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Research on the Highly Reliable Multi-Source Multicast Algorithm based on Wireless Ad-hoc Network

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Abstract: The transmitting environment in the wireless ad-hoc network is usually face with the excessive competition of the channel resource so that the multicast data transmission is squeezed out. The node's continuous movement causes the frequent alteration of the network topology so that maintaining the multicast tree structure is very difficult. Therefore, the study proposes four mechanisms (Expanding Ring Search, Action Prediction, Virtual Net and Bidirectional multicast Data Transmission Tree) to reduce redundant control packeting, build a stable multicast topology and improve the reliability of the multi-source multicast. Finally, the method is proven through the simulated methods.

Key words: Wireless network, multicast data, multicast topology, multicast tree

INTRODUCTION

The multi-source multicast application in the wireless ad-hoc network has two kinds of types: the first application is led by each source node and then builds its own clusters. Therefore, there are many clusters in the network and the members of the clusters many be overlapped. The operation in each cluster is individual and the node can choose to add or leave the cluster. Randomly selecting the video system belongs to the type. Users can choose to watch their favorite programs and server just provides the multicast service to the video. The other type is that the network just has a cluster and each node will play the role as the data's provider and receiver. The two roles can maintain the cluster's operation together. Adding or leaving the cluster is just happen in the existing cluster. Distance education and video conference belong to the application. The participants can not only receive the information of others, but also send the information. The study will do the design aiming at the latter application.

There have been many researches on the multicast routing protocol in the wireless ad-hoc network in recent years, but most of researches was just aiming at the signal-source multicast network, seldom discussed the multi-source multicast network. There were abundant multi-source multicast researches under the wired network situation. The existing multi-source multicast research (Sato, 2009; Selvam and Patanisamy, 2010; Su *et al*., 2005) in the wireless ad-hoc network based on ODMRP (On-Demand Multicast Routing Protocol) (Lee *et al*., 2000) does not consider the wireless network's problems encountered in the algorithm design and simulation, such as wireless radio wave interference, radio wave attenuation and channel source access privilege. At present, the multi-source multicast in the wireless ad-hoc network adopts the ideal wireless network environment as the design reference. The network multicast routing used in the real wireless environment may be confronted with redundant control peculating and the opportunity of transmitting the data packeting is blocked. What's worse, the interference and collision caused in the packeting transmitting can be suffered. All of these are the problems confronted by the network multicast routing in the wireless environment.

Therefore, the tree-based multicast routing is suitable in the real wireless network environment in the process of researching the multi-source multicast issue. Compared with the network routing, the tree-based routing just uses small control packeting and is more likely fit with the wireless environment with limit node capacity. Different from the past multi-source multicast research, MAODV(Multicast Ad-hoc On-demand Distance Vector) (Royer and Perkins, 1999) is adopted to improve. In order to make MAODV have better operation in the real wireless network environment, the importance of the research is to effectively reduce the control packeting and build more stable tree-based topology so that the multi-source multicast data transmission in the wireless ad-hoc network is more reliable.

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RELIABLE MULTI-SOURCE MULTICAST ALGORITHM RMMP

There is a common part when adding the cluster, repairing the link and merging the multicast tree in the MAODV's cluster managing operation that is, sending the request to the whole network with the broadcast method and making the RREQ's packeting distribute to the network, then the node which is accorded with the qualification to RREP. Finally, the routing path is back to the requester. The node without being accorded with the qualification continues to being broadcast. The model can cause the increasing of the number of the control packeting, especially RREQ. What's worse, the normal transmission of other packeting will be obstructed. The proposed algorithm modifies Expanding Ring Search mechanism for avoiding the continuous broadcast behavior in the network. The TTL segment should be added into the RREQ so that the range of the broadcast can be narrowed. If the capacity of the surrounding topology in the network node can effectively save the repeating broadcast times.

