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# Comparison of Energy Efficiency of Nodes in Next Generation Wireless Network

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***Abstract*****—** Energy saving is an important task in wireless networks. Mobile nodes have limited battery energy and it is difficult to recharge or replace the battery of the nodes. In this paper, a wireless network has been designed for comparing energy by means of various scenarios, using battery model and energy model. There are three scenarios used for comparison, which are 1) Mobility 2) Number of hops 3) Distance. . The proposed networks are compared and on the basis of the performance analysis, it provides results for a wireless Adhoc network with the AODV routing protocol, under different scenarios. In this paper, we have concluded that the energy consumption and power dissipation is more in case of mobile nodes than the stationary nodes and also increases with the number of hops and the distance of nodes.The tool used for the purpose of simulation was QualNet 5.0.

***Keywords*****—** AODV routing, Adhoc network, battery model, energy model, QualNet 5.0.

## I. Introduction

There is a need to save energy due to increase in energy demand today as wireless networks have high power consumption. The largest elements of power consumption are access networks (wired and wireless) rather than the core networks. By reducing power consumption of wireless networks we can improve the energy efficiency.

Ad-hoc routing technology has been developed primarily for networks of mobile nodes. An Ad-hoc Network is an infrastructure less wireless network which is a collection of self organized mobile nodes that dynamically forms a temporary network which doesn't have any fixed infrastructure and centralized control, unlike cellular wireless networks. Often ad-hoc network topology is dynamic. In ad-hoc network, the nodes which are in the transmission range of each other communicate directly otherwise communication is done through intermediate nodes which are willing to forward packet hence these networks are also called as multi-hop networks. The nodes thus serve as packet source, packet sink as well as router. Nodes must route packets for other nodes to keep the network fully connected.

These mobile nodes have limited battery energy, when battery discharges then it becomes very difficult to recharge or replace the battery of nodes. These nodes need to be energy conserved tomaximize the battery life as well as lifetime of nodes. We have considered routing protocol AODV for mobile ad-hoc network and evaluated the energy performance metrics.

The Ad hoc- on Demand distance vector (AODV) routing protocol provide wireless communication in three modes namely unicast, multicast and broadcast. The source node (node who wants to communicate) in AODV initiates route discovery. The route is required to maintain a path between source and destination. It follows route request. Whenever source wants to communicate, it sends data to an unknown destination by broadcasting RREQ (Route Request). The nodes receiving RREQ, if not the destination, broadcasts this RREQ and also creates a route to the source. If the intermediate node receiving RREQ is the destination, it sends back RREP (Route Reply).

Once the RREP is received and route is discovered, source can start sending its data to the destination. As the hop count is an important factor in AODV, thus the source node selects the route with shortest hop count if multiple RREPs are received. As data flows from the source to the destination, each node along the route updates its routing table maintain the route. The nodes are mobile so there is always a possibility of link breakage. If the link is broken while data is flowing and is detected then a Route Error (RERR) is sent to the source of the data in a hop-by hop fashion. Whenever a source receives a RRER, it invalidates the route and reinitiates the route discovery.

The paper has the following scenarios considered for comparison of energy of various nodes:-

1) Mobility
2) Hopping
3) Distance

Different Traffic and energy consumption modes used in the simulation are:

*Traffic Model*

Traffic model used in the simulation is (CBR),which represents constant-bit-rate traffic. It is generally used to either fill in background traffic to affect the performance of other applications being analyzed, or to simulate the performance of generic network traffic. The CBR model collects the following statistics:

- Time when source to destination node session isstarted.
- Time when source to destination node session is closed.
- Number of bytes sent.
- Number of bytes received.
- Throughput.



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*Energy Consumption Model*

The battery power consumption of the mobile devices depends on the operating mode of its wireless network interfaces. Considering a broadcast transmission between the nodes of the active network, the wireless interfaces can be assumed to be in any of the following operating modes:

- Transmit: source node packet transmitting.
- Receive: source to destination node packets received.
- Idle: in this mode the node is ready to transmit packets.
- Sleep: it is the low power consumption mode state when a node cannot transmit or receive until woken up.

The model used in this paper for calculation is Generic Radio Energy Model.

*Battery Consumption Model*

Battery models capture the characteristics of real-life batteries, and can be used to predict their behavior under various conditions of charge/discharge. The model used in this paper is Linear Battery Model which uses coulomb counting technique.

