Project 3. Measuring Wireless Throughput Capacity

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Overview

In project3, we are required to use ns3 to measure and compare the efficiency (total number of bytes received divided by total number of bytes generated) of a ad-hoc wireless network under different node density, transmission power, routing protocol and traffic intensity.

Methodology

We choose to vary only one parameter for each experiment run and fix the other parameters as their initial values. And we run experiments separately for ADOV and OLSR.

Initial value:

LAN area (meter^2): 1000 * 1000

Wireless network standard: 802.11a

Node number: 50

Power (dBm): 16

Traffic intensity: 0.9

Two Protocols: ADOV and OLSR:

1) Ad-hoc On-demand Distance Vector (AODV)

It is a reactive and on-demand routing protocol that it only initiates the routing discovery when a node want to send data.

AODV uses three kinds of message: RREQ, RREP and REPR.

a) Advantage

AODV protocol is a flat routing protocol it does not need any central administrative system to handle the routing process. The AODV protocol is loop free and avoids the counting to infinity problem. AODV has higher bandwidth share, and also tries to keep the overhead small. If the miss rate is low in routing table, then the overhead of the routing process will be minimal.

b) Disadvantage

When the routing information increases, miss rate will increase. The fetching of routing information will cause increase in latency, which may degrade the performance.

2) Optimized Link State Routing protocol (OLSR)

It is a proactive link-state routing protocol that nodes maintain tables representing the whole topology of the network. They update the topology information periodically.

a) Advantage

OLSR has less average end-to-end delay. Thus it is suitable for application that requires QoS of less delay. OLSR is also a flat routing protocol; it does not need central administrative system to handle its routing process. Since each node contains a routing table that has topology information of the whole network, it increases the protocol suitability for ad-hoc network with the rapid changes of the source and destinations pairs. OLSR protocol does not require that the link is reliable for the control messages, since the messages are sent periodically and the delivery does not have to be sequential.

b) Disadvantage

OLSR consumes extra power and bandwidth to update the topology information. It also costs a lot to inform and change the routing table of each node when a broken link has been found.

3) Comparison

a) Resource usage

Since OLSR need to update the topology information periodically and also need to contain useless routing information, it requires much more storage. In addition, the control message overhead burns much more energy.

On the other hand, AODV initiates routing only on demand, thus only active routing information are stored on the node, which leads to less storage. In addition, no periodic update also reduces the energy consumption and bandwidth occupation.

b) Scalability

As proactive protocol, OLSR must maintain the routing table for all the possible routes. Thus when number of mobile hosts increases, the overhead for sending control messages also increases. This control message might start to congest the network. This constrains the scalability of the OLSR protocol. The OLSR protocol works most efficiently in the mobile networks.

The overhead of reactive protocols like AODV is related mostly to the discovery of the new route and the updates of the usable routes. So for network with light traffic and low mobility, such reactive protocol scales perfectly with low bandwidth and storage overhead. The undesirable environment for reactive protocols is the network with heavy traffic and large number of fast-moving nodes. This would lead to a low hit rate and thus the idea of cached routing information fails to work.

Simulation results and analysis

1、Node density

Node density is average node number per unit area. We randomly put nodes in a 1000m * 1000m area (area fixed during the whole simulation).

By varying node number, we change the number of nodes density from 20 / km^2 to 150 / km^2.

The figure below is only for the ADOV protocol with node number from 20 to 250.

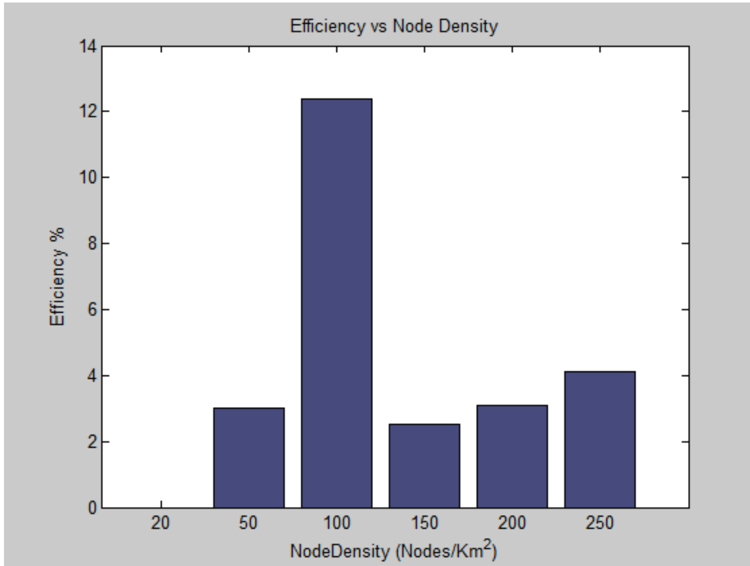

Figure 2. Efficiency over node density of AODV

Analysis:

As we can see from the figure, when node number is relatively small (equal and less than 100), efficiency goes larger with the increasing of the node number. We can also find, when the node density is extremely small (20 / km^2), the efficiency drops to 0. This is because nodes are spread too far away from each other that the distance between each other exceeds the transmission range under given transmission power. As more nodes are being added to the area, more node pairs drop into the transmission range, which leads to an increase in efficiency. However, as the node density keeps increasing, the communication collision begins to dominate. This explains the sharp drop in efficiency when node number increases to 150. When the node number increases further, although collision rate increases, that increase is "outweighed" by the decrease of bit error rate (BER) due to increased energy per bit. Thus we can observe a slight increase in efficiency.

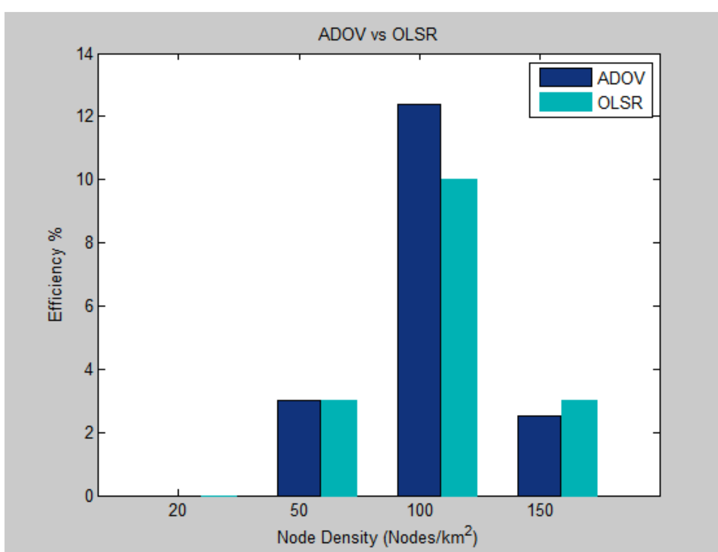

Figure 1. Efficiency over node density of OLSR and AODV

Analysis:

As we can see from this figure, AODV has better performance than OLSR. It is because that AODV initiates route discovery process only when a node wants to send packets. It does not need to update the topology information periodically as OLSR, which costs much more overhead both in energy consumption and bandwidth. Therefore, when the network is relatively less dense in terms of nodes, AODV that introduces lower overhead would gain better performance.

Thus, we can see that when node number is equal or larger than 100, OLSR has better performance than AODV. When the node density keeps increasing, the network efficiency of both AODV and OLSR decrease obviously. The reason is that AODV is a reactive routing protocol, which means that nodes need to calculate the routing path each time when there is no valid route information being cached. And that cache miss rate becomes higher with the increase of node number. Thus more latency will be introduced and thus performance will be degraded.

2、 Transmission Power

In this section, we want to analyze the influence of transmission power in both routing protocols. We vary the transmission power range of each node from fairly small (5 dBm) to large (30 dBm). For each single simulation run, we keep the transmission power of all nodes the same for convenience. The figure below shows result of AODV.

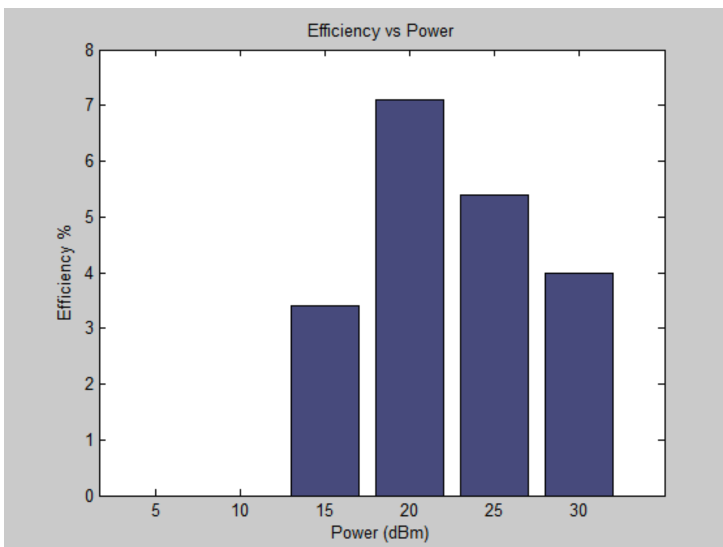

Figure 3. Efficiency over transmission power of AODV

Analysis:

As we can see from Figure 3, when the transmission power is too small (5 or 10 dBm), the transmission range is not large enough for a successful packet transmission. Thus we see a 0 efficiency. When the power increases, more and more successful packet transmissions can be made, and the efficiency goes up. At around 20 dBm, most of the nodes fall the range of other. When power goes up further, the range becomes larger, and transmission collision becomes serious and starts to degrade the performance. That is why the efficiency begins to decrease.