When a node wants to join the cluster, the request should be sent to the network. The node have not directly spread the RREQ packeting to the whole network in the algorithm. The ERS mechanism (Efficient Expanding Ring Search) will be adopted so that the RREP is kept being waited and gathered. When the node possesses many RREP, the node will chooses the shortest path from the existing cluster members as the multicast routing. While the method is not suitable in the wireless ad-hoc network framework whose nodes are moved frequently. Therefore, the survival time of the routing path should be considered so that the longest sustaining routing can be selected. The proposed algorithm is designed in terms of the concept. In addition, the survival time of the routing path will be estimated through the relative velocity among nodes. Therefore, the concept of the movement prediction is added. The information of GPS added in the Beacon (Hello) information of the node periodic exchanging is adopted to predict the node velocity and direction.

The root node of the tree is very important in terms of the tree-based structure, so is MAODV. The root node is not only responsible for transmitting the data but also maintaining the whole cluster state. If the root node is failure or off-line, the behavior of the whole cluster will be influenced. While MAODV has not the special recovery mechanism to the root rode so that the root node is regarded as the ordinary member node and then the root node is failure. Therefore, if another tree-based structure is rebuilder, much time and the exchange of the control picketing will be consumed. The virtual net mechanism is proposed to rapidly recover the problem of the root note failure. The information of the root node candidate will be added in the Group Hello information of the original periodic transmission. If the original root node is failure, other nodes can make rapid response. Later, the new root is regarded as the candidate to rebuild the tree-based structure so that a large number of information exchange and the redundant recovery time can be saved.

The stable core tree-based structure has been built through the movement prediction and virtual net. If the core-tree-based multicast transmission mechanism is merely applied in the multi-source multicast environment, lots of data will be temporary stored by the root node so that the data is difficult to be transmitted and then the bottleneck is formed. How to effectively transmit the multicast data through the tree-based structure is an important issue. The bi-directional multicast transmission tree different from the core-tree-based data transmission is proposed in the study. The method is designed for the tree-based multi-source multicast, to improve the disadvantage of transmitting the data through the root node in the core-tree-based data transmission mechanism. Each node in the tree can transmit the data to the parent node and the subnode that is, the data can be transmitted up and down at the same time. The method can avoid the bottleneck and can effectively transmit the multicast data to the whole tree.

The Reliable Multisource Multicast Routing Protocol (RMMRP) is proposed to stabilize the multisource multicast data transmission. The stable tree-based structure is built through the movement prediction by quoting ERS to reduce the RRE number of the control packeting and modifying the original procedure. In order to effectively transmit the multisource multicast data and reach the rapid recovery multicast tree structure, the bidirectional multicast transmission tree mechanism and the virtual net mechanism are proposed. The illustrations of each mechanism are as follows:

ERS: The purpose of ERS is to narrow the transmitted RREQ packeting in the small range and then collect the surrounding topology information through RREQ. Therefore, the requester should add TTL in all RREQ. After the node in RREQ is received, check whether TTL is larger than 0. If is, after TTL is being subtracted 1, the obtained TTL in RREQ will be transmitted by the node. If not, the TTL will be abandoned. In order to search the topology information, each node should maintain a Relay flag. After the node receive a RREQ, judge whether the information is received before. If it is the first time received, the address should be put in the packeting and then broadcast, Otherwise, If it has been received before, observe whether the address has been in the packeting. If it is, after the Relay is set as true Q, the transmitted RREQ through the same requester will be received and then the receiver will check its own Relay flag. If the Relay is set as true U, the RREQ will be broadcast outside. Otherwise, the RREQ will be abandoned.

Movement prediction: Each node will continuously transmit the Hello packeting to the surrounding node for maintaining the network topology and confirming the situation of the neighbor nodes. The study adds the extra GPS information in the Hello packeting. The GPS information includes the present position of the node (X, Y) and t. After the surrounding neighbor node receive Hello, the present direction and velocity can be obtained through the two GPS information whose time is different, as shown in Eq. 1-2. Later, the Link Expiration Time (LET) will be estimated through the following equation:

$$\theta = \tan^{-1}\frac{Y_2 - Y_1}{X_2 - X_1} \quad (1)$$

$$v = \frac{\sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2}}{t_2 - t_1} \quad (2)$$

Each node exchanges Hello information. Therefore, each node can maintain the LET. When the node wants to add in the cluster, the longest routing in the LET can be selected as the multicast data transmission path.

