International Journal of Smart Home
Vol. 9, No. 11, (2015), pp. 63-72
http://dx.doi.org/10.14257/ijsh.2015.9.11.08

The Research of Ad hoc Network Routing Protocol Based on Energy

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Abstract

Ad hoc network is a self-organized, does not rely on fixed infrastructure wireless network, the organization fast, convenient and not limited by space and time, both can be applied to the meeting, rescue, adventure, war or hazardous environments goal surveillance applications, but also for a limited extension of the network end network services. This paper introduces the basic concepts and key technologies of Ad hoc, and summarized the traditional Ad hoc network routing protocol, commonly used for energy saving existing routing protocol control strategy focuses on. Introduced and compared four typical Ad hoc network routing protocols AODV, DSDV, TORA and DSR performance in energy control. After in-depth study of Ad hoc networks in the energy physical layer, MAC layer, network layer control problems, proposed an Ad hoc network routing protocols based on improved energy control - control of distributed energy source dynamic routing protocols. Finally, the proposed protocol simulation, reflecting its advantages in energy control.

Keywords*: Energy Control; Ad hoc networks; Routing Protocols*

1. Introduction

Ad hoc network as a special kind of mobile network forms, since each node can move freely, without a fixed base station, to achieve dynamic links, coupled with its mobile and networking is very convenient, strong survivability features, make up the shortcomings of digital cellular mobile communication systems and cable networks, has an irreplaceable role in many evil little environment can be widely used in disaster relief, defense readiness, *etc*. But some just temporary need a wired communication environment too costly or impossible to get a wired network support, in addition it can also serve as strong backup network survivability. Therefore, the study of Ad hoc network for the advancement of technology is very helpful .Meanwhile, with the development of the continuous development of Ad hoc networks and related products, Ad hoc networks will more and more people pay attention, there will be more and more application, so it has broad prospects for development and research. Routing protocol as an important factor affecting the network is to ensure that the Ad hoc network running important point. And because Ad hoc network routing protocols are mainly used in mobile devices with a small battery pack for energy, and therefore, the energy consumption of an Ad hoc network is also the focus of its network performance analysis. How can reduce the loss of battery power , thereby extending the lifetime of the whole network routing protocol research has become a new and important hot spots[1].

Ad hoc networks to expand in order to extend the survival of life, is the Ad hoc network routing protocol is more excellent articles from the following main points were studied and discussion:

1) The main function of Ad hoc networks for some analysis discussed in detail Ad hoc network routing protocols, definitions, some difficulties exist and typical network routing protocols.
2) For reducing the energy consumption of nodes and prolong survival time Ad hoc network requirements, study and organize a variety of energy to protect the routing

ISSN: 1975-4094 IJSH

strategy. Depending on the routing protocol to obtain the corresponding energy-saving program, the most integrated of the relationship between the various protocol layers, presents a cross-layer design of energy using a routing policy [2].

3) A large number of comparisons and references multiple Ad hoc network routing protocol of the energy efficiency performance, the DSR routing protocol as the network layer protocol for Ad hoc networks, and DSR routing protocols usually carried out under the energy control strategy to improve, then proposed improved Distribute Dynamic Energy Control Source Routing protocol, and the use of simulation platform OPNET Modeler its performance simulation.

2. Related Works

With the development of Internet and information technology, people on the wireless environment to provide data service needs become more urgent. In recent years, digital cellular mobile systems, LEO satellite communication systems, wireless local area networks and other mobile communication technologies have emerged. So far, the wireless network based on its structural characteristics can be divided into two categories: no fixed infrastructure, wireless networks and fixed wireless network infrastructure [3].

Fixed wireless network infrastructure, including a small number of powerful fixed nodes and large number of mobile nodes. Inter-base station using a cable connection, the coverage area of the mobile node and a base station via a wireless communication medium, the mobile node during communication can be. When the original base station the mobile node leaves the radio coverage area, then it may make one base station is connected and to continue to communicate via the base station. Such communications and networking, the location of the base station is stationary, such as CDMA or GSM system. This model can be effectively utilized existing infrastructure such as base stations can be easily communicate within a coverage area of the base station. However, this approach also has some shortcomings, the problem is that the mobile user to switch between base stations. This requires the user to simultaneously switch, cannot have a significant data loss and delay. Another problem with this model is that it utilizes the infrastructure of cellular mobile communication base stations, although it has some inconvenience, but it also limits efficient communication can be achieved only within the coverage area of the base station.

