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Energy Consumption analysis under Random Mobility Model

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Abstract. The wireless ad hoc networks are restricted in the node energy. So the network lifetime rely heavily on the energy consumption of nodes. In this paper, we give an energy model and analysis the consumption of nodes using extensive simulations. The results shed a light on the future research of relative MANET fields

Keywords: MANET; energy consumption; AODV;DSR; energy model

1. Introduction

Wireless Ad hoc networks constitute a great part of next generation wireless communication networks, in which nodes communicate with each other through direct or multi-hop model. This kind of networks do not need the infrastructure that traditional communication networks rely on. Among them, the Mobile Ad Hoc networks have been widely deployed, especially in the environments such as battle fields or emergency relief scenarios [1].

The nodes in MANET act as hosts or routers and uses a multi-hop communication model. MANETs exhibit characteristics like dynamic topologies, bandwidth constraints, energy constraints, and link instability[2]. These characteristics pose critical challenges while providing survivable communication for MANET. Among them, energy consumption is the most important factor.

So, due to the limited battery resources owned by nodes in a MANET, its energy consumption should be modeled and analyzed. On evaluating the consumption problem, the routing protocol of MANET should be chosen carefully. We focused on the tree common ones: AODV, DSDV, DSR. It is an opportunity of this research to shed a light on the effect of protocols on the broken links. Also, the mobility models which control the movement of nodes in MANET have a crucial role to play in the consumption analysis. In this paper, we choose the random waypoint model as our mobility models , which is frequently used in the research area[3-4].

Also, we incorporate different mobility rates and different node density in our analysis. The node speed also take into consideration. Now we focused on the energy consumption under CBR traffic which is based on UDP.

The paper is organized as follows. In Section 2, we describe related work. In Section 3, we describe the mobility models and energy consumption model used. In Section 4, the NS-2 simulator and its simulation environment with the results are discussed. Section 5 concludes the papers..

2. Related work

J. Broch [5] analyzed routing protocols on wireless ad hoc networks like DSDV, AODV, DSR, and TORA. They used RWP mobility model and CBR traffic. Ioannis B [6]did a performance comparison of routing protocols for large-scale ad hoc networks. They carried out their experimentation on two simulators, namely, QualNet and NS-2. They claimed that AODV outperforms TORA in terms of packet delivery. They used CBR-based UDP traffic and random waypoint model. Chen and Hwa [7]conclude that the performance of routing protocol heavily depends on the mobility model it runs over in their work on mobility impact on energy conservation, They used DSR, AODV, TORA, and DSDV routing protocols for experimentation over various models using CBR traffic on NS-2 simulator.

3. System model description

3.1. Network Model Definition

Our network model is very similar to the ones used in [1]. We assume an ad hoc network can be modeled as a directed graph $G(N,A)$, where N is the set of all nodes and A is the set of all directed links (i,j) where $i,j\in N$. Let L_i be the set of all nodes that can be reached by node i with a certain power level in its dynamic range. We assume that link (i,j) exists if and only if $j\in L_i$. Each node i has its max communication range r_0 depends on the power level P_i. The wireless nodes are uniformly distributed within a rectangle area with width R. Each node is equipped with an Omni directional antenna which is responsible for sending and receiving signals. An ad hoc network is established by assigning a transmission power to each transceiver Energy model

We assumed in our paper that the consumed energy of nodes depends only on three factors: First, energy consuming happens when a node transmits a packet, and it follows the equations:

$$E_{Trans} = \alpha l E_0 \tag{1}$$

Secondly, when a node received packets, it also uses its energy. The using model follows the equation

$$E_{Receive} = wlE_0 \tag{2}$$

Last but not least, when a node is idle ,it also consumes energy because of listening the signals ,though the consuming unit is much smaller compare to the above two factors. And the energy consumed depends lineally with the time intervals

$$E_{Idle} = \gamma t E_0 \tag{3}$$

Where α,w and γ, are the energy factors. L is the packet length and E_0 is the energy consumed by unit length packet.

