

# The Research on Ad Hoc Network Routing Based On Residual Energy

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## **Abstract**

*With the rapid development of new technologies, Ad Hoc network has become an important technology for mobile communications. Ad Hoc network is a peer, ad hoc, multi-hop autonomous system, which consists of nodes by devices with wireless transceiver is composed. Each node in the network can either be used as a router as a host, and can be changed, so that the topology of the network will change frequently. So, how will the network to improve the reliability of routing protocols, and network routing reconstruction and maintenance is Ad Hoc network research focus. In this paper, through the study of the energy characteristics of the model, based on AODV routing protocol, through improved routing, we propose a new routing protocol based on residual energy. Simulation results show that the proposed routing protocol routing protocol overhead, end to end packet transmission rate, and the average end to end transmission delay aspects have been greatly enhanced network performance, more suitable for real-world network environment.*

**Keywords:** *Ad Hoc network, residual energy, routing protocol*

## **1. Introduction**

With the rapid development of high technology, wireless communication technology that people are increasingly high requirements. Common are the center of the network, including cellular mobile communications and wireless LANs, they are with a fixed infrastructure, and have access to the service node, a foreign agent such as a base station or central control device. However, there is the disadvantage of a fixed network infrastructure construction costs are long, high cost of network building, suited to the dynamic changes of the network, you need not rely on the scene quickly and other infrastructure communication, it appeared to be inadequate, so Ad Hoc randomly generated network [1].

According to the performance characteristics of wireless communication technologies and the need for fixed network infrastructure, it will be divided into two types of wireless communication networks, one is a network-centric, the other is no network-centric, Ad Hoc network is no network centers. Ad Hoc network is not centered; it is by a wireless connection and no fixed infrastructure support. Ad Hoc network is a peer, ad hoc, multi-hop wireless autonomous systems, by a group of mobile nodes with wireless transmitters and receivers. Ad Hoc network through distributed control, no fixed infrastructure support, you can always delete and add nodes in the network as needed. Is equal relationship between the nodes, they both can be used as a router can also be used as a host. Due to the high-speed mobile Ad Hoc network has the characteristics of its earthquake reconstruction, field expedition, undertaken to promote the battlefield, and some cannot rely on pre-built applications in wide range of applications. Wireless Ad Hoc Networks [2] as an advanced, can temporarily fast networking has enormous potential wireless communication technology has been rapid development and application.

It and wired networks or other wireless networks biggest difference is dynamic topology; nodes can dynamically join or leave the network. Features wireless nodes transmit power limited and distributed network topologies require network each node has the dual function of routers and hosts, formed an intermediate host for multi-hop relay network. Over the years, with the development of network and wireless communication technology, mobile Ad Hoc network has been in-depth discussion and research, and has made certain achievements. And traditional network, compared with fixed facilities , Ad Hoc network has some of the following key features:

1) Dynamic network topology. Because of the Ad Hoc network nodes can move randomly and dynamically delete and join the network, so the Ad Hoc network has dynamic topology.

2) Self- organization and distributed topologies. Ad Hoc networks can be self-organizing reconstruction anywhere and at any time, and does not require an established infrastructure be supported. Robustness and self-organization of each node in the network must have equal status, must adopt a distributed topology.

3) The limited nature of the mobile terminal. Ad Hoc Networks CPU processing capability of the mobile terminal is relatively low, less memory, and comes with the transmitter power supply is very limited, so that the network design becomes more complex.

4) Limited wireless bandwidth. Channel wireless mobile communication environment is very harsh, competition and share all kinds of noise interference, signal fading and wireless transmission channel gave a big challenge.

5) Poorsecurity. Wireless channel security is relatively poor, it is easy to attack, eavesdropping and intrusion. In addition, Ad Hoc network using a distributed architecture further reduces the security of the network.

In addition, because of its poor scalability, there are one-way links, network lifetime is short, are also different from the general characteristics of Ad Hoc network. Therefore, Ad Hoc network than traditional fixed networks face greater technical difficulties. So far, there is no more mature business Ad Hoc network appears that most technical issues still in the exploratory stage theory and practical application there is a certain distance. Currently, the difficult and hot research field focused on the following points:

1) Routing technology. Good development of Ad Hoc network routing protocol is the primary problem, a routing protocol is currently the most difficult and hot research. Dynamically changing network topology is the most difficult routing protocol, the traditional routing protocols are not able to meet the dynamically changing network topology. If applied to the development of new highly dynamic Ad Hoc network routing protocols can be a good way to solve some problems. At the same time, efficient and timely, distributed algorithms, security problems, run on demand, energy consumption, etc. are required to consider routing protocol design, routing technology is already in Ad Hoc network the most critical technology [3].