3. Traffic Intensity

In this section, we analyze the impact of traffic intensity on the efficiency of the network.

We tried again to run the experiment with a larger range of traffic intensity, which is shown in Figure4. This time we can see when traffic intensity increases to a fairly high level (greater than 0.6), the efficiency tends to drop due to highly congested network and collision.

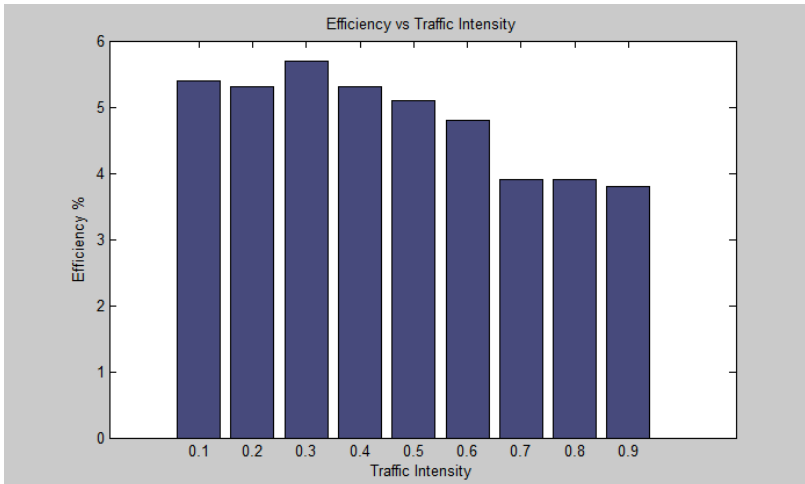

Figure 4. Efficiency over traffic intensity of AODV

Traffic intensity is defined as the total data demand on the network divided by the theoretically maximum possible data transmission rate. We set the traffic intensity of the network to {0.5, 0.6, 0.7， 0.8}, and the results are as shown in the figure below.

Analysis:

As can be seen, the efficiency tends to fluctuate with intensity. Theoretically the trend should be a decreased one. The second figure can partly explain the decrease. ADOV outperforms OLSR, which is expected due to previous discussion. The fluctuation can be explained by the randomness of node positions, and we didn't run multiple times for each configuration of parameters.

4、 Routing protocol

Here we use Figure1 and Figure5 to compare these two transmission protocols.

For the two figures, ADOV outperforms OLSR. For Figure1, we can see that when node number is equal or larger than 100, OLSR has better performance than AODV. This can be partly explained by the features of them: AODV is a reactive routing protocol, which means that nodes need to calculate the routing path each time when there is no valid route information being cached. And that cache miss rate becomes higher with the increase of node number. Thus more latency will be introduced and thus performance will be degraded.

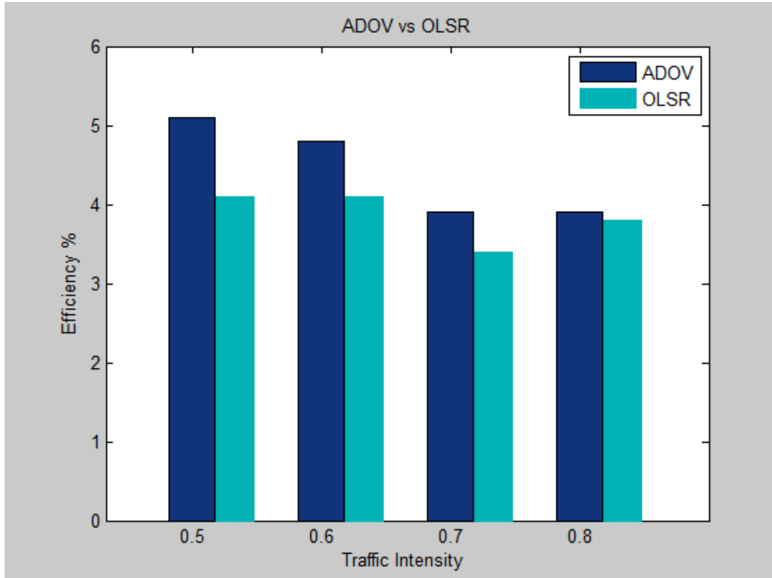

Figure 5. Efficiency over traffic intensity of AODV and OLSR