Ad hoc network is a no fixed network infrastructure. Ad hoc network is a mobile network node entirely constituted by a wireless connection [4], the network does not have a fixed router , the topology can change dynamically over time, each node is both the routing device and the host is responsible for maintaining and find links to other nodes path and a fixed wireless network nodes compared, Ad hoc networks are more durable, more robust and does not require fixed infrastructure provided, people can communicate wirelessly with each other through the network. So, Ad hoc network mainly for military service, or some emergency situations, such as communications and other remote areas, disaster areas or exploration occasions.

Ad hoc network technology is an important technology in the field of wireless communications, data communications has become one of the most important business Ad hoc networks. With the development of new communication protocol development and wireless access technology, Ad hoc networks can give access nodes provide higher bandwidth communication quality and better. Wireless Internet technology and wireless routing technology to support the Ad hoc networks can be rolled out late in the wired network, or inconvenience to spread the area of mobile flexible, fast network. Internet technology and wireless router to provide a strong guarantee for the Ad hoc network management and planning.

Generally accepted that there is no infrastructure network is seen in the 1970s, after the exchange of messages generated soon, the US Defense Advanced Research Projects Agency began funding research packet radio network, that allow the exchange of packets from a wired or fixed run- down infrastructure constraints of the environment. This is the beginning of the purpose is to meet the military needs of the battlefield [5]. Under harsh

conditions battlefield communications equipment cannot rely on good communications equipment have been built, one of these facilities may be destroyed at any time, so the one hand, these facilities may simply not exist. Therefore, rapid self-organization, mobile infrastructure equipment is of such a network is different from other commercial cellular system the most basic elements. Structurally, this network is composed of a series of mobile nodes, and is a self-organizing network, it does not depend on any existing network infrastructure. Any node in the network and dynamically distributed among the nodes connected by wireless, packet switching concept will be extended to the field of broadcasting networks. This work opens up the development of mobile ad hoc network beginning. Meanwhile, the US government has done some research and development of other projects, which include low cost packet radio, the Internet and the recent tactical radio, adaptive network survivability, survivable communications network and other projects. However, these projects at the time was very confidential, in the late 20th century, it is difficult to obtain valuable research and technological achievements and theoretical support in open publications. Because self-organizing network can be widely used in many fields of police and medical rescue departments, battlefield command and control communications, classroom education and sensor networks, it is extremely important strategic significance. Currently Ad hoc network is not yet fully reached the practical stage, much of the work is still in the experimental stage and simulation, experimental scale in the tens of nodes, simulation scale in hundreds to thousands of nodes.

As mobile Ad hoc network is a multi-hop, mobile, self-discipline systems, and therefore some of its main features include the following:

1) No center: the same position all the nodes, the nodes can always leave the network, any node failure does not affect the operation of the entire network, and is a strong anti-destruction, no central structure of the symmetrical network.
2) Independent network: the network layout without relying on any network previously been built, after the node can automatically open, quickly form an independent network.
3) Multi-hop routing: Due to the limited coverage node, the node transmission power is limited. When you want a node outside the scope of its coverage to communicate, requiring an intermediate node forwards, that is, to go through a multi-hop.
4) Self- organization: no strict control centers, all nodes distributed algorithm or by a hierarchical network protocols to coordinate their behavior.
5) Dynamic topology: the nodes of the network is that you can move randomly, and you can always turn off the radio, transmission power can be varied, send affect species diversity antenna device, the wireless channel interference, a combination of factors such as weather and terrain, resulting in network the topology is difficult to predict.
6) The power is limited: Due to the characteristics of the network node can be moved, because the majority of the nodes are battery powered, and thus energy saving during system design is very important as an indicator [6].
7) Link bandwidth is limited: Due to the topology change results in each node itself as a non- forwarding destination of traffic changes over time, and therefore different wireline networks, it becomes the link capacity characteristic is exhibited.
8) Limited physical security: Mobile network more vulnerable to security threats than fixed networks, new security risks require customer service wireless links and mobile security weaknesses brought topology.

3. Proposed Scheme

3.1. The Key Technology of Ad hoc Networks

Due to the special nature of Ad hoc networks , a variety of technologies and protocols conventional cellular digital mobile communications and wired networks cannot be

directly used, need ah yo technologies and protocols designed specifically for Ad hoc networks. Ad hoc networking protocols and technologies involved in many, but these mainly reflected in several aspects of power control, adaptive technology, hybrid ARQ, multiple antenna technology, adaptive resource allocation.

