IJCSC International Journal of Computer Science & Communication Vol. 1, No. 2, July-December 2010, pp. 65-70

Enhancing the Performance of a Nodes in Ad-hoc Networks using Mobile Relay

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ABSTRACT

Nodes in Ad-hoc Networks are battery powered and hence have limited life time. Due to excessive utilization a node may die which can result in energy depletion problem and thereby affect overall network performance. Local rate of energy consumption on a node can be monitored. We can estimate the remaining battery life of a node (residual energy in a node) based on the rate of consumption. Thus early detection and avoidance of energy depletion problem is possible based on monitoring of power (rate of energy consumption) and remaining battery life (residual energy in a node). To avoid energy depletion problem due to excessive energy consumption at a higher rate, we introduce the mobile relays. These mobile relays reduce the power consumption in the node by sharing the load. As and when the rate of energy consumption returns to efficient levels, the mobile relay is released so that it can be made available for other critical nodes. This technique can be applied to any protocol used in Ad-hoc Networks. Our implementation is based on Ad-hoc On Demand Distance Vector (AODV) protocol. A history of the use of the Mobile Relay is maintained for further analysis of network performance.

Keywords: Ad-hoc Networks, Energy Depletion Problem, Mobile Relays

1. INTRODUCTION

Efficient utilization of energy of a node in Ad-hoc Networks [2] is required because these mobile nodes have limited lifetime. In recent years there has been considerable interest in power aware routing protocols [5], to extend the lifetime of networks. These protocols usually measure only the residual energy (remaining battery life) [4] of a node. They do not take into consideration the rate at which the energy is consumed. A high rate of consumption with a low residual energy is a potential problem. This problem we call the energy depletion problem. It may lead to the rapid demise of the node. And if this node happens to be critical node in the Ad-hoc Network, this will lead to the overall performance degradation or due to the ad-hoc nature, an alternative route being discovered. Alternate routes do not necessarily mean enhanced performance because as the nodes along the optimal routes are depleted of energy, only non-optimal routes remain, further compounding the problem. In fact it could be more power consumption and more delay (due to longer route) which again lead up to performance degradation.

2. EARLY DETECTION AND AVOIDANCE OF ENERGY DEPLETION PROBLEM

Our proposed idea takes into consideration the residual energy of a node and the rate of energy consumption (REC) at a node as well. This method acts as a probe for early detection of energy depletion problem in a node. To avoid the energy depletion problem due to excessive energy consumption at a higher rate, we introduce the mobile relays [1]. The two assumptions in this method are that every node in the network is capable of calling the service of a mobile relay and that mobile relay always has sufficient energy to provide service to the critical nodes in the network.

2.1. Overview

Every node in Ad-hoc Network has some amount of initial energy. The energy of a node decreases as and when an event occurs. The events that can occur at a node are: receiving a packet, transmitting a packet, energy consumption in idle state, energy consumption in sleep state and transition from sleep state to active state. Receiving packets and transmitting packets are major events that consume most of the node's energy.

In the proposed idea, we monitor the rate of energy consumption (REC) and residual energy of a node over a fixed sampling time interval T seconds. If more events (mainly receiving packets and transmitting packets) occur at a node over this sampling interval of T seconds, more energy is consumed. Similarly if less events occur at a node over this sampling interval of T seconds, less energy is consumed. Hence we differentiate the rate of energy consumption (REC) at a node into three different levels: Low Rate of Energy Consumption (LREC), Average Rate of Energy Consumption (AREC) and High

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Rate of Energy Consumption (HREC) based on two thresholds: *thresh1* and *thresh2*. Also, for each level (Low, Average and High) of rate of energy consumption, we differentiate the residual energy of a node into: low residual energy (indicates node is critical) and high residual energy (indicates node is not critical). Critical or not critical is based on yet another threshold: *rthresh.* . The values of *rthresh* for LREC, AREC and HREC are different. For HREC *rthresh* may be set high. The criteria for setting the thresholds: *thresh1*, *thresh2* and *rthresh* are subjective.

2.2. Low Rate of Energy Consumption (LREC)

If the rate of energy consumption on a node over an time interval of T seconds is below *thresh1*, it is considered as Low Rate of Energy Consumption (LREC) on a node. For a node with Low Rate of Energy Consumption we set a threshold *rthresh* to monitor the residual energy.