## II. SIMULATION ARCHITECTURE

The basic architecture of the adhoc wireless network is as follows:-

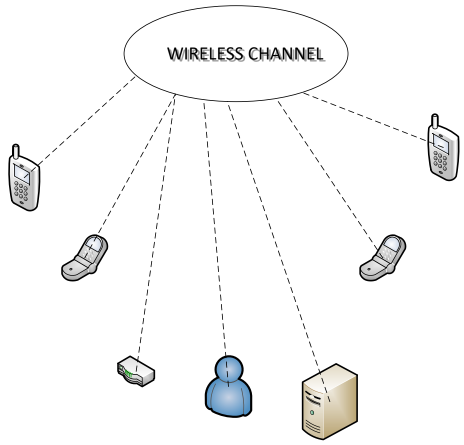


Fig. 1. Basic architecture of wireless adhoc network.

The specifications used in our simulation are as follows:

- *Node type*: Two types of nodes are used one being stationary and other mobile for the purpose of com
- *Routing*: The routing scheme is AODV. Different routing schemes are used for the purpose of comparison.
- *Application Server*: CBR has been used to cater the load generated by the users.
- *Radio Type*: All nodes communicate via IEEE 802.11b type radio link.

We have considered three different architectures for the purpose of comparison. The scenario evaluated in each is described as follows:

*Mobility*

In the first architecture we have considered two types of nodes, i.e., mobile nodes and stationary nodes which form a wireless adhoc network. the mobile/sink nodes generate application request and communicate via IEEE 802.11b type radio link. The packets are demanded between nodes by using CBR link. Data is transmitted form source to destination by hopping through various nodes in between. AODV routing protocol is used. The energy consumed by each node is then compared.

*Hopping*

In the second architecture we have considered stationary nodes which form a wireless adhoc network. The nodes communicate via IEEE 802.11b type radio link. The application request is generated using a CBR link. Packets are transmitted form source to destination by hopping through various nodes in between. In this we have considered three sub cases.

- Three hops
- Four hops
- Five hops

The energy of each case is then compared.

*Distance*

In the third architecture we have again considered stationary nodes which form a wireless adhoc network. The nodes communicate via IEEE 802.11b type radio link. The application request is generated using a CBR link. Packets are transmitted form source to destination by hopping through various nodes in between. In this we have compared the energy dissipation of nodes with respect to distance.

## III. SIMULATION MODEL

There are different simulation models that were simulated, considering different parameters for the desirable results. These are as follows:

*Mobility*

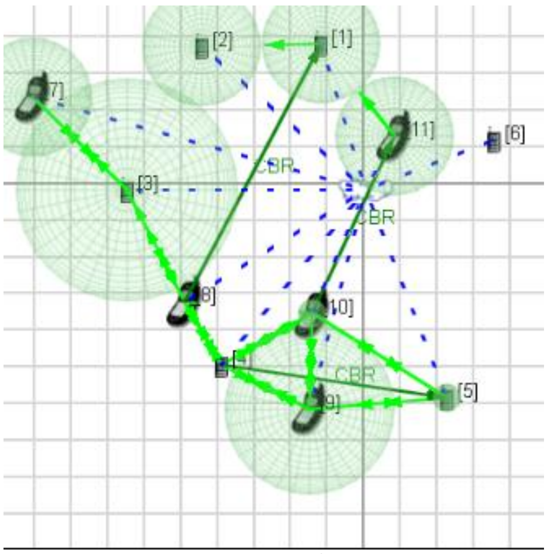


Fig. 2. Mobility of nodes.

A mobile node in wireless network is the one whose location may frequently be changed. Mobility can widely vary. A stationary node consumes less energy than a mobile node.



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*Number of hops*

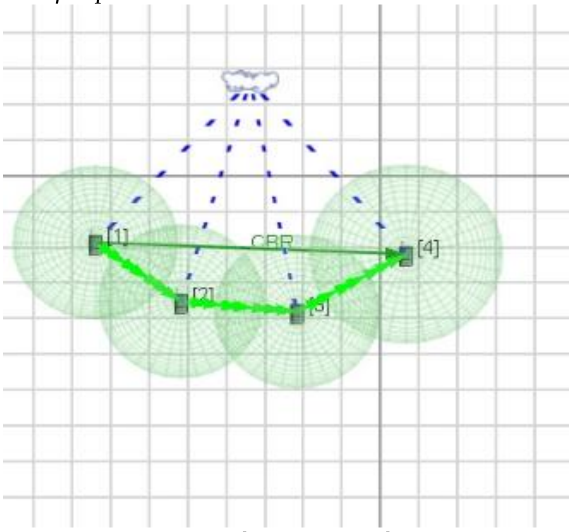


Fig. 3. Three Hop network.