2) Access control technology. Ad Hoc Networks MAC layer faces hidden terminal and exposed terminal problems. How to design a good back off algorithm and MAC protocol packet radio channel conflict as low as possible, to improve the overall performance of the network, reduce overhead and improve channel utilization has important significance.

3) Qos technology. Ad Hoc wireless network resources are very limited, so that the data needed Qos protection becomes very difficult, the current research in this area is still in its infancy. Qos routing technology is Ad Hoc Networks Qos protection scheme provided by Qos find a path in line with the conditions to guarantee the quality of data transmission services.

4) Energy supply problems. Energy supply problem is an important issue Ad Hoc network needs to face. Excess energy consumption will not only reduce the transmission of power , causing problems with unidirectional links may also be deleted in advance because some network nodes and cause network segmentation , forming stub network , so

communication will be interrupted . Because the power of the mobile node is very limited, how to design energy-efficient routing protocol to reduce the chip operation becomes very important , algorithms and protocols should be as simple as possible , the extra overhead as little as possible[4] .

5)Security issues. Security issues is an issue that must be addressed to be the practical application, the problem is all the networks have to face. Wireless open network links are very vulnerable to shocks. Active camouflage, passive eavesdropping, message retransmission with a range of security issues need to be addressed, such as sabotage, random operation and distributed network architecture nodes to further increase the difficulty of security.

6)Location management and forecasting. The greatest difficulty faced in the Ad Hoc network technology is to solve the topology change and random mobile node problem, how to obtain the location information of the nodes, there is a destination and routing data transmission has very important significance. Location prediction based routing technology can improve the reliability and effectiveness of routing, reduce packet overhead, increases the success rate of routing.

In addition, communications, mobile network technology, as well as a one-way link -level transmission services, heterogeneous networks are important Ad Hoc network research.

Ad Hoc network is a very promising wireless network, and has broad application prospects. Civilian facilities in the conference, a variety of disaster relief, celebration occasions,and military battlefield mobile networks have developed on the Ad Hoc network provides space for. Cost is small, the formation of the rapid and strong invulnerability are the main advantages of Ad Hoc network , is currently the leading cause of Ad Hoc network research hotspot.

## 2. Related Works

Predecessor Ad Hoc network is a packet radio network, combined with emerging network technologies and high-speed mobile terminal technology, Ad Hoc network not only in the military field, or in the civilian communications have played out their great advantage. For example , Ad Hoc network and sensor technology combined can detect changes in the environment in the air , in the medical field of minimally invasive surgery can be performed to reduce the patient's pain , improve the success rate of surgery .The earliest American wireless packet networks first study , its purpose is to be widely applied to this network on the battlefield , so that the troops were able to advance at a faster rate , and when a node is damaged, you can exit the network quickly , does not affect communication with other networks. Ad Hoc network has a strong survivability, 1991 IEEE802.11 standards committee formally defined Ad Hoc wireless ad hoc networks [5].

Ad Hoc network is very important because of these years in many regions and countries are beginning to study the Ad Hoc network. Currently Ad Hoc network routing protocol is no specific standard, people on the Ad Hoc network research focused on the self-organization algorithm and routing algorithm concerns, how to design a standardized and efficient routing is the focus of today's research. Ad Hoc typical routing protocols include DSR protocol, DSDV protocol, AODV and TORA protocol and other protocols. AODV\_BR protocol is based on AODV routing protocol improved on , which is mainly based on the basis of the number of hop as a path selection, link load much impact on network performance and energy consumption for consideration. This paper presents an improved A\_AODV\_BR routing protocol, which is the path selection based on the remaining energy of nodes, which can further improve the performance of the network.

Ad Hoc networks do not require a fixed network infrastructure, network nodes can be used as both a router can also be used as a host, the network topology institutions frequently changes, nodes can be dynamically added or removed from the network.

Design a good network routing protocols to meet the dynamic changes of the Ad Hoc network topology is the difficulty and focus of today's research. How to improve the efficiency of routing protocols, performance and security, the need for mobile ad hoc networks for further research, which has important practical value and theoretical significance.