1) Physical layer adaptive technology

Due to limited resources of energy, physical layer design Ad hoc networks have a lot of difficulties. Due to multipath fading caused by phase and amplitude of the perturbation, the delay spread caused by inter-code crosstalk, interference from other nodes factor signals, *etc.*, so that the radio channel unit bandwidth capacity is relatively small. Ad hoc network design goals physical layer under conditions of less energy, so that the data rate close to the minimum capacity of the channel [7].

The actual radio channel has two main characteristics: attenuation characteristics and time-varying characteristics. Thus, the capacity of the radio channel is a time-varying random variable, only when the power of the transmission capacity of the channel increases with vary, *i.e.*, so that coding and modulation scheme is adaptive, in order to make the channel capacity is maximized. How to make full use of limited energy resources and the limited bandwidth, based on the characteristics of the QOS requirements and applications, to maximize network throughput and extend the life of the energy -constrained networks, minimize energy consumption, will be adaptive physical layer To focus on solving technical problems. The solution mainly adaptive coding and modulation, according to the capacity to determine the appropriate modulation and coding to determine the current channel capacity of the channel under the circumstances, in order to maximize send information to achieve a relatively high rate. Variable rate modulation method implementation are the following: variable spreading gain CDMA, variable rate quadrature amplitude modulation, adaptive coding and modulation with variable rate adaptive trellis coded modulation, multi-code code division multiple address. There are also adaptive retransmission redundancy, adaptive frame length mechanism, adaptive link adjustment mechanism.

2) Power control

In order to improve system performance, power control is a very important mechanism, the data link layer of the power control capable of multipath fading compensate random variation can reduce power and reduce the error rate in the meet and data rates premise interference system. The data link layer in the power control can reduce or increase the signal to noise ratio unchanged signal power, or increase the rate of data in the case of good channel conditions.

Power Control Strategy for the data link layer is divided into three types: adaptive power, not for strict control of power delay; large fixed SINR strategy, energy consumption; QOS -based distributed power control algorithm, to meet different the QOS business needs. The fixed rates based QOS distributed power control algorithm, and more focus on ensuring the reliability and latency. Under variable rate control algorithm based QOS distributed power, under the requirements of the delay is not very stringent conditions, focusing on maximizing the number of bits transmitted per unit of energy and improve the average throughput of the link.

3) Hybrid ARQ

Is the automatic retransmission request ARQ, ARQ communication link in the presence of a normally closed-loop link, there is a feedback response signal, the error correction capability of itself does not. ARQ and FEC will be combined to achieve the error detection and correction function, referred to as hybrid ARQ. Current technologies include stops waiting for ARQ and Selective Repeat two.

Hybrid ARQ is a link adaptive technology, FEC and ARQ error correction method of combining the former, in FEC together to complete error-free transmission protection. In

the current HARQ in order to increase data throughput, usually self terminating data frames associated with two methods: combined coding and diversity combining. The combined number of encoding can be minimal, the codon encoding rate of R combine to give a coding rate R is less than the codeword, such code words have a stronger error correction capability. Collection points and will go through the code word when the same format has deleted retransmission, then merge. Relatively simple to achieve, without too complex algorithms.

4) Multi-antenna technology

Sending or receiving end of the use of multiple antenna technology will greatly improve system performance, reduce power transmission. More Antenna system using multiple input multiple output MIMO technology, diversity combining or beamforming.

Collection points and is a common technique used to reduce the impact of flat fading. By significantly mitigate the impact of flat fading, diversity combining can effectively save power system.

MIMO systems [8] have been receiving and the transmitting side multi-antenna technology, can improve the data transfer rate. Multi- antenna techniques can reduce the power of the transmission signal, but increases the signal processing capability of the system requirements, and therefore energy -limited systems, where there is a compromise solution. Because MIMO or multiple antenna technology overcharged major breakthrough wireless mobile communication smart antenna technology is the key technology of next generation mobile communication system must be used, while Ad hoc network technology will also be organized in the form of next generation mobile communication network system, so this combination of the two will be the inevitable choice. In Ad hoc networks can be used at the same time to replace the conventional smart antenna array antenna system can reduce interference and improve spectrum efficiency and capacity of the system. The techniques include adaptive beamforming, pre-multi-beam forming, but increases the complexity and channel correction system.