Virtual net: The core-based tree structure is built in the MAODV protocol to transmit the multicast data. The core-based tree transmission method will cause the power running out through the root node's continuous transmission and reception. When root node is failure, the MAODV protocol will start up the recovery mechanism. The recovery mechanism will consume much time and produce a large number of the control packeting. Therefore, the virtual net is proposed in the study for rapidly recovery the topology breakage caused by the root node failure. The root node will send Group Hello to all multicast tree members regularly for maintaining the cluster situation in the MAODV protocol. A candidate's segment should be added in the Group Hello, the candidate (ID is the smallest in the nodes) will be selected by the original root node. When the root node is failure, the candidate can replace the function and continue to maintain the multicast tree.

The sub-node in the original root node will store the candidate's information in the multicast routing table. Once the original root node is failure or detected, the node will send the request to the candidate and then regard the candidate as the new node to rebuild the multicast tree.

Bidirectional multicast transmission tree: All multicast data will be transmitted to the multicast tree root node through the source end in the core-based tree structure. The data is transmitted to the whole tree through the root node will make the surrounding wireless channel of the root node be long-term occupied and produce low effective multicast. The rapid multicast data mechanism in the study is proposed that is, bidirectional multicast Transmission Tree. After a multicast topology is built in the cluster, the source end in the multicast data just needs to transmit the data to one of members. The members who receive the multicast data need to transmit the data to the parent node and sub-node until all members receive the data. In this way, all data can be avoided in the root node.

SIMULATED RESULTS

Simulated environment and parameter setting: The algorithm operation is proposed in the study. The details in other wireless network environment and the storage of the channel resource are finished through the simulated software OMNeT++ with MiXiM. OMNeT++ is used to build the network environment, MiXiM is developed to simulate the usage situation of the wireless ad-hoc network and wireless network. The wireless radio wave interference, radio wave signal's power attenuation or channel resource caused by the distance are implemented. MiXiM is adopted to offset the disadvantage of the physical layer and the network environment. The IEEE 802.11 ad-hoc model in the channel source storage is adopted as the standard to control the wireless resource in each moving node.

Each node in the wireless ad-hoc network is distributed and determines ite present action. Therefore, the action among each node is individual and noninterference. Each movement of the node is simulated as Busong distribution, such as adding the cluster, leaving the cluster, transmitting the signal cast data and multicast data. The movement is granted an individual ë, the node individually determines its movement according to the probability of the Busong distribution. In order to be simulated in the actual environment without being considered the node power, the node may add an extra globle network movement when the node is failure with the power running out or malfunction. Leader is failure that is, the root node in the multicast tree-based structure. Actually, in the core-tree-based operation, the failure node in the network is not only Leader, but also a large number of operations and data transmission in the multicast tree root node will rapidly be failure. Therefore, there is only Leader failure in the experimental environment. When Leader is failure, the tree-based structure in the network in terms of the algorithm method can be recovered.

Table 1: Simulated environment parameter

Network plane space	1000×1000 (m)
Node No.	(10, 20, 30, 40, 50)
Node transmission power	100 mW
Movement model	Random waypoint
Node moving speed	Uniform (0, 5mps)

Table 2: Node movement parameter: Poisson (λ)

Adding cluster	Poisson (10 sec)
Leaving cluster	Poisson (20 sec)
Unicast data transmission	Poisson (5 sec)
Multicast data transmission	Poisson (10 sec)
Leader failure	Poisson (30 sec)

The comparative object is MAODV. Modifying MAODV will make it operate in the multisource multicast that is, Multisource MAODV (MMAODV) (Table 1-2).

Frequency recovery: There are many factors for the broken connection in the wireless ad-hoc network. The main two factors is as follows: (1) Middle node can not be operated for the lack of the power and (2) The distance is becoming further beyond the transmission range for the node movement. There is not the problem of the lack of the power in the simulated environment. Therefore, the broken connection times in each node is regarded as the basis of measuring whether the tree-based topology is stable.