The importance of routing technology in the fixed network is already obvious, particularly Ad Hoc network further increases the difficulty of the route network and routing relies on routing technology design, routing technology is already in Ad Hoc Networks most urgent problems, is currently the focus of the study and difficult.

Dynamically changing network topology routing requirements must be established promptly, limited wireless network resources and energy requirements of routing protocols must have less overhead and energy consumption. Traditional routing technology has been unable to adapt to the dynamic changes of the Ad Hoc network topology, you must design new features for Ad Hoc network routing protocols.

At present, many domestic and foreign universities and institutions related to the beginning of the study of Ad Hoc network, especially on routing technology. In the nineties of the last century, there are many research institutes submitted to the MANET routing protocol working group, such as Carnegie Mellon University, presented a dynamic source routing protocol such as DSR and ABR. These routing protocols are based on different metrics and the starting point, on-demand mechanism to solve the problem of dynamic topology. In the past, a lot of the work is based on the analysis and comparison of various routing protocols, the lack of a number of standardized evaluation metrics, and many routing protocols are based on different simulation platform and development environment, the performance of Ad Hoc network routing protocol comparison and analysis are relatively great restriction.

Since recent years, as well as in-depth study of a step by step improvement of a variety of simulation software (such as NS-2, OPNET), which greatly facilitates the analysis and comparison of the performance and development of Ad Hoc routing protocols. There have been some early improvement program for routing protocols, depending on the angle of these programs, some of the technology in this field (such as power saving, location, location) on the basis of a combination of performance analysis on a variety of issues AGREEMENT made some improvements, the routing network reliability and validity have been improved, the overall performance of the network has also been greatly improved.

Qos routing technology is an extremely challenging task, to establish a fully reliable route with Qos security in Ad Hoc network is very difficult, mainly due to limited wireless bandwidth and fast changing network topology does not provide sufficient resource guarantee. Nevertheless, the sector still got great results, some based on different starting point Qos routing solutions have been proposed. Current research in this field is still in its beginning stages, and how reliable safeguards were provided Qos still face many difficulties [6].

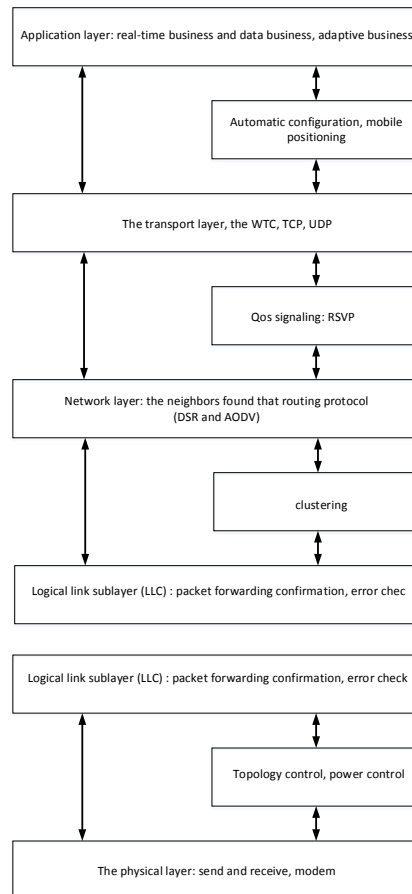
Despite the current improvement program as well as the presence of various routing protocols, this does not mean Ad Hoc routing technology matures. Current, MANET working group and no Ad Hoc network routing protocol standard definition, various routing protocols are submitted as a draft to be discussed, therefore, Ad Hoc routing technology on the whole, still in the initial stage, the need for further research and discussion.

### **3. Proposed Scheme**

#### **3.1. Ad Hoc Network Architecture**

According to the characteristics of Ad Hoc network, refer to TCP / IP architecture and

the OSI reference model. People can be Ad Hoc network protocol stack is divided into five main, the application layer, transport layer, network layer, data link layer and physical layer, the layers can be independently designed and has good robustness [7]. Ad Hoc network architecture shown in Figure 1.



**Figure 1. Ad Hoc Network Protocols Five-Story Structure**

Ad hoc network protocol stack layers function as follows

1) The application layer can provide a variety of application services to users, including the application of adaptive, real-time traffic and packet business.

2) According to the TCP / IP reference model and the OSI model , the transport layer is mainly used for the application process communication between two host connections, which includes a connectionless and connection-oriented services, and the characteristics of Ad Hoc network is self-organizing wireless network, which uses a connectionless service [8]. Some common agreement also includes two protocols UDP and TCP.

