor and sends the packet to the next node to reach finally to the end destination. This entails severe loss QoS.

In designing the RFID controller for the MANET, each node is taken into account as offline for the controller. Then routing procedure and intermediate nodes usage instruction is given to the nodes and they communicate with each other as per the controller instruction.

Taking routing into account, the routing protocols like AODV, DSR, SEAD, ARAN, SAODV, ARIADNE may be implemented on the network based on the type of network application. If the security is meant in the network, the ARIADNE or ARAN secure protocols can be defined on the network. Or for security reasons in the multi-routing protocols, by defining the ELMAR, SMR, MDS or AOMDV protocols, the controller executes the routing.

In the first case, an initial topology is created. In this initial topology all the nodes are related to each other and to the RFID controller. In this case all the nodes constitute a network and are related to the RFID controller.

After initial topology of the nodes (offline in RFID reader) in which each node communicates with the nearest nodes, each node requests a route from the RFID controller for sending data to communicate with the destination node. The RFID controller specifies the route considering the nodes' velocity of the intermediate nodes, number of the node jumps, the distance from the destination or using other protocols, and sends the data to the destination after formation of the origin node link.

As the movement location of the nodes is known by the RFID controller, the nodes protocols may be defined offline but on the RFID reader. The RFID reader controller is tasked with sending the results of the protocols and algorithms to a certain node. processes such as routing, controlling the nodes power, controlling the loss rate of the data packets, controlling the errors, implementing the learning automation, and investigating the nearby nodes are among the processes applicable on the RFID controller.

This designed MANET is implementable without the need for the controller, and upon separating a group of the nodes can form smaller connected components.

IV. SIMULATION

A number of the nodes are considered in a defined space for simulation. The network nodes are arranged in the desired space and a random movement is then defined for the nodes. Each node randomly selects a node in the space and starts moving towards it.

For selecting a point in this space, the function "rand" is used which is a random digit with even distribution.

At first a movement stepsize is specified for the node and a Euclidean distance between the previous and next position of each node is calculated.

$$d = ((x_2 - x_1)^2 + (y_2 - y_1)^2)^{1/2}$$

The starting and end points of the movement are (x_1, y_1) and (x_2, y_2) .

To calculate the number of intermediate points between two main points of each node, the Euclidean distance is divided against the stepsize.

$$n = [d / \text{step}]$$

For gaining the intermediate coordinates of each node in n th intermediate position (x_n, y_n) , m is the slope of the line.

$$\begin{aligned} \theta &= |\tan^{-1}| \\ x_n &= x_1 + [n] * \text{step} * \cos \theta ; \text{ if } x_1 < x_2 \\ x_n &= x_1 - [n] * \text{step} * \cos \theta ; \text{ if } x_1 > x_2 \\ y_n &= y_1 + [n] * \text{step} * \sin \theta ; \text{ if } y_1 < y_2 \\ y_n &= y_1 - [n] * \text{step} * \sin \theta ; \text{ if } y_1 > y_2 \end{aligned}$$

Each node randomly selects a time between the 0 and 5 seconds and it reaches to the next point after elapsing the selected time.

$$\text{movetime} = \text{ceil}(5 * \text{rand})$$

Movetime: shows the moving time from a point to the next.
Ceil: is used for rounding off the number to the higher digit.
The speed of the node between two points is gained.

$$\text{speed} = \text{step} / \text{movetime}$$

Speed: is the velocity of the node which is in direct relationship with the Step. So the mobility of the nodes is dependent to the network step.

In the end the random waypoint is designed.

Then initial communication is established between the network nodes. This is for communicating between controller and the network.

Some of the nodes as transmitter send data transmission request to the RFID controller. So some of the nodes are specified as the sender and some others as the receivers.

As the RFID controller is responsible for establishing a valid link according to the predefined protocols, it processes the link between the sender and receiver and issues the creation order of the link to the intermediate nodes.

Therefore, in link creation on priority basis: selection of any intermediate node with lesser mobility is considered as data transmitter to the destination with higher priority than the other nodes. Any route having shorter distance is selected with higher priority than other routes. Any route with fewer passing from the intermediate node selected with higher priority than other routes.

The power control also has been investigated in simulation.

The transmission power value among the nodes is determined based on the distance between the nodes. In other words, if the distance between the nodes is decreased upon communication between the nodes, the Max transmission power is decreased relative to the distance and close to the interrupt threshold. The power control is performed by the controller and the order for decreasing the transmission range is sent to each node.

Also as most of the nodes' processes are done by the RFID reader central controller, the the processes of a node including the packet forwarding, routing and cooperation with other nodes causes loss of the stored power of that node. Here again the power consumption of the nodes is decreased. The results of the power control simulation in two states with and without central controller in the network is shown in fig. 4.

The QoS has been depicted with packet loss in simulation.

Also the packet loss in two parts of network with central controller and network without central controller has been investigated and the results have been shown in fig.5 and table.1.