Pseudo code: if (REC < *thresh1*)

REC = LREC;

If the residual energy of a node is below *rthresh*, the node is considered as critical. At this point, the service of a mobile relay is required to share the load. If the residual energy of a node is above *rthresh*, the node is not considered as critical and hence the service of a mobile relay is not required.

```
Pseudo code: if (LREC)
{
if (residual energy < rthresh)
node = critical; //Call for mobile relay
else
node != critical;
}
```

2.3. Average Rate of Energy Consumption (AREC)

If the rate of energy consumption on a node over an time interval of T seconds is between *thresh1* and *thresh2*, it is considered as Average Rate of Energy Consumption (AREC) on a node. For a node with Average Rate of Energy Consumption we set a threshold *rthresh* to monitor the residual energy.

Pseudo code:

if ((REC > *thresh1*) && (REC < *thresh2*))

REC = AREC;

If the residual energy of a node is below *rthresh*, the node is considered as critical. At this point, the service of a mobile relay is required to balance the load. Once the rate of energy consumption (REC) returns to lower level, the node is no more in a critical state and hence it can release the mobile relay so that it can provide service to other critical nodes in the network.

If the residual energy of a node is above *rthresh*, the node is not considered as critical and hence the service of a mobile relay is not required.

```
Pseudo code: if (AREC)
{
if (residual energy < rthresh)
node = critical; //Call for mobile relay
else
node != critical;
}
```

2.4. High Rate of Energy Consumption (HREC)

If the rate of energy consumption on a node over an time interval of T seconds is above *thresh2*, it is considered as High Rate of Energy Consumption (HREC) on a node. For a node with High Rate of Energy Consumption we set a threshold *rthresh* to monitor the residual energy.

Pseudo code: if (REC > *thresh2*)

REC = HREC;

If the residual energy of a node is below *rthresh*, the node is considered as critical. At this point, the service of a mobile relay is required to balance the load. Once the rate of energy consumption (REC) returns to lower level, the node is no more in a critical state and hence it can release the mobile relay so that it can provide service to other critical nodes in the network.

If the residual energy of a node is above *rthresh*, the node is not considered as critical and hence the service of a mobile relay is not required.

```
Pseudo code: if (HREC)
{
if (residual energy < rthresh)
node = critical; //Call for mobile relay
else
node != critical;
}
```

It is also possible that a node which is in critical state due to HREC and low residual energy may be not critical for LREC with the same low residual energy. So we can see that a node has multiple thresholds based on rate of energy consumption (REC) rather than a single threshold

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based on simple energy awareness analysis. This approach enhances the overall lifetime and the performance of the Ad-hoc Networks.

3. PERFORMANCE EVALUATION

The performance of the proposed idea is evaluated using the simulation tool Network Simulator - 2 (NS - 2) [8]. We measure the performance [11] in terms of residual energy of a node in the network at the end of the simulation. The results obtained are compared to the existing methods of solving energy depletion problem.

The simulation is carried out on Fedora Core 8 platform using NS-2 (ver2.33) [12]. Tool Command Language (TCL) is used along with C++ constructs to create the topology structure, to configure source nodes, intermediate nodes and destination nodes, to create the statistical data trace file, etc. NS - 2 also provides an inbuilt Energy Model [8] that uses the traditional method of keeping track of the residual energy of a node. Once the trace file is generated, AWK scripts are written for extracting the information from the trace file. Based on the output of these AWK scripts graphs are plotted for residual energy of a node v/s time for all critical nodes.

3.1. Simulation Setup

The simulation is carried out with two different scenarios:

3.1.1. Monitoring Only Residual Energy of a Node without Using Mobile Relays

In this scenario, the simulation is performed on 7 nodes which are deployed and distributed in a 500m x 500m boundary. We assume that nodes have no mobility. Simulation is performed for 100 seconds with Ad-hoc On - demand Distance Vector (AODV) routing protocol [9]. We set the Radio Propagation model of wireless networks as Two Ray Ground reflection model and set the maximum transmission range of nodes as 250 meters. The Medium Access Control (MAC) protocol is set to IEEE 802.11 and the bandwidth of the channel is set to 10Mbps.