3.2. The Traditional Ad hoc Network Routing Strategies

Ad hoc networks to establish the most important issue is to establish a good routing policy routing strategies now and in the manner established by the time the route can be divided into on-demand routing strategies and table-driven routing policy. Demand routing policy does not require the maintenance of all nodes destined route, it just did not go to the destination node in the route when it is on-demand route discovery, which effectively saves memory and bandwidth, but obviously when the route is established extension for the price, especially the majority of existing routing setup procedure but also through a wide range of broadcast routing information, which will lead to surge in instantaneous flow.

3.3. Ad hoc Network Routing Strategy Based on Energy Control

Ad hoc networks and traditional networks is an important distinction which node has the ability to move, which requires the device as small as possible, and not simply rely on the small battery powered. Thus, the need for energy saving, to extend the life of the node. Because computer power and miniaturization and equipment compared to the development of battery technology will have to be a lot slower, so improving the energy efficiency of mobile nodes, the key lies in the design of higher software layers on the rational design of routing policy which can greatly reduce energy consumption.

1) The minimum transmission energy routing policy

Routing strategies are designed in accordance with the minimum of routing hops. But according to radio propagation models, routing the minimum number of hops is not necessarily the most energy efficient. Minimum transmission energy routing strategy is found between the source node and the destination node of a total transmission path of least energy to achieve energy savings. This problem can be represented by the following

formula.

$$Router = \arg \min_{q \in \theta} \left\{ \sum_{n_i \in q} q_{tran}(n_i, n_{i+1}) \middle| n_i \in (n_0, n_1, \ldots, n_n) \right\} \quad (1)$$

Where θ represents the set of all possible paths, and $q_{tran}(n_i, n_{i+1})$ represents the energy loss between the two adjacent nodes n_i, n_{i+1} transmission. As the power of the transmission signal satisfies the equation attenuation of radio signals, *i.e.*,

$$q(d) = md^n \quad (2)$$

Where n is the attenuation coefficient, $n \geq 2$.

According to (2), when a node N_j between nodes n_i, n_{i+1}, represented by the formula (3)

$$q(k) + q(d - k) \leq q(d) \quad (3)$$

It will use less energy transmission path $(\ldots, n_i n_{i+1}, \ldots)$ to replace the original path $(\ldots, n_i n_{i+1}, \ldots)$. Therefore, based on the minimum transmission energy routing policy will select the transmission energy in general smaller, but more hops path.

2) Energy- based Routing Topology Control Strategy

Dynamic topology of Ad hoc network is another important feature, so the topology control strategy has important significance in Ad hoc networks. Topology control can reduce conflicts between networks, which can be greater throughput and spatial reuse greater degree; topology control can affect the energy utilization; (between any two nodes in the network topology can be controlled jump radius the maximum value of the shortest path), and thus can reduce the delay. Studies have shown that in the case of two-way Unicom network protection, power can be achieved by adjusting the maximum power utilization. In Ad hoc networks, topology control strategy has important significance. Topology management and traditional network topology information is contained in the routing strategy. Recent studies have shown that the topology management can be separated from the network layer, and in the Mac introduce control layer and network layer management topology, as shown in Figure. Explore how effective routing and topology control strategy has combined both separation and achieved many research results, according to the specific topology control strategy can be divided into the card and transmit power to change the mode of operation of these two pathways.

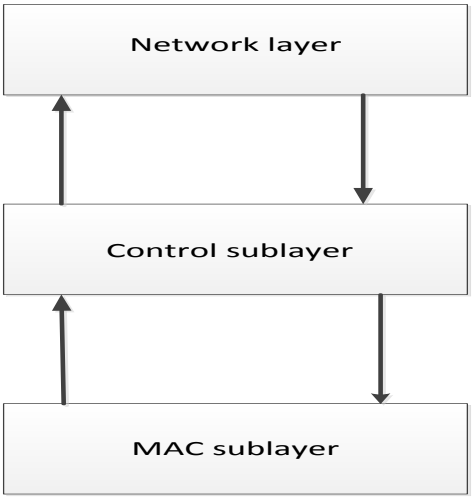

Figure 1. A Routing Policy Schematic Diagram Based on Topology Management

3.4. Based Ad hoc Network Routing Protocols Energy Control

DDECSR (Distributed Dynamic Energy Control Source Routing), distributed dynamic power control source routing protocol to work on different levels: end- hop routing and routing. DDECSR protocol is based on a pre-selected the appropriate hop transmit power, in order to reduce energy consumption and improve the performance of the entire network. In addition, the nodes transmit power and residual energy level joint function as a link state for route selection [9].

