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An Efficient Approach for Increasing Power Optimization in Mobile Ad-Hoc Networks

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***Abstract*— Power saving mechanism in general represents the techniques used to maximize the time that nodes spend in a low power consumption sleep state. These techniques require the sender to notify the receiver about the pending traffic using some form of traffic announcement. Asynchronous traffic announcement mechanisms are mostly suitable for the ad-hoc environment. This involves relatively limited power savings. In this, a power saving mechanism is proposed. The aim is to improve the efficiency of asynchronous traffic announcement mechanisms by reducing the proportion of time that nodes need to spend awake, by maintaining good connectivity properties. The power save procedure is based on allowing traffic announcements and these are rebroadcast by neighbouring nodes. At last, a comparison is made between with synchronization and without synchronization modes. It is found that without synchronization is effective compared to synchronization mechanism.**

Keywords*— *Power save, Asynchronous Traffic Announcement, Synchronization, Energy and Rebroadcast.

I. Introduction

Computer networks have made revolutionary changes in our life. With the advance of technology, new generation of data networks operate at a faster speed and are more convenient. The advance has made the computer networks more easy to use in terms of both bandwidth and compatibility. To make computer networks easier to reach people no matter where they are, wireless data networks have become essential in both today's industry and research institutes. Power saving in wireless networks is an important and challenging issue particularly for battery operated nodes such as mobile devices and sensor nodes. The most popular approach towards saving power is to periodically switch off network nodes or few of its components for a certain time interval. IEEE 802.11 [1] is the most widely adopted protocol standard for wireless local area networks (WLANs). WLAN specifies two modes of operation and it is shown in the fig.1. A Mobile Ad-hoc Network (MANET) is an autonomous network that consists of mobile nodes that communicate with each other over wireless links. This type of network is suited for use in situations where a fixed infrastructure is not available, not trusted, too expensive or unreliable. In the absence of a fixed infrastructure, nodes have to cooperate in order to provide the necessary network functionality.

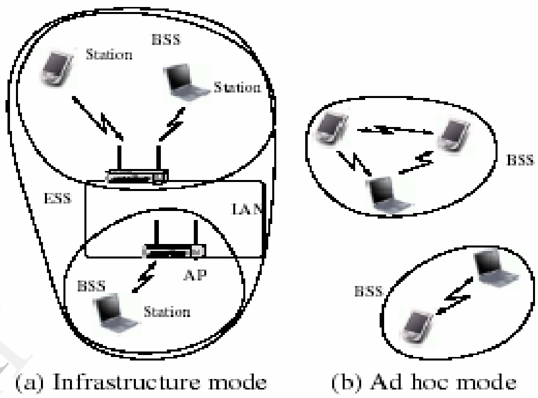

Fig. 1. System architectures of IEEE 802.11

The rest of the document is organized as follows: Section 2 gives related work regarding the power saving mechanism. Section 3 describes the proposed power save procedure. Section 4 deals with the NS-2 simulation setup with the results and its performance analysis and Section 5 concludes the optimization procedure and it describes the future work that can be carried out in this area for ad hoc networks

II. POWER SAVING MECHANISM

Power saving strategies make an effort towards maximizing power efficiency, which is one of the most important aspects in mobile networks for saving power in mobile devices. The IEEE 802.11 standard adopts a sleep wake power saving scheme in MAC layer and in the ad hoc mode, it uses a fully connected network. Power saving is an important and challenging issue in wireless networks, in particular for battery operated nodes such as mobile devices and sensor nodes. A popular approach [2], [3] to save energy is to periodically switch off a node or a few of its components for a certain time interval. In wireless ad hoc networks, switching off network nodes might not only have impact on the reach ability of a single node but also on the connectivity of the whole network.

Several approaches therefore propose to introduce synchronization mechanisms among the ad-hoc network nodes. Nodes may wake up in a synchronized way, exchange data, and fall into sleep again after data exchange.

Synchronization however is not easy to achieve and introduces also some overhead. IEEE 802.11's power management scheme puts idle stations into sleep by shutting down their transceivers [4], [5]. The power management of IEEE 802.11 is based on a well synchronized system. A mechanism is proposed that avoids synchronization and try to take advantage of intermediate nodes that can relay traffic indication map messages between a sender and a receiver node.

A. IBSS Power Management

In the architecture mode, the AP coordinates the operations of other stations, so does not throw challenging issues like power and mobility. To save energy, stations go to the Power Save (PS) mode if it doesn't have any incoming or outgoing traffic. In PS mode, the system is in a sleep state and its transceiver is shut down to save power. In order to let the stations in PS mode be able to respond to incoming traffic, all stations, including those in PS mode, have to wake up periodically to transfer or receive special traffic notifications. If a station has not received such notification, or if it has no traffic to transfer to other stations, it goes back to the PS mode after the short awake period until the next scheduled wake up time. A TSF is defined in IEEE 802.11. In TSF, each IBSS has a parameter called Beacon Period, which defines the length of the beacon interval adopted by the IBSS. Every station in the IBSS sets up a series of Target Beacon Transfer Times (TBTTs) whenever exactly a Beacon Period can divide the clock value of the station. At each TBTT, all stations wake up and try to broadcast a special packet called beacon packet.