So,the total energy consumed by a node until time t follows the equation

$$E_{Total}(t) = E_{Receive} + E_{Trans} + E_{Idle} = wl_{Trans}E_0 + \alpha l_{Receive}E_0 + \gamma t E_0 \tag{4}$$

4. Simulation study

In this simulation study section, the energy consumption evaluation of MANET under random mobility model and Constant bit rate traffic model based on our energy model will be explain. Before analyzing the results obtain with our energy model a description of the scenarios used and how they were produced will be done. The choice made for the traffic model, the speed and the random model will be explained.

4.1. Parameters setup

In order to study how long the network lifetime is and how energy consumption changes under our energy model, we set the default parameters as follows:

The nodes' initial position are uniform randomly chosen from the two dimension squared simulation area of 2000m*2000m, the radio coverage is 250m, simulation time is 900s.Node initial energy is 200 J. The node idle Power is 0.5w. The node receive power is 1.0w and the node transmit power is 2.0w.

We use the common three routing protocols: AODV,DSDV,DSR as our based routing protocol.

4.2. Random movement model

At the beginning of simulation, every node is in-dependably choosing its mobility status: move or pause. If node is moving at beginning, it will choose a random destination waypoint in the simulation area and choose a speed according to a norm distribution between [Vmin,Vmax]. If node is pausing at time zero, after a normal distributed random time period, it will change to moving phase. If node is moving, it will keep moving until it reached the destination. After that, it will pause for a normal distributed random time period and go to the moving phase, again.

To generate random motion movement according to RWP model, with various velocities, a tool called setdest has been used.

4.3. Data traffic model

We use the Constant Bit Rate (CBR) traffic model as our Data traffic model. We use cbrgen tool to generate a random data communication scene.

Two sets of scenarios have been used, they are loose traffic scene and dense traffic scene . For the first kind , one using 1 source and 1 destination . For the second kind, may be up to 100 sources could be used .

A UDP agent is attached to a CBR flow. The aim of this first set of scenarios is to evaluate how a protocol can performs in very limited communication environment,

We also varies the simultaneous connections between source and destination to simulate different traffic scenes. The traffic model is generated by “cbrgen.tcl” tool. In order to see the node density effect under different amount of traffic, we use three types of traffic pattern.

4.4. Evaluation metrics

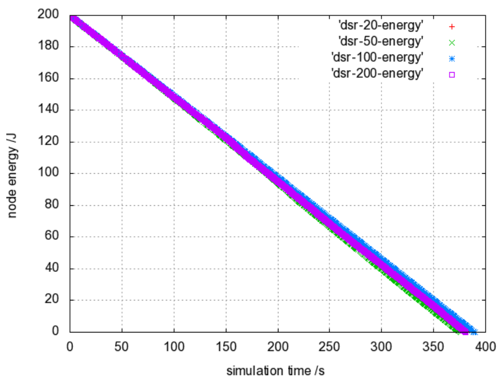
4.4.1 Node Density Effect

In order to see how the energy consumption is changing with a specific node density under our topology some different scenarios have been used with a maximum of 20 ,50 and 100 nodes, respectively. A squared 2000m by 2000m area is used as the simulation area. The choice of random moving nodes number is based on the fact that these settings have been used at most studies .Most of them are using parameters close to these one. These parameters have been set to be close to the reality and to be not too computer intensive.

We choose the RWP mobility model as our node mobility model. The setdest tool is used to generate the movement scene. It take over one hour to generate the 100 nodes movement scene, the 200 nodes scene take us over nigh hours!

The common three routing protocols: AODV,DSDV,DSR are used as our base routing protocol. The energy consumption are analyzed and showed below:

Each node can transmit up to 250m. A simulation time of 900s is used, which is long enough to evaluate our energy model.