Each node in the network has an initial energy of 100 joules. A node consumes energy of 1W on receiving a packet, 5W on transmitting a packet, 0.005W when node is in idle state, 0.0002W when node is in sleep state and 0.03W during transition from sleep state to active state. The size of data packets is set to 1000 bytes and traffic rate varies to 2, 3, 4, 5, 6, 7, 8, 9, 10 packets/sec.

Based on the inbuilt Energy Model of NS - 2, the nodes change their color from green to yellow and from yellow to red based on the measure of the residual energy. Green color indicates that a node has sufficient amount of residual energy. Yellow color indicates that only 50% of the initial energy is left in a node. Red color indicates only 20% of the initial energy is left in a node.

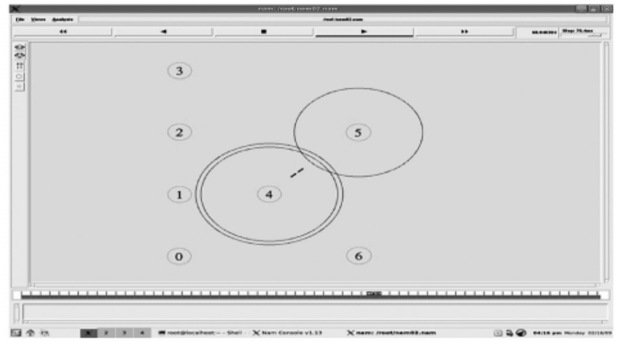

Fig. 1: Topology of 7 Nodes in 500m × 500m Boundary

In the above shown topology nodes 0, 1, 2 and 3 are the source nodes that generate the data traffic. Nodes 5 and 6 are set as the destination nodes. Node 4 is the intermediate node that transmits the data from source nodes to destination nodes because source nodes and destination nodes are not in communication range of each other. Being an intermediate node, node 4 looses its energy at a higher rate in receiving and transmitting packets from source nodes to destination nodes. Thus, the color of node 4 changes from green to yellow indicating that only 50% of the initial energy is left in the node. It is shown in Fig. 2. Also after sometime the node 4 changes its color from yellow to red indicating only 20% of initial energy is left.

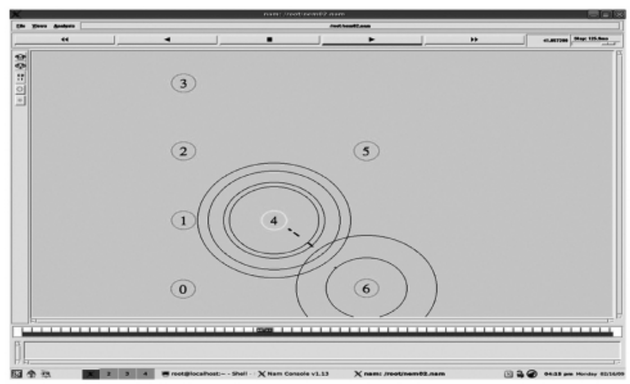

Fig. 2: Node 4 Changes its Color from Green to Yellow

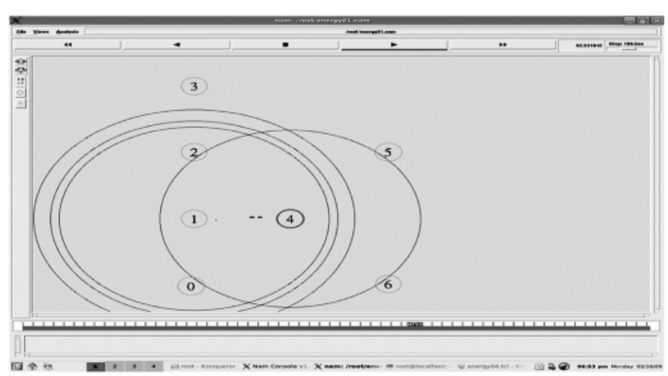

Fig. 3: Node 4 Changes its Color from Yellow to Red

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3.1.2. Monitoring Residual Energy and Rate of Energy Consumption (REC) of a Node and Use of a Mobile Relay

In this scenario, the simulation is performed on 8 nodes (7 mobile nodes + 1 mobile relay) which are deployed and distributed in a 500m x 500m boundary. We assume that nodes have no mobility. Simulation is performed for 100 seconds with Ad-hoc On - demand Distance Vector (AODV) routing protocol. We set the Radio Propagation model of wireless networks [10] as Two Ray Ground reflection model and set the maximum transmission range of nodes as 250 meters. The Medium Access Control (MAC) protocol is set to IEEE 802.11 and the bandwidth of the channel is set to 10Mbps.