The beacon packet contains the clock value of the sending station along with other important information such as a Beacon Period and Service Set Identification (SSID). To avoid the collision of beacon packets, every station randomly backs off. The back off window ranges between 0 and twice of the minimum value of CW (Contention Window) and then follows the back off algorithm defined in the standard. Once a beacon is received, all other stations cancel the pending beacon transmission, and compare the timestamp recorded in the beacon with their own clocks. A station will adjust its clock only if the receiving station's clock is slower than the sending stations clock. So the TSF in IEEE 802.11 has the following characteristics: one - there is only one station sending beacon in each beacon interval, two - clocks are adjusted forward only. According to the standard, this TSF can maintain a timer accuracy of ±0.01%. With all stations in an IBSS synchronized by the TSF, the IEEE 802.11's power management is shown in figure 2.

In each beacon interval, following a successful beacon broadcast, there is an Ad-hoc Traffic Indication Message (ATIM) window of a fixed number of slots. If a station has some buffered packets for another station, it tries to send an ATIM packet to the destination station to inform about the incoming traffic. ATIM packets are sent based on the Carrier Sense Multiple Access / Collision Avoidance (CSMA/CA) access scheme with an initial random back off. Each successful ATIM packet is acknowledged. All stations in IBSS stay awake from the start of the beacon interval till the end of the ATIM window. At the end of the ATIM window, only those stations that have sent an ATIM packet and received the acknowledgement or an ATIM packet stay in Active Mode (AM) for the whole beacon interval to transmit data. All other stations go to PS until next beacon interval.

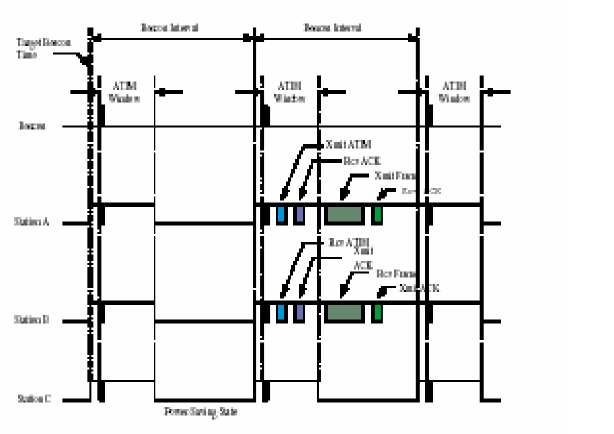

Fig. 2. Power management in IBSS in IEEE 802.11

All the stations in AM are ready to transfer at the end of ATIM window, the CSMA / CA algorithm loses its randomness. Every station detects an idle medium at the beginning of the data window, so they all start transferring after the Distributed coordination function Inter Frame Space (DIFS). Then all those transmissions collide and the stations start back off algorithm with minimum contention window. To avoid collision, the standard requires each transmitting station uses the back off procedure for transmitting the first frame following the ATIM window. If the transmitting stations do not finish sending the data packets during the beacon interval will have to resend ATIM packet in the next interval.

III. PROPOSED METHODOLOGY

A. ATIM Message Forwarding

IEEE 802.11 introduces Ad-hoc Traffic Indication Map (ATIM) messages that can be used in an IBSS (Independent Basic Service Set) ad-hoc network to indicate that a node has data for a certain destination node. The ATIM messages are broadcast at the beginning of a beacon interval during the so- called ATIM window. All nodes must wake up at the beginning of the beacon interval and remain awake during the ATIM window. A node goes back to sleep at the end of the ATIM window if it does not hear an ATIM for itself in the ATIM window.

Each node divides its beacon intervals into groups of n consecutive intervals. MTIM (Multi-hop TIM) messages are sent by the nodes at the beginning of an interval. This mechanism ensures that even if two hosts are not synchronized (i.e. they select the starting point of an interval in an asynchronous way), a node will receive a MTIM message not later than after all intervals. This also means that we need many, but very small intervals to reach very low wake ratios. This increases the overhead of the approach, since the MTIM messages must be sent many times then. In our evaluation we used wake periods with durations that depend on the number of nodes. Intuitively, wake periods should be shorter for high node densities and longer for lower node densities.

Power is arguably the scarcest resource for mobile devices, and power saving has always been a major design issue for the developers of mobile devices, wireless communication protocols and mobile computing systems. Many power conservation schemes have been proposed for mobile devices. Some have proposed schemes adjusting transmission power to conserve energy, while some others have discussed power-aware routing protocols. Power can be saved during the clustering stage and also by reducing contention in the MAC layer. Also research has been done based on IEEE 802.11's power management Scheme, which puts idle stations (those with no traffic coming in or out) into sleep by shutting down their transceivers.