The protocol requires that each node can record the combined value of the transmission power level function F_{EX} and the node transmit power level P_{TX} and the node remaining energy level in an appropriate packet. In addition, it should also require a wireless transceiver can estimate the power of the received signal P_{RX} . After obtaining P_{RX} and nodes will be able to estimate the attenuation of the link. In particular, you can know that a node receives from its neighboring nodes to a data packet, then the decay channel can be calculated as $P_{TX} - P_{RX}$. When considering the case of a symmetric channel, ignoring the channel periodic shock and interference power is assumed equal level, then the impact of the attenuation on the transmission between nodes can be expressed as $P_{TX} - P_{RX}$. Therefore, for the transmission power $\hat{P}_{TX}$, a relatively good choice for

$$\hat{P}_{TX} = P_{TX} - P_{RX} + G_R + L_{TH} + \int V_{node} dt \tag{4}$$

Wherein the data packet is received to ensure a minimum power level G_R ; channel interference is taken into account and the channel state power surplus introduced L_{TH} ; $\int V_{node} dt$ nodal motion is taken into account the impact of the mobile node for the incremental transmission of introduction.

In DDECSR protocol, hop transmission power levels also, and the remaining energy level of the nodes constituting the joint function F_{EX} , which can be used to select the low-power path. Can be defined at some point node remaining energy level:

$$Y_i^t = -\log_2\left(\frac{E_i^t}{E_F}\right) \tag{5}$$

Here, Y_i^t is the node i remaining energy level at time t; E_F is a saturated energy of node i; E_i^t is the residual energy of the node i at time t. Formula (5) The larger the value Y_i^t , t indicates the time remaining energy level node worse, which requires to reduce the energy consumption of the nodes; The smaller the value Y_i^t , indicating that the remaining energy level of the more prominent nodes at time t, conditional nodes consume more energy. According to the formula (4) and (5) can be combined function definition node remaining energy level and transmit power levels for

$$F_{ET} = \frac{\hat{P}_{TX}}{Y_i^t} = \frac{P_{TX} - P_{RX} + G_R + L_{TH} + \int V dt}{-\log\left(\frac{E_i^t}{E_F}\right)} \tag{6}$$

In fact, all the links are associated and joint function is F_{ET} , therefore, F_{ET} can be seen as a function of the state of the routing algorithm is used to select the data packet to the transmission path, so that you can achieve the level of energy savings in the end [10].

Target DDECSR agreement is to reduce the energy consumption of nodes, then the Ad

hoc network service longer. When a node is off busy network may lead to separate, resulting in an active node cannot communicate directly. Therefore, the balance of the network packet traffic, and choose low-power transmission path is the key to solving the problem. Then, the routing algorithm formula DDECSR protocol can be expressed as

$$Router = \arg\max_{q \in \theta} \left(\sum_{n_i \in q} F_{ETn_i} \right) \tag{7}$$

Wherein, the set of all paths is optional θ, and n_i is a node on the path q. Joint function F_{ET} can be considered as the link state, the greater F_{ET}, the state of the communication, the better. Finally, you can choose the link path as the sum of the state 's largest route. Not only F_{ET} consider the feasibility of routing link, and reflects the relationship between the residual energy of nodes and node transmit power levels, and achieving a balance between energy consumption and transmission path of network traffic.

The worst case time complexity of DDECSR routing protocol is O (n (2N-1)), the worst-case message complexity can be expressed as O (3 (N-1)), the worst-case complexity of the calculation degree, compared with O (n (N-1)). The complexity of the analysis can be proved as follows.

Suppose N is the number of nodes in the network, L is the number of links on a path contained, n is the path to the source node collects the number of messages that the elapsed time overhead per one link is a unit of time, the successful establishment of a connection the time complexity is O (n (2L-1)), since the N -node network, the maximum number of links is N-1, so in the worst case, the time complexity is O (n (2N -1)). Since the algorithms for each link up to the same path of a transmission time of request packet ID, so for a single connection request message, the request for the worst-case route complexity is O (N-1); On each link in the selected path most one acknowledgment message or an error message, so that the maximum acknowledgment message complexity is O (N-1), and the worst-case error message complexity is O bang) I, so message complexity in the worst case of O (3 (N-1)).

Assuming n is the path to the source node collects the number, is the number of links contained in the i-th path, N is the number of nodes in the network, in the worst case, namely: the source node collects all paths to the n NI contains links, then calculate routing protocol complexity is O (n (N-1)).