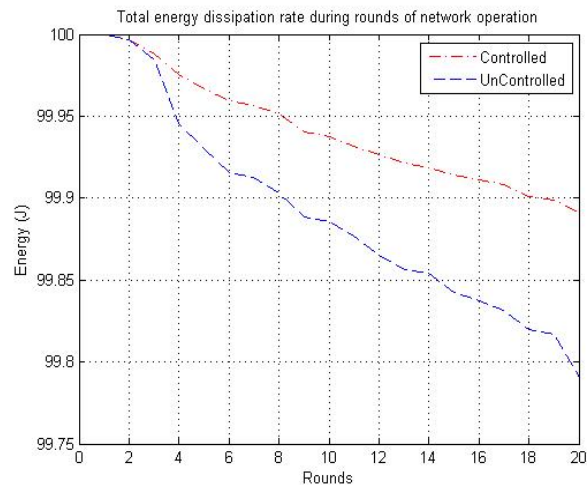


Fig.4 The simulation results & the comparison diagram of the MANET total loss of the stored power

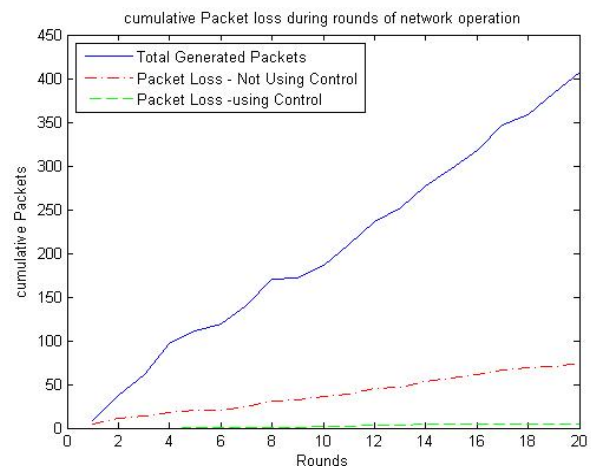


Fig.5 The simulation results & The comparison diagram of the packet loss in two states with and without topology contro

Node=100
Stepsize=30
Rounds=20
Energy=1
Total energy=100

Rounds	Total Generate Packet	Packet Loss Uncontrolled	Packet Loss Controlled
1	8	4	0
2	30	7	0
3	23	3	0
4	36	4	0
5	14	2	1
6	8	1	0
7	21	4	0
8	31	6	0
9	1	1	0
10	14	4	1
11	24	3	0
12	26	6	1
13	16	2	0
14	25	6	1
15	20	4	0
16	21	4	0
17	29	5	0
18	11	3	0
19	25	1	0
20	24	5	0

Table.1 The comparison table of the packet loss in two states with and without topology control

V. CONCLUSIONS

By designing this controller, the topology of the MANET is improved.

Protocols like routing, learning automaton, cellular automation, power and transmission range controller of the nodes, mobility prediction, topology control protocols, etc. can be defined on the RFID reader central controller.

The QOS is improved: packet loss is decreased, the routing is controlled and the error recognition is done more conveniently.

The power consumption is improved: Considering a more centered management, the node power loss is prohibited, fewer node processes are executed, and transmission power in each node is decreased relative to the distance between the nodes.

Security is strengthened for to controlling the routing and the network topology and defining safe algorithms on the RFID controller.

It is predicted that this design defines a starting point for an outstanding development in the field of MANET.

REFERENCES

- [1] Kegen Yu, Member, IEEE, and Y. Jay Guo, *Senior Member, IEEE* "Statistical NLOS Identification Based on AOA, TOA, and Signal Strength"
- [2] Myungsik Kim, *Associate Member, IEEE*, and Nak Young Chong, *Member, IEEE* "Direction Sensing RFID Reader for Mobile Robot Navigation"
- [3] MyungSik Kim, Hyung Wook Kim, and Nak Young Chong "Automated Robot Docking Using Direction Sensing RFID" *2007 IEEE International Conference on Robotics and Automation Roma, Italy, 10-14 April 2007*
- [4] Sree Divya Chitte, Soura Dasgupta, *Fellow, IEEE*, and Zhi Ding, *Fellow, IEEE* "Distance Estimation From Received Signal Strength Under Log-Normal Shadowing: Bias and Variance"
- [5] Ahmad Shafiei Soork, Reza Saadat and Ali Akbar Tadaion, *Member, IEEE Department of Electrical Engineering, Yazd University* "Cooperative Mobile Positioning Based on Received Signal Strength" *2008 International Symposium on Telecommunications*
- [6] Wilson M. Yeung, Joseph K. Ng *Department of Computer Science Hong Kong Baptist University Kowloon Tong, Hong Kong* "Wireless LAN Positioning based on Received Signal Strength from Mobile device and Access Points" *13th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA 2007) 0-7695-2975-5/07 \$25.00 © 2007*
- [7] Kun Liu¹, Amr Youssef², and Walaa Hamouda¹ *1Department of Electrical and Computer Engineering 2Concordia Institute for Information Systems Engineering Concordia University Montreal, Quebec, H3G 1M8, Canada* "A Directional Routing Protocol for Ad Hoc Networks with Angle-of-Arrival Estimation" *2007 IEEE International Symposium on Signal Processing and Information Technology*
- [8] Bor-Sen Chen, *Fellow, IEEE*, Chang-Yi Yang, Feng-Ko Liao, and Jung-Feng Liao "Mobile Location Estimator in a Rough Wireless Environment Using Extended Kalman-Based IMM and Data Fusion" *IEEE*
- [9] Victoria Ying Zhang, Albert Kai-sun Wong. *Department of Electronic and Computer Engineering* "Combined AOA and TOA NLOS Localization With Nonlinear Programming in Severe Multipath Environments" *IEEE*
- [10] J Jieun Yu and Wonjun Lee, Network Research Lab., Dept. of Computer Science and Engineering, Korea University, Seoul, Republic of Korea "GENTLE: Reducing Reader Collision in Mobile RFID Networks" *The 4th International Conference on Mobile Ad-hoc and Sensor Networks*