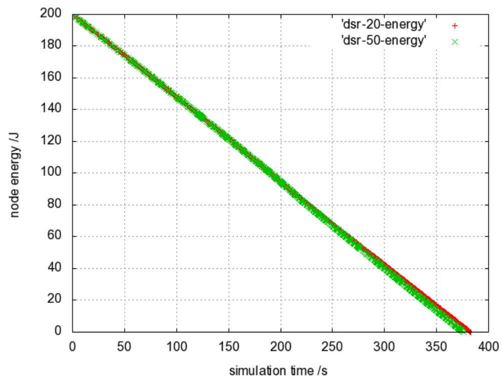
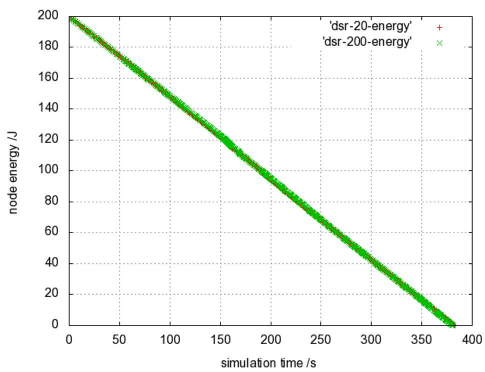


Figure 1. DSR under node density change between 20,50,100,200 nodes

Figure 2. DSR under node density change between 20 and 50 nodes



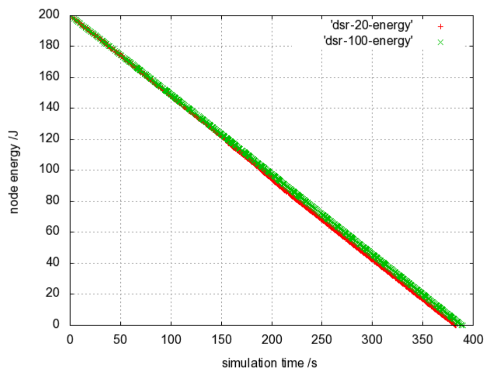


Figure 3. DSR under node density change between 20 and 200 nodes

Figure 4. DSR under node density change between 20 and 100 nodes

From the figures we can know that the effect of routing protocol and nodes density is minor under the loose traffic scene. We notice the network life time is about equal to the node idle time energy consumption, that is 200j/0.5=400s except some little difference.

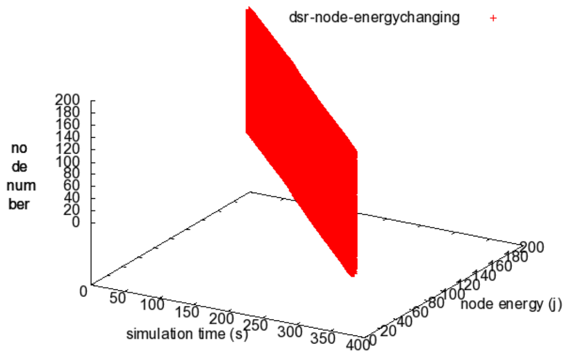


Figure 5. node energy changing under DSR and 1 traffic connection

We use 200 nodes and make them mobile under DSR routing protocol, the traffic scene contains a up tree maximum connection. The figure show that there is little difference for every node in the simulation area.

4.4.2 Velocity

As the velocity is an important parameter that can influence the proactive or reactive protocol performance like DSR,DSDV,AODV , and as it is known that DSR performs better in low mobility than in high mobility, it is sure that the energy consumption could changes according to the velocity. So both low and high velocity scenarios has been studied.