3) The network layer is very important layer in Ad Hoc Networks five protocols; it can realize the network addresses to physical addresses. The selection process for routing data communication, to find the most appropriate path for communication. In order to expand the Ad Hoc network performance can be fully utilized, it is necessary to establish good routing algorithms, Ad Hoc network routing protocols should have security, routing without performance ring, demand type and energy and other areas, based on the traditional distance vector routing protocol and link will not meet the above requirements.

4) The data link layer is mainly sent from the physical layer bit stream with the necessary tail and head, and then encapsulated in a frame, which may be network layer service. Its main function contains the complete frame delimitation, error control, transparent transmission, flow control; check the sender's rate is greater than the rate at

the receiving end. The data link layer protocols as well as collision avoidance multiple access collision detection.

5) The physical layer uses the free radio channel based 2.4GH of ISM, transparent transmission bit stream, the data link layer provides data transfer services. Detecting a wireless signal, modulation and demodulation, in order to achieve high data transmission capabilities.

### 3.2. Classified Ad Hoc Network Routing Protocols

According to different routing algorithms, you can put the Ad Hoc network routing protocols into the following categories:

1) According to different topology routing protocols can be divided into Ad Hoc network routing protocols and routing protocol suite planar structure.

2) According to the number of nodes required for the business is not the same, can be divided into multicast routing protocols and unicast routing protocols.

3) According to the standard routing protocol selection is not the same, can be divided into on-demand routing protocol, table-driven routing protocols, routing protocols and hybrid reactive routing protocols [9]. Demand routing protocol called by reactive routing protocol, data communication, the source node via the routing table lookup to find the route to the destination node to communicate, it is maintained and the route by route discovery composed of two parts, and table-driven routing compared protocol, routing overhead is relatively small. Table-driven routing protocols can also be called a priori routing protocol, each node maintains a table, and this routing table contains routing messages from other various nodes. When the network topology changes, the node sends a message to update routing tables.

Figure 2 Ad Hoc network routing protocols different path selection criteria for the classification structure.

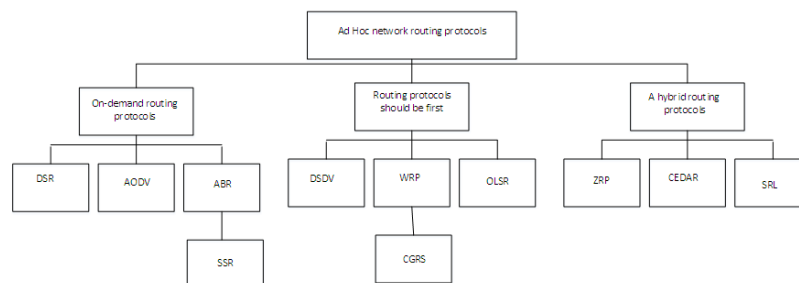


Figure 2. Various Routing Protocols Ad Hoc Networks

### 3.3. Improved AODV Routing Protocol

AODV protocol features of the DSDV and DSR together, borrowed DSR routing maintenance and discovery methods. AODV uses a hop found ways to support Qos. AODV routing protocol by two mechanisms, and three kinds of message components.

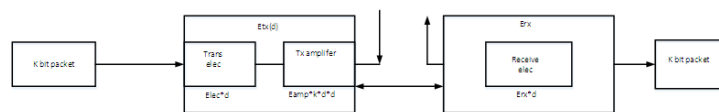
AODV routing protocols including routing discovery and routing maintenance of two mechanisms, in the process of communication, the source node routing table by looking to see if there is a route to the destination node, it is sent directly. Conversely flooding method utilizing the adjacent node sends a route request packet RREQ, after the middle of the node receives the serial number to see if you receive the packet before that too, chose to discard. If not received after sending a route to the destination node, the destination node receives the RREQ message to the source node routing reply RREP, establish a path source node to the destination node.

AODV\_BR [10] routing protocol based on AODV routing protocol to take a backup

routing policy, in the case of the control information is not increased, leading to a number of the destination node routing maintenance, by grouping the broadcast routing, each neighbor node to other nodes can send data, and then get back up the routing information. On the basis of AODV\_BR routing protocols, we propose an improved energy-based routing protocol E\_AODV\_BR.