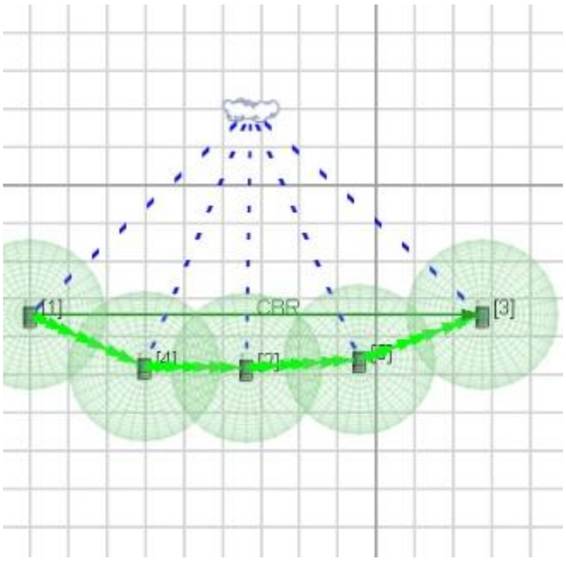


Fig. 4. Four Hop network.

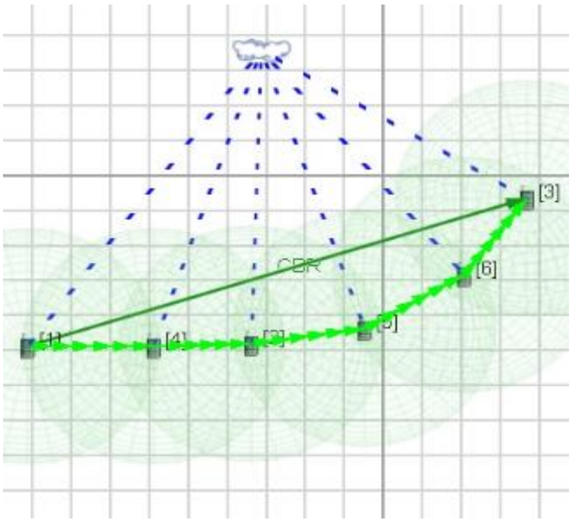


Fig. 5. Five Hop network.

A hop represents one portion of the path between source and destination. When communicating over the Internet, for example, data passes through a number of intermediate devices (like routers) rather than flowing directly over a single wire. Each such device causes data to "hop" between one point-to-point network connection and another.

*Distance*

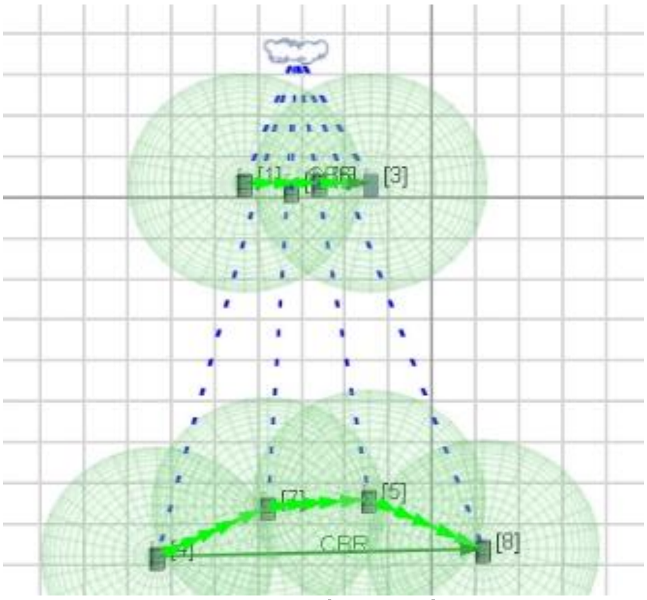


Fig. 6. Distance between nodes.

Different number of nodes are placed at varying distances. Energy dissipated increases with the increase in the distance of nodes, with respect to each other.

## IV. Simulation Parameters

QualNet 5.1 software is used for simulating the various scenarios. Different networks are simulated, using different number of hops, varying distances from the nodes and mobility. These networks had varying number of mobile nodes and the traffic generated .The simulation parameters which we have configured for our network are summarized in Table 1 below.