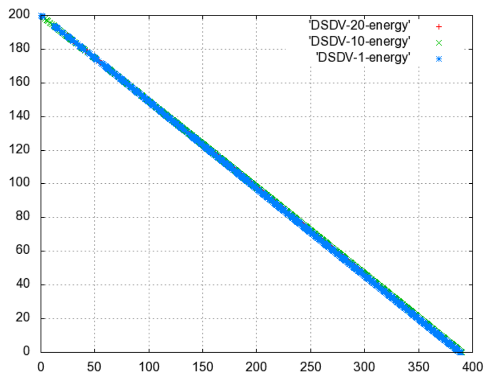


Figure 6. DSDV under different velocities

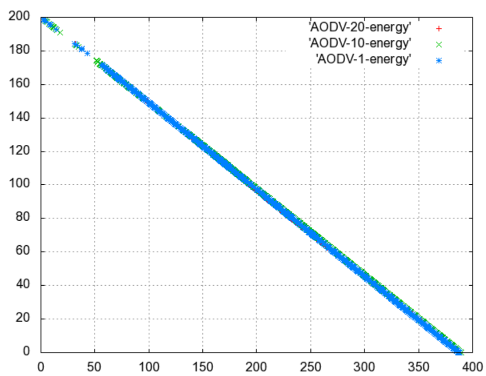


Figure 7. AODV under different velocities

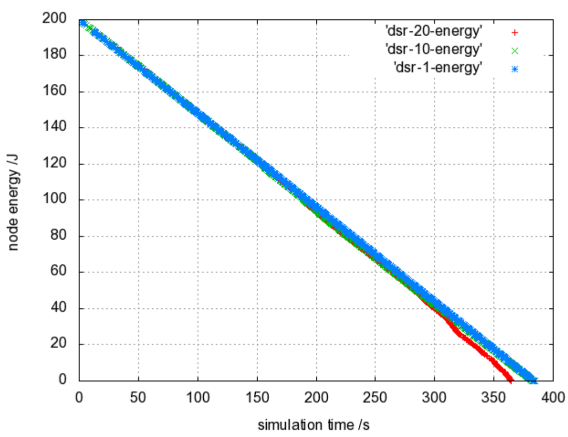


Figure 8. DSR under different velocities

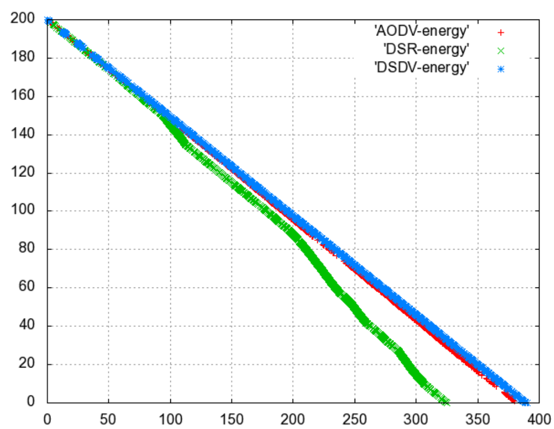


Figure 9. three protocols effect

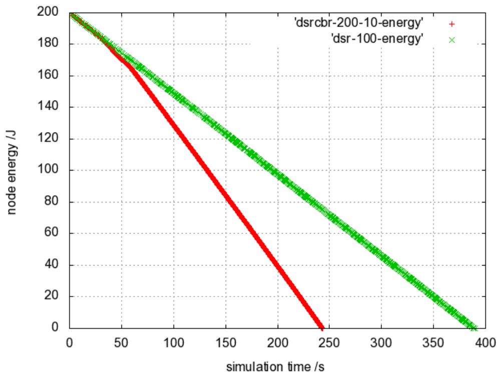
First two speed grades have been used: a high speed (20m/s) and low speed (1m/s). The high speed set of scenarios is close to the velocity of a car (20m/s or 72km/h) and the low speed one is similar to the velocity of a pedestrian (1m/s or 3,6km/h) But as the difference between 20m/s and 1m/s is large a medium value of 10m/s has been used which is close to the speed of a (fast) bicycle, in order to obtain more accurate results. Three set of scenarios have been produced :

We can see that the network lifetime do not change with velocity value under the AODV, DSDV routing protocol. But, in the DSR routing protocol, the lifetime is shorter when the nodes in high mobile environment.