AODV using the shortest path first algorithm is a distance-vector protocol; choose the path less hops to communicate. When the network topology changes, the node have a new route discovery path, find the path of least number of hops as the main route. Above routing policy does not take into account the residual energy of the nodes, in some cases, a node may be in a multi-hop path, if inter-node constantly forwarding information, then the residual energy taking into account the node, its energy is likely to be exhausted.

References and the literature can be calculated move tissue changes since energy consumption of nodes in the network model based on his proposed energy. Energy consumption model shown in Figure 3.



**Figure 3. Energy Consumption Model**

The case according to the energy consumption model, a state is assumed when the node does not work, *i.e.*, no data transmission and reception of energy is maintained.

Assuming the internal nodes send and receive data, data required per unit of energy consumed for  $E_{elec}$ , transmit energy data amplifier unit require for  $E_{amp}$ , the squared signal of the modulator and the energy required transmission distance ( $d^2$ ) is proportional.

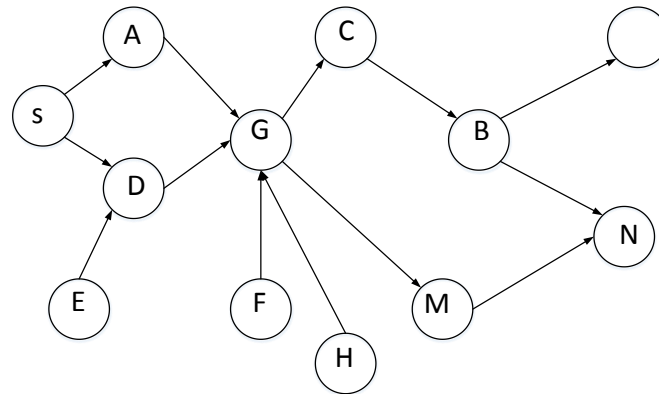
$$E_{tx}(k, d) = (E_{elec} + E_{amp} \times d^2) \times k \quad (1)$$

$$E_{rx}(k) = E_{elec} \times k \quad (2)$$

According to the above formula can be seen, the energy consumption is proportional to the packet size and the number of normal working successfully transmitted and received, the number of packets successfully transmitted and received more, the greater the energy consumption values. According to the formula (1) and Equation (2) can be derived, the mobile node in the normal case, the  $k$ -bit source data sending a data receiving energy required for

$$E_{total}(l, k, d) = E_{elec} \times l + (E_{elec} + E_{amp} \times d^2) \times k \quad (3)$$

Can be derived from the formula, the energy consumption is proportional to the distance between nodes and send the value of the amount of information transferred. In AODV routing algorithm to select the least number of hops routing node as a standard, but it does not consider the residual energy of nodes. When this energy is depleted nodes, link outage occurs.



**Figure 4. The Key Node Energy Consumption Model**

In Figure 4, the path SDGB, EDGM, AGC, the node G is the critical path nodes. When the data communications network, the forwarding information is also more than other nodes, the faster the energy consumption. If you only take into account the number of hops, when the link is disconnected, we must find a new route, the performance overhead of such a network is relatively large.

#### **4. The Experimental Results and Analysis**

In this paper, nowadays more popular simulation software NS-2 simulation. NS-2 simulation software is the most prominent advantage is by analyzing network traffic to detect whether the network congestion phenomenon. Article simulation scenario to 2km \* 2km, a total residence time of 20 nodes, nodes were 10s, 20s, and the average moving speed 30s, set the node to 15m / s; the duration of the simulation is 100s.

##### **4.1. Simulation Performance Evaluation Factors**

- 1) The survival time of the network

Survival time of the network refers to a network where all of the energy of the mobile nodes is all exhausted by the elapsed time.

- 2) Routing overhead

Routing overhead refers to the degree of congestion in a network node and a network of energy supply. The ratio of the total number of packets of the packet number received and transmitted numerically equal. The larger overhead then showed more useless information network congestion caused by the greater networking opportunities.

- 3) The average delay end

End including average delay time required for the route discovery time and data transfer process in the queue in the elapsed time. To measure by the end of the delay can determine whether a network is unobstructed.