TABLE 1

| | |
|---|---|
| **Physical Layer Parameters** | |
| Radio type | 802.11b |
| Antenna height | 1.5m |
| Antenna model | Omnidirectional |
| Antenna Efficiency | 0.8 |
| Energy model | Generic |
| Path loss model | Two ray |
| No. of channels | 1(2.4GHz) |
| Routing protocol | AODV |
| **Application Layer Parameters** | |
| Applications | CBR |
| Packet Size | 512 Bytes |
| Items sent | 1004 |
| Average talking time | 20 seconds |
| Call status | Accept |
| Encoding CODEC | G.711 |
| Packetization Interval | 20 milli-seconds |
| **MAC Layer Parameters** | |



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| | |
|---|---|
| MAC protocol | 802.11 |
| Station Scan Type | Passive |
| **Network Layer Parameters** | |
| Network Protocol | IPv4 |
| Routing Protocol | AODV |
| **Transport Layer Parameters** | |
| TCP | Enable |
| TCP Variant | Lite |
| Maximum Segment Size | 512 bytes |

## V. Result and Analysis

The simulation results are gathered and compared in a graphical form. The following parameters are compared:

- Energy consumed in Transmit mode.
- Energy consumed in Receive mode.

*Mobility*

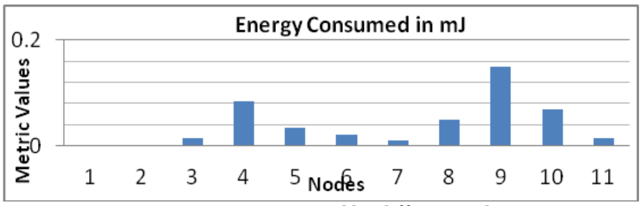


Fig. 7. Energy consumed by different nodes

*Analysis:* Node 9 consumes maximum energy. It is a mobile node transmitting large number of packets. Node 8 and 10 being mobile nodes also consume significant amount of energy. Node 4 is involved in large number of hops so its energy consumption also appears more. Nodes 1 and 2 are stationary and not involved in transmission of packets so consume negligible energy.

*Hopping*

1) *Case 1*

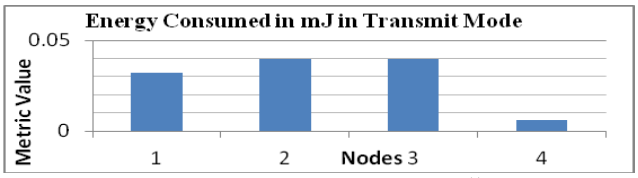


Fig. 8. Energy consumed in transmit mode by different nodes.

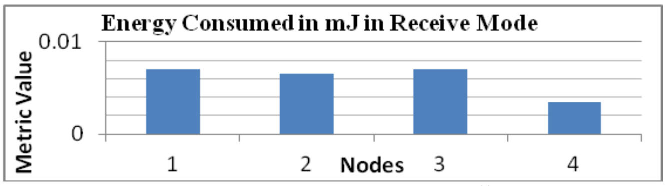


Fig. 9. Energy consumed in receive mode by different nodes.