The method of detecting the broken connection in the MAODV is judged through each node's periodic transmitted Hello information. If the detected surrounding neighbor node has no transmission information beyond hello_interval×(1+ allowed_hello_loss), the connection is regarded as broken and then the recovery mechanism should be started. The study detects whether the connection is survival with the method. If the parent node is accorded with the situation in the multicast tree, the broken times should be accumulated.

The recovery times in RMMRP are lower than in MMAODV, as shown in Fig. 1. When the numbers of the cluster members are increased, the slope of the data is smaller. The movement prediction technology proposed in the RMMRP can make the tree-based topology more stable.

Number of the control packeting: The control packeting in the algorithm is to build the control information managed by the routing and cluster. Many studies discuss how control the reduction number of the packeting. In order improve the reliability of the multisource multicast and reduce the production of each control packeting. The main purpose is to adopt the fewer control packeting to search the routing and the cluster. The chapter discusses the control packeting influenced by the number of the node and different method matching.

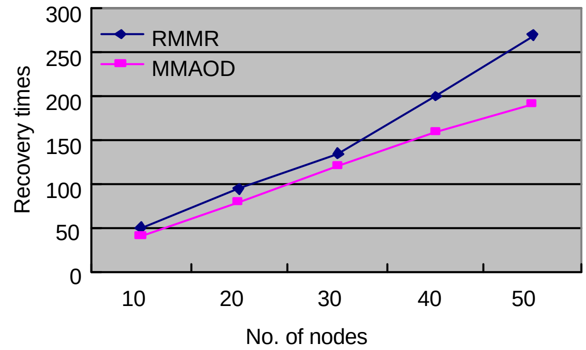

Fig. 1: Connection recovery times

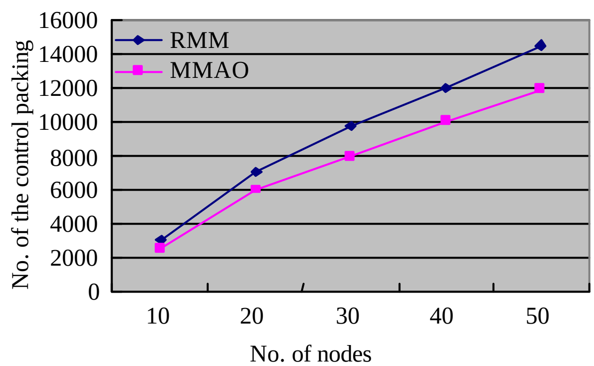

Fig. 2: No. of the control packeting

The control packeting in the section just count the packeting sent by the network layer: RREQ, RREP and MACT. Other ARP and RTS/CTS sent by MAC layer cannot be counted.

The number of the control packeting in RMMRP is much more than in MMAODV, as shown in Fig. 2. ERS can effectively reduce the number of RREQ and the virtual net can make the multicast tree more effective during the process of the recovery. In addition, the control packeting recovered by the request can be improved owing to the reduction of the recovery times.

Transmission success rate: The data packeting may not be transmitted to the destination end in the network, such as collision and beyond transmission distance. The calculated method of the transmission success rate is as follows: If the Unicast data packeting is successfully received, the transmission success rate is 100%. If not, the transmission success rate is 0%.The numbers of the members in the clusters and the numbers of members receiving the data will determine the number of the multicast data. If the numbers of the members in the clusters are M, the numbers of members receiving the data