Each node in the network has an initial energy of 100 joules. A node consumes energy of 1W on receiving a packet, 5W on transmitting a packet, 0.005W when node is in idle state, 0.0002W when node is in sleep state and 0.03W during transition from sleep state to active state. Both traffic models UDP/CBR and TCP/FTP are used. The size of data packets is set to 1000 bytes and traffic rate varies to 2, 3, 4, 5, 6, 7, 8, 9, 10 packets/sec.

Based on our proposed idea, the nodes change their color from green to yellow based on the rate of energy consumption (REC) and the measure of the residual energy. Green color indicates the node is not in critical state and service of mobile relay is not required. Yellow color of the node indicates it is in critical state and the service of a mobile relay is required to share the load.

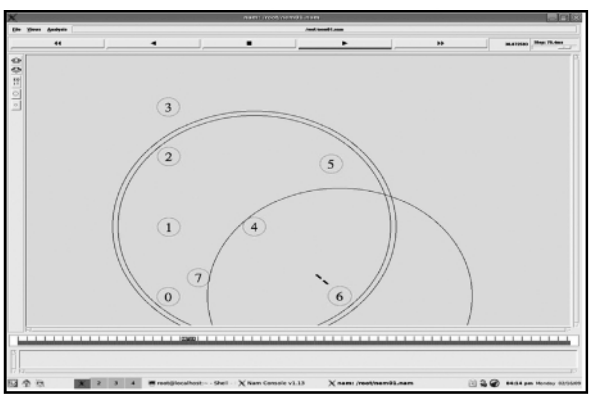

Fig. 4: Topology of 8 Nodes in 500m × 500m Boundary

In the above shown topology nodes 0, 1, 2 and 3 are the source nodes that generate the data traffic. Nodes 5 and 6 are set as the destination nodes. Node 4 is the intermediate node that transmits the data from source nodes to destination nodes because source nodes and destination nodes are not in communication range of each other. Node 7 acts as a mobile relay and keeps moving around the topology waiting for the critical nodes to call for its service.As and when a node becomes critical based on rate of energy consumption (REC) and residual energy, the node changes its color from green to yellow and calls for the service of a mobile relay. As shown in Fig. 5, the mobile relay (node 7) shares the load on the critical node (node 4).

Once the rate of energy consumption (REC) returns to lower level the node changes its color from yellow to green again and releases the mobile relay so that it can be used to provide service to other critical nodes. As shown in Fig. 6, the mobile relay (node 7) is released by critical node (node 4). Also the critical node (node 4) changes its color back to green from yellow indicating it is no more in a critical state.

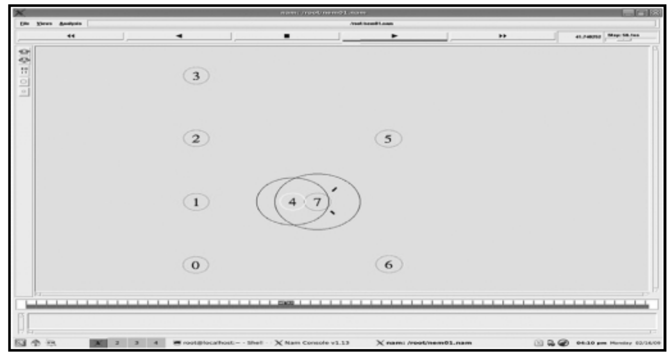

Fig. 5: Service of Mobile Relay is Called to Share the Load

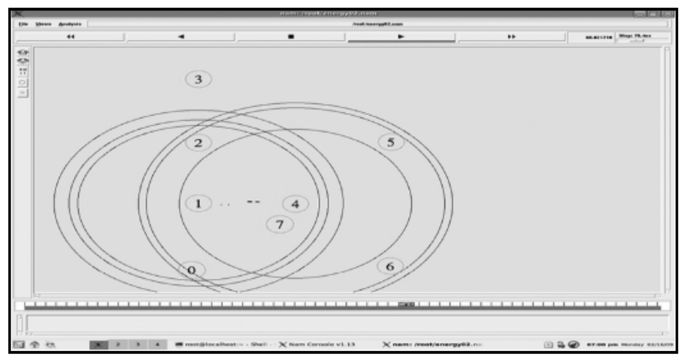

Fig. 6: Mobile Relay is Released and Node 4 Becomes Green

3.2. Simulation Results

The results of each of the above mentioned scenarios are evaluated as below:

3.2.1. Monitoring Only Residual Energy of a Node Without Using Mobile Relays

The simulation is performed for 100 seconds and the residual energy at the end of the simulation is observed for critical nodes. In our scenario we have only one critical node (node 4). The result obtained at the end of the simulation is as follows:

Table 1
Residual Energy at the End of Simulation

Critical Node id	Residual energy
4	6 joules

The graph of residual energy v/s time is as shown below:

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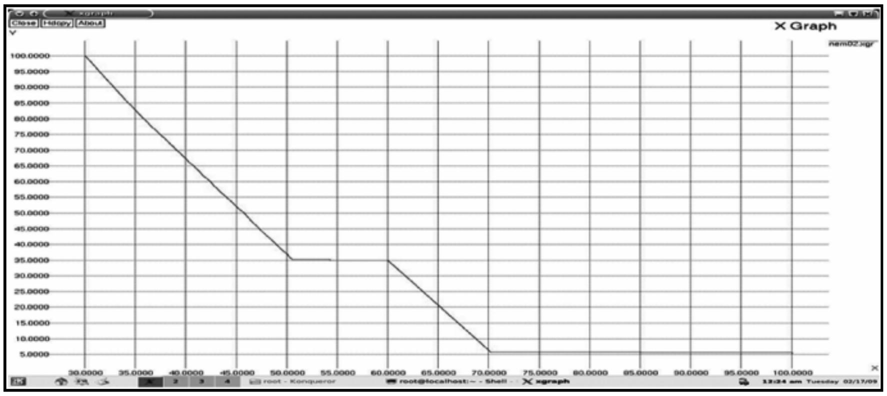

Fig. 7: Graph of Residual Energy v/s Time for Node 4

3.2.2. Monitoring Residual Energy and Rate of Energy Consumption (REC) of a Node and Use of a Mobile Relay

The simulation is performed for 100 seconds and the residual energy at the end of the simulation is observed for critical nodes. In our scenario we have only one critical node (node 4). The result obtained at the end of the simulation is as follows: The graph of residual energy v/s time is as shown below:

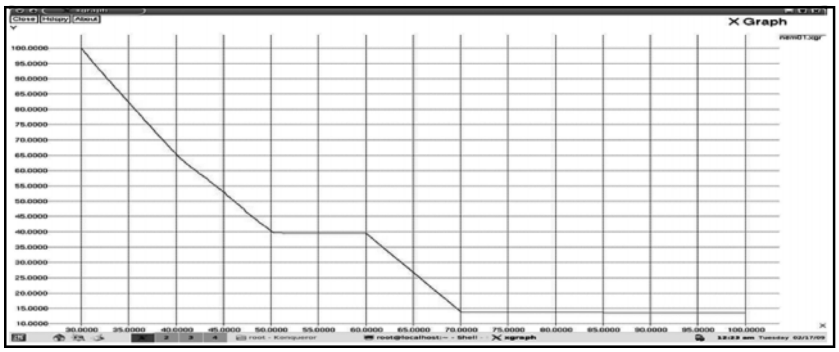

Fig. 8: Graph of Residual Energy v/s Time for Node 4

Table 2
Residual Energy at the End of Simulation

Critical Node id	Residual energy
4	14 joules

3.2.3. Comparing the Two Scenarios

Fig. 9 shows the performance of our proposed idea as compared to the traditional Energy model.