2) *Case 2*

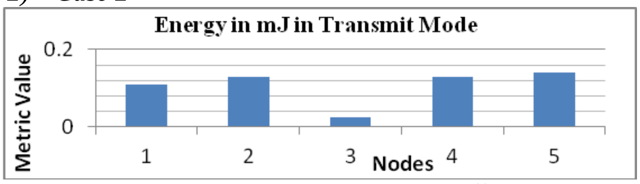


Fig. 10. Energy consumed in transmit mode by different nodes

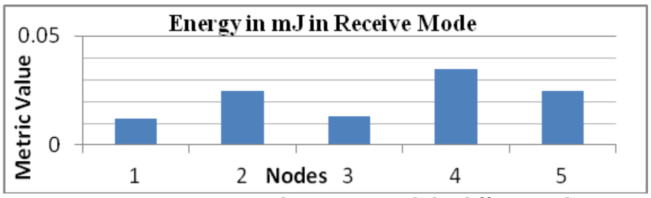


Fig. 11. Energy consumed in receive mode by different nodes

3) *Case 3*

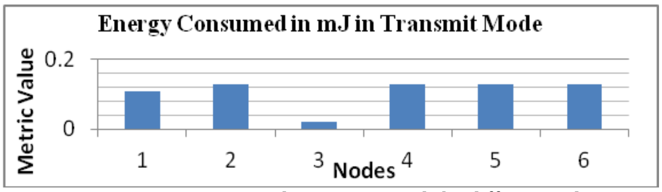


Fig. 12. Energy consumed in transmit mode by different nodes

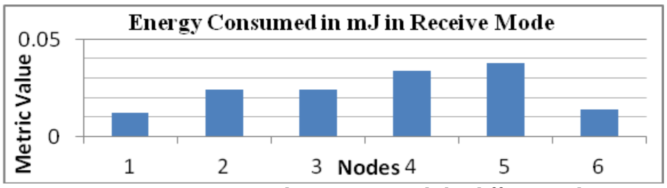


Fig. 13. Energy consumed in transmit mode by different nodes

*Overall comparison:*

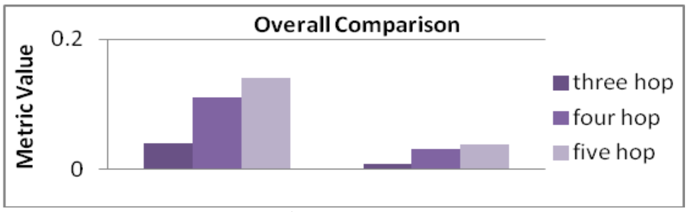


Fig. 14. Overall Comparison of Energy consumed in transmit and receive mode by different nodes

*Analysis:* As it can be seen from Figures above, there is a gradual increase in the number of hops from the source to destination. With this increase, there is a corresponding increase in the energy dissipation of the nodes from 0.04mJ to 0.14mJ (milli Joules) in transmit mode and from 0.007mJ to 0.038mJ (milli Joules) in receive mode.

*Distance*

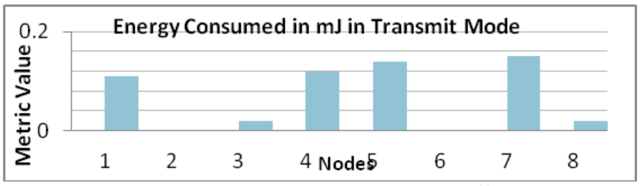


Fig. 15. Energy consumed in transmit mode by different nodes



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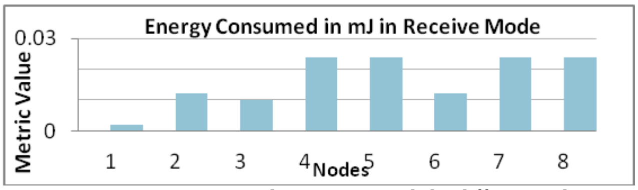

Fig. 16. Energy consumed in transmit mode by different nodes

*Overall comparison:*

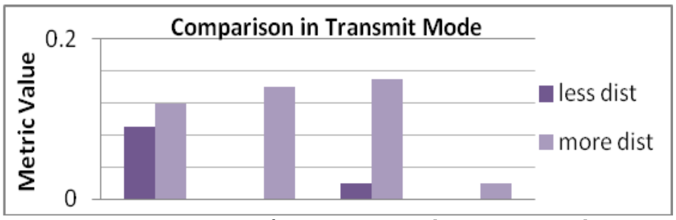

Fig. 17. Comparison of Energy Consumed in Transmit Mode

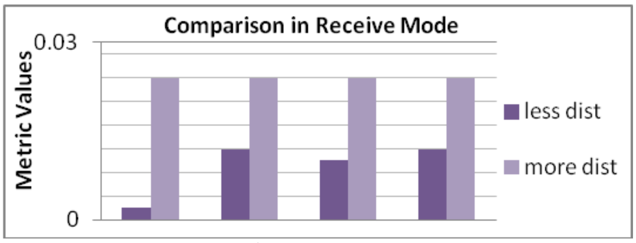

Fig. 18. Comparison of Energy Consumed in Receive Mode

*Analysis:* As it can be seen, the nodes which are separated by a larger distance i.e. nodes 4, 5, 7 and 8 represented by light color, consume more energy while the nodes which are located close by represented by dark color consume less energy (nodes 1, 2, 3, 6).It can be concluded that energy consumed increases directly with increase in distance between the nodes as more energy is required for packets to hop from one node to another.

## VI. Conclusions

In this paper energy dissipation in different types of nodes has been compared using a wireless adhoc network using battery and energy models. On the basis of simulated results and analysis, it can be concluded that mobile nodes consume more energy as compared to stationary nodes. Secondly, as the number of hops required for transmission increases the energy required also increases. Thirdly, energy consumed is directly proportional to distance between the nodes, i.e., more the distance more will be the energy required.

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