4. The Experimental Results and Analysis

Performance evaluation of a mobile communication network is good, it can be judged from the following several parameters.

1) End to end delay: This is a statistical parameter signal transmitting node to the receiving node from the elapsed time.
2) Routing protocol overhead: This parameter is the number of statistical information in the routing node sends all the time in the control unit and
   Number
3) Node: The parametric statistics is the impact of the network topology of the routing protocols.
4) Network Throughput: This parameter is the amount of statistical data for all nodes in a unit time received.
   Status
5) Node movement: the parametric statistics is the impact on the state of motion node routing protocols.

In the simulation, the use of such a two-way channel for communication between nodes is assumed, and each node randomly placed within the simulation range. In the course of the simulation carried out, each node is called the pause time between the period of staying at the current location.

Impact on the survival time of the network in Figure 2 show the network throughput. From the figure it can be observed that, when the throughput is constantly increasing, the survival time of the network decreases. This is mainly because when the amount of transmission data is increased, resulting in an increase in energy consumption. At the same time, you can see DDECSR agreement on energy consumption than the DSR protocol excellent control, although the increase in network throughput process, to reduce the lifetime of the network, but the network DDECSR agreement than DSR longer survival time.

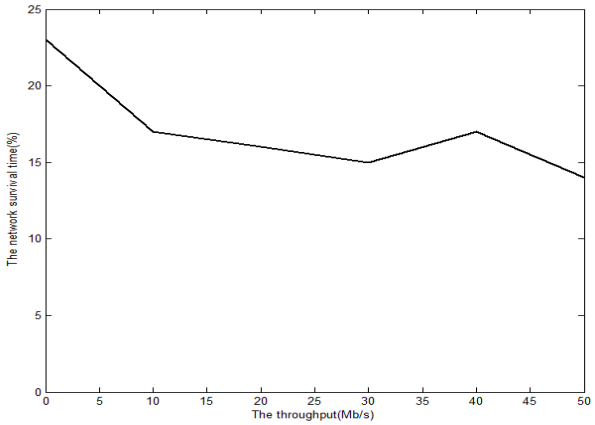

Figure 2. The Impact on the Survival Time of the Network Throughput

DDECSR protocol routing discovery phase increases the period of time called the collection routes and routing algorithm complexity is increasing, these two factors have caused an increase in route calculation time, the impact of the network throughput. Can be seen from Figure 3, DDECSR agreement than DSR protocol has worse limited network throughput. Network throughput is limited with respect to the survival time in terms of network routing protocols, as DDECSR than DSR protocol network services agreement with a longer time, so network throughput is good or bad has not been determined.

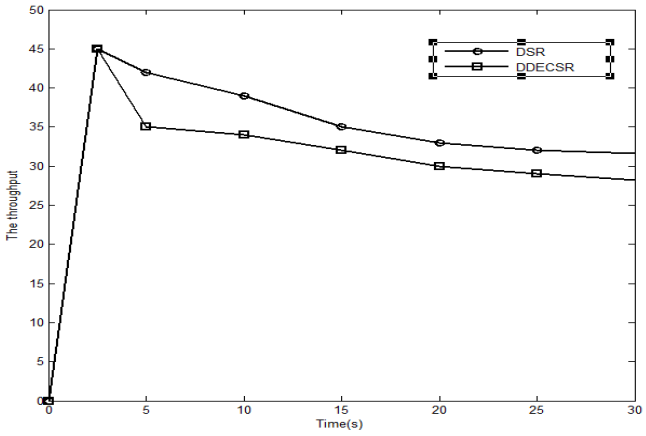

Figure 3. Both Protocols Network Throughput

5. Conclusion

Dynamic control of distributed energy source routing protocol is a dynamic routing protocol based on the new Ad hoc network routing protocol by introducing low-power routing algorithm to reduce the transmission energy routes, and increases network routing protocols energy control capability. DDECSR protocol uses a cross-layer design approach, the choice of routing node residual energy comprehensive information and links, which makes this agreement not only balances the network traffic flow, but also reduces the energy required for the transmission path. Despite the use of DDECSR agreement will increase the data processing and storage overhead, but this routing energy control and prolong the lifetime of the network, effectively reducing the energy of nodes.

Through simulation and analysis can be, DDECSR agreement in balancing network traffic, reduce node energy consumption and prolong the survival time of the network, than the DSR protocol has better performance. In summary summary can be seen, DDECSR protocol is a control with excellent energy performance of Ad hoc network routing protocols.

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