- 4) End to end packet transmission rate

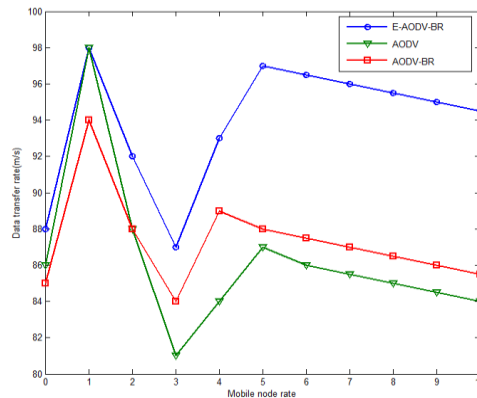
End to end packet transmission success rate is equal to the value received in the ratio of the number of packets and the number of packets sent. This parameter can well react protocol characteristics, the greater the ratio, the more that the received data packet, the network throughput is higher.

##### **4.2. Simulation Results**

Figure 5 depicts the three routing algorithm AODV, AODV\_BR and E\_AODV\_BR

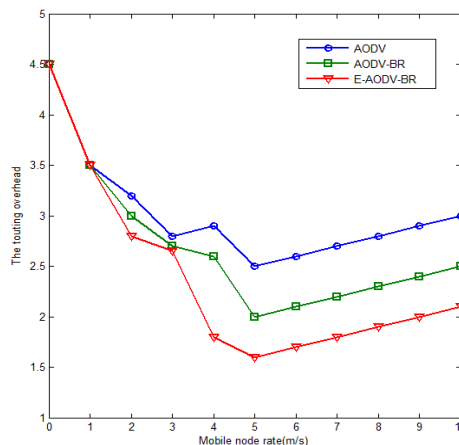


relations move at maximum speed packet transmission node rate. The probability of occurrence of breaking the link with the node will increase the rate of movement becomes larger, thus increasing the number of links repaired, then the probability of successful delivery of the agreement will also be greatly reduced. After the routing protocol to improve, with a residual energy of route repair mechanism detects the link is interrupted when, instead of routing nodes to repair the link by looking for a node with the highest remaining energy as. Packet transmission success rate will be higher than the other two routing protocols, and when the moving speed of the mobile nodes increases, this advantage will be more prominent.



**Figure 5. Packet Transmission Rate and the Maximum Moving Speed**

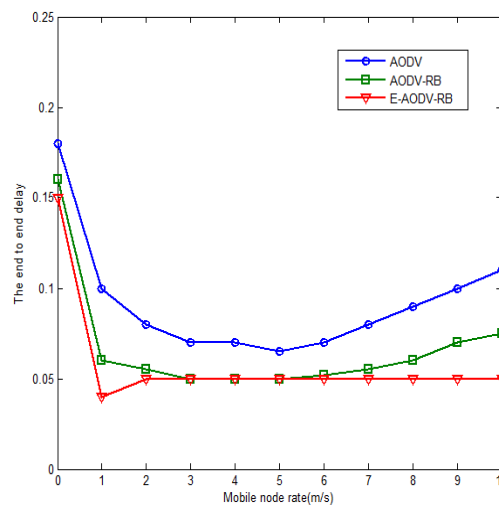
Figure 6 compares the relationship between the three routing protocol overhead and maximum speed of movement. Improved routing protocol can be seen in the case of all of the maximum speed, almost all made minimal routing overhead. With the moving speed of the mobile node is increasing, the number of route repair also will be more, because of the improved routing protocol based on the remaining energy in the case of failure of the primary route, the route can be used to repair immediately, effectively improve the routing efficiency, the number of links repair will greatly reduce the routing overhead in the network will also be greatly reduced.



**Figure 6. Relationship Routing Overhead and Maximum Speed**

Figure 7 compares the relationship between the three protocols delay and maximum moving speed. You can see the rest of the routing protocol based on energy, compared with the other two protocols in terms of delay and reduce the 40% percent to 70%. When the moving speed of the node is bigger than ever, end to end delay also will become

bigger and bigger. Based routing protocol delay energy is relatively small , because the improved routing protocol adds residual energy values, view the status of the node can know whether the link is interrupted, repair delay generated also be significantly reduced.



**Figure 7. Relationship End Average Delay and Maximum Speed**

## 5. Conclusion

In this paper, based on the remaining energy improvements routing protocol, routing requests for routing protocols , routing response, connectivity routing error messages and detect the link between improved. The energy model, design a node's residual energy, describes routing and routing protocol maintains route discovery process. Finally, the simulation results show that the improved routing protocol based on residual energy in the end to end packet transmission rate, network overhead and end average delay aspects have been improved performance, improved protocol can adapt to the dynamic changes network topology.

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