4.4.3 Routing protocol effect

We can see for DSR routing protocol, the energy fluctuate frequently, while for the other two protocol, the energy consumption decreasing lineally with time.

4.4.4 Node density and traffic amount combination effect



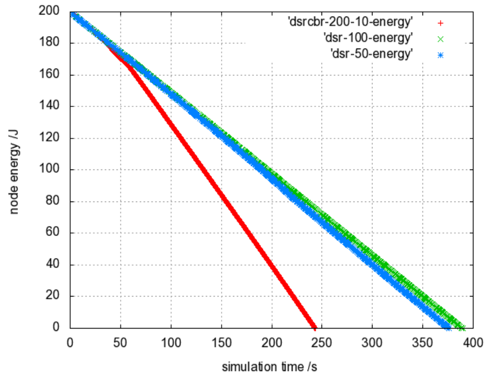


Figure 10. 200 nodes and 10 connections V.S. 100 nodes and 1 connection

Figure 11. 200 nodes and 10 connections V.S. 100 nodes and 1 connection and 50 nodes,1 connection

4.4.5 Traffic amount effect

We use DSR as the routing protocol and generate 200 nodes movement scene. The outcome of simulation trace file is very slowly. It took about twenties hours for the simulation to end. The movement scene generate by setdest tool also cost about 3 hours. The file is as big as 1.8 gigabytes!

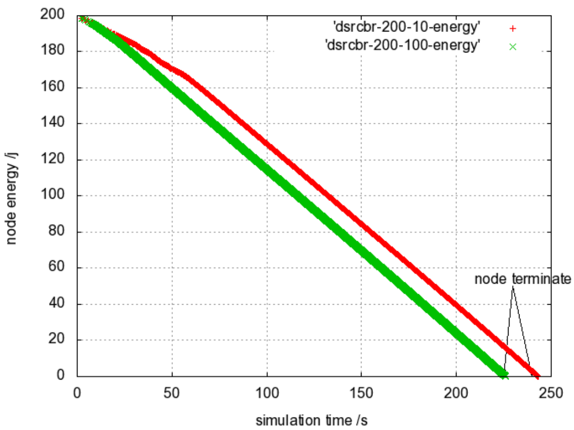


Figure 12.200 nodes and 10 connections V.S. 200 nodes and 100 connection

From the figure we can see when the nodes-traffic ration is big, say 20,then the network lifetime changes dramatically.

4.4.6 Source node lifetime and immediate node lifetime

We evaluate the lifetime of source node and immediate node under loose traffic scene, the figure show that the difference between these two kinds of nodes is small. One can image it is because the node do not have much opportunity to forwarding packets, so the node life time depend heavily on the node idle energy consumption.

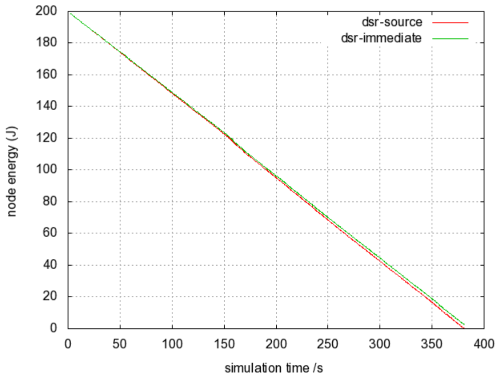


Figure 13. Source node and immediate node energy consumption under DSR.

5. Conclusion

In this paper, we have derived the relationship between the node density and the network lifetime. The relationship between network energy consumption and node velocity are also analyzed. We find that the routing protocol have little effect on node energy consumption based on loose traffic environment. We simulated the network energy consumption under different traffic model. The results show that about 3.6 % energy is saved by using the ten connections compared with the one hundred connection in two hundred DSR nodes environment. Finally, future research should be done to extend our simulation to discover more facts

6. References

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