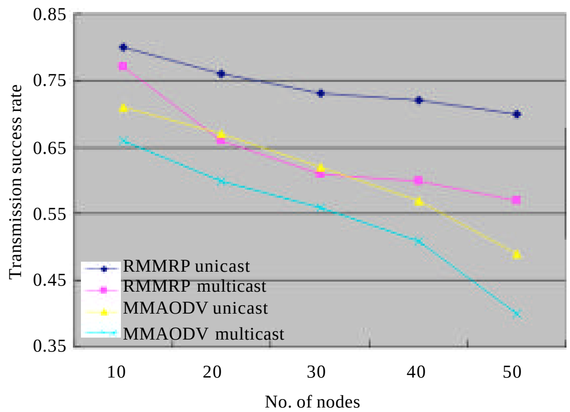

Fig. 3: MMAODV with the mixture of Unicast and multicast

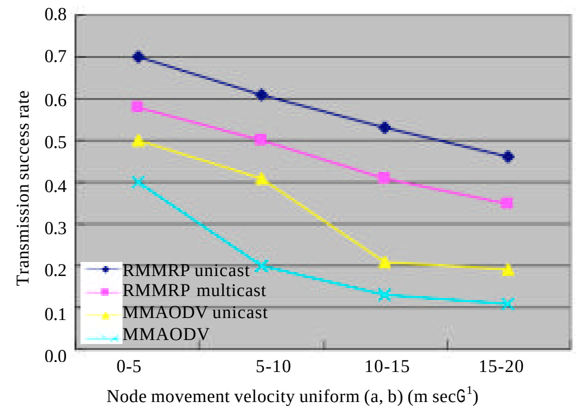

Fig. 5: Network environment with different moving velocity and the mixture of Unicast and multicast

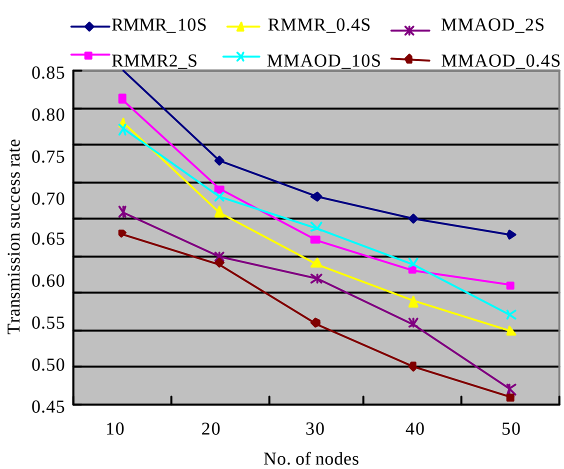

Fig. 4: Environment with multisource multicast and velocity λ caused by different materials

are N, the transmission success rate is N/M. When the transmission success rate is higher, the routing algorithm is more reliable.

The network is just responsible for determing the routing in the simulated process. The data chain layer and the physical layer should comply with the IEEE 802.11 design.

RMMRP does not only improve the multisource multicast success rate, but also can improve unicast success rate, as shown in Fig. 3. RMMRP lies in reducing the control packeting. When the numbers of the control packeting in the network reduces, the Unicast can have more stable transmission.

In order to compare the multisource multicast success transmission rate, the study changes the multicast data velocity in the multicast environment and then observes the RMMRP influence, as shown in Fig. 4. When the data load in the network increases, the success transmission rate will be declined. While RMMRP also can obtain good results in the high load network environment.

When the node movement velocity in the network increases, RMMRP and MMAODV is difficult to obtain better transmission success rate. Compared with MMAODV, RMMRP can have the optimum result and can extend the algorithm collapse velocity (the slope is 45) for RMMRP adds the movement prediction mechanism.

CONCLUSION

The research on the wireless ad-hoc network has been many years and each algorithm is just applied in the assumed environment. There is no one can be applied into each application solution for there are many factors influencing the efficiency in the wireless medium. There is a certain limitation in each moving node operation and handling capacity. Therefore, each algorithm has its own limitation; The study tries to design a multi-source multicast algorithm. From the experimental results, the algorithm actually can have the stable multicast data transmission in the unstable network environment. With the increasing of the load in the network, the excessive competition in the wireless channel cannot be avoided and each node is difficult to obtain the sources access privileged so that the topology is difficult to maintain and the correct data transmission is difficult. Therefore, the algorithm proposed in the study cannot solve the problem.

The network algorithm proposed in the study is not enough to find out the optimum solution of the data transmission in the wireless ad-hoc network, the data chain routing layer algorithm is also needed. What's more, the research on other layers cannot be avoided. After integrations the data chain routing layer, there are more effective wireless medium access mechanism and transmission efficiency.

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