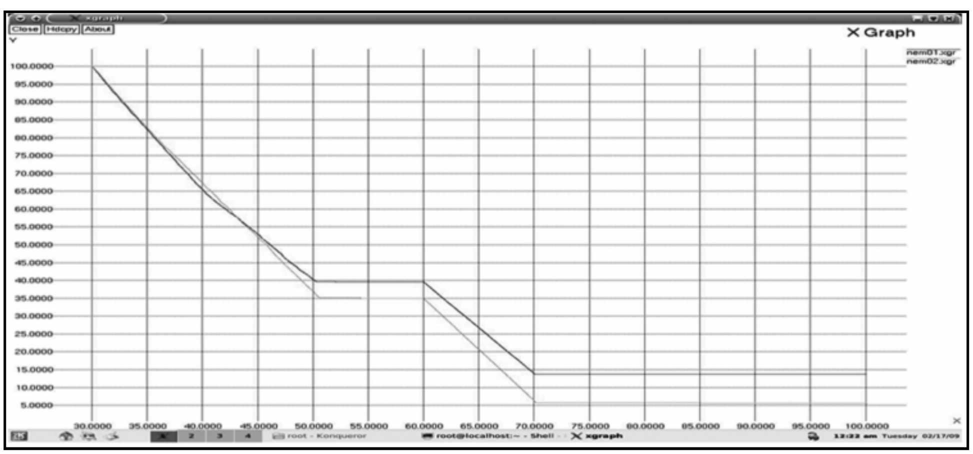

Fig. 9: Graph of Residual Energy v/s Time for Node 4

Green line in the graph indicates the performance of existing energy model and Red line indicates the performance of our proposed idea. We can see that the residual energy of the critical node (node 4) is 8% more in our proposed idea as compared to the existing energy model. And this has the potential to extend the life time of the node.

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4. CONCLUSION AND FUTURE WORK

Early detection and avoidance of energy depletion problem in Ad-hoc networks is possible based on monitoring the rate of energy consumption (REC) and remaining battery life (residual energy in a node). To avoid energy depletion problem due to excessive energy consumption at a higher rate, we introduce mobile relays in Ad-hoc Networks.

The lack of Ad-hoc Network capacity theory has stunted the development and commercialization of many types of wireless networks including emergency, military, sensor and community mesh networks. Information theory, which has been vital for links and centralized networks, has not been successfully applied to decentralized wireless networks [3]. Our proposed idea acts as a probe to analyze the performance of these decentralized wireless networks.

REFERENCES

[1] Wei Wang, Vikram Srinivasan, Kee-Chaing Chua "Extending the Lifetime of Wireless Sensor Networks through Mobile Relays", *IEEE/ACM Transactions on Networking*, **16**, No. 5, October 2008.

[2] Sanjay Chatterjee, Siuli Roy, Somprakash Bandyopadhyay, Tetsuro Ueda, Hisato Iwai, Sadao Obana "A Power Aware Routing Strategy for Ad-hoc Networks with Directional Antenna Optimizing Control Traffic and Power Consumption", *Indian Institute of Management*, Calcutta, India and ATR Adaptive Communications Research Laboratories, Kyoto, Japan.

[3] Jeffrey Andrews et al, "Rethinking Information Theory for Mobile Ad Hoc Networks" *IEEE Communications Magazine*, December 2008.

[4] Chao Gui, Prashant Mohapatra "SHORT: Self Healing and Optimizing Routing Techniques for Mobile Ad-hoc Networks", *Computer Science Department*, University of California, Davis.

[5] J. Gomez, A. T. Campbell, T. J. Watson, "Power Aware Routing Optimization (PARO) Protocol".

[6] T. X. Brown, S. Doshi, S. Bhandare, "Energy Aware Dynamic Source Routing (EADSR) Protocol" University of Colorado.

[7] S. Singh, C. S. Raghavendra "Power Aware Multi Acess Protocol with Signaling Ad-hoc Networks (PAMAS)".

[8] NS-2, "The ns Manual (Formally known as NS Documentation)" Available at *http: //www.isi.edu/nsnam/ns/doc.*

[9] Ian D. Chakeres, Elizabeth M. Belding-Royer. "AODV Routing Protocol Implementation Design".

[10] Magnus Frodigh, Per Johansson, Peter Larsson. "Wireless Ad hoc Networking—The Art of Networking Without a Network".

[11] Gao Fang, Lu Yuan, Zhang Qingshun, Li Chunli. "Simulation and Analysis for the Performance of the Mobile Ad Hoc Network Routing Protocols".

[12] Fu Qi, Jiang Yunxia,Jiang Ruilin. "NS2-Based Implementation of Routing Protocol Simulation in Ad Hoc Networks", *Computer Engineering and Applications*, **42**, No 5, Feb, 2006.

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