B. *Message Forwarding With Synchronization*

The network is created with 20, 40, 60, 80 and 100 nodes by generating scenario file for each networks, the traffic files are created. The traffic file includes the agent used to establish data transfer between the nodes. UDP agent is used for transferring packets from one node to the other node in the network. The network properties such as channel type, protocols are included for packet transfer. In this method, the wake ratio properties such as receiving power, transmitting power, idle power, and sleep power are given by default. The above setting values modify the default MAC protocol. Therefore, the energy consumed for forwarding message from source to the destination is calculated. The overall energy consumed is calculated and compared with the initial energy of the network. The term energy referred here is meant the power taken to do the action such as transmitting, receiving and idling of the nodes. The overall energy of the network is calculated by using the C++ file with the help of the trace file given by the network.

C. *Message Forwarding Without Synchronization*

The networks are created as for the above, the one variation is the wake ratio properties are not given by default. These properties are set be assumed automatically by the network itself. Modifications done in the MAC protocol are setting wake ratio parameters for the entire network. Therefore the nodes will come to idle and sleep state after transmitting and receiving data. The nodes with higher energy are having excess of power within it. The nodes with less energy lead to link breakage in the network and fail to communicate with their neighbour nodes. So, the powers in both the case are neutralized to enable a contention free data transfer throughout the network. The data transferred using the UDP agents; the energy consumed by the overall network is calculated by comparing the trace file of the network with initial energy given.

D. *Analysis of Failure Probability*

The failure probability decreases for large wake periods, but also decreases for a large number of nodes in a given area. It requires a wake ratio of 50 % for 10 nodes to achieve a failure probability below 5 %, this can be achieved with a wake ratio of 20 % for 50 nodes and 10 % for 100 nodes.

Here, the failure probability of the network up to 100 nodes is found. For the wake ratio of 0.05% and 5%, the networks show a wide difference. As said earlier, the failure probability decreases for the network with higher wake ratio and decreases when the network consists of more number of nodes.

The failure probability is achieved by calculating packet delivery ratio also by monitoring the packets delivered and dropped. The trace file shows clear definition about the packet transfer in the network.

IV. SIMULATION RESULTS

The simulation of the network is done using Network Simulator – 2 [7] and the comparison between the power saving between networks with synchronization and without synchronization is analyzed.

For the simulation, the simulation parameters, such as the type of network, data packet size and message size are chosen. At first, a network with 20 nodes is created; average energy consumed by the network is calculated. Similar process is done for the networks with 40, 60, 80 and 100 nodes. Average energies consumed by the networks are calculated using a C++ file.

This whole process is done for both the networks with and without synchronization, and the results are compared. The output is shown in the graphs. Fig. 3 represents the network scenario with 40 nodes. Similar scenarios are created for the test nodes of 20, 60, 80 and 100.

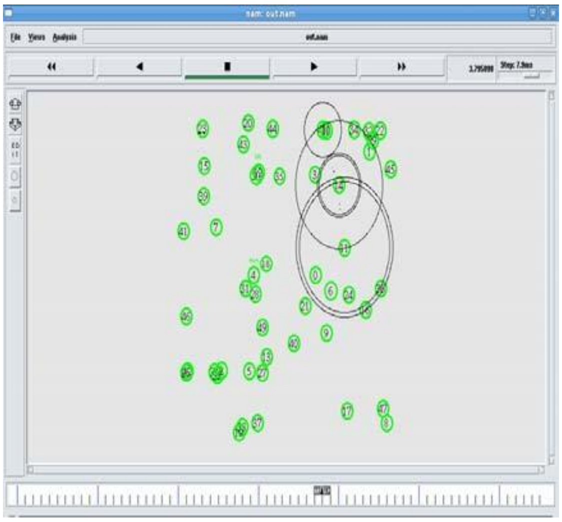

Fig. 3 Network Node Setup

Figure 4 shows the energy consumption of the nodes for with synchronization and without synchronization. X-axis shows the number of nodes like 20, 40, 60, 80 and 100. The Y-axis shows the energy consumed.

From the graph, it is interpreted that the energy consumption for with synchronization mode is almost equal to 100. And the energy consumption for without synchronization mode is lesser than 100 and it is almost equal to 93.

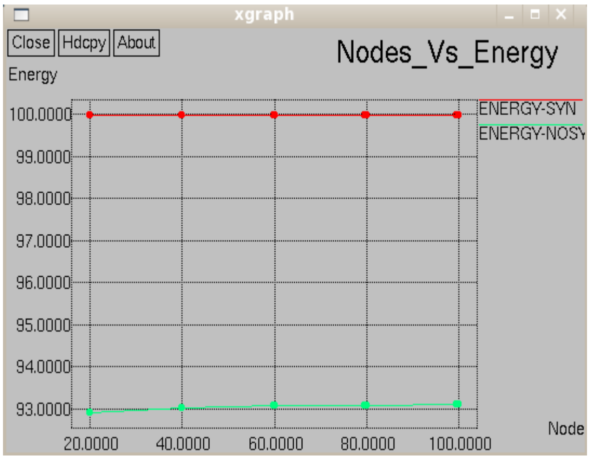

Fig. 4 Energy Consumption with Synchronization and without Synchronization

Figure 5 gives a scenario of number of nodes versus failure probability for the wake ratios of 0.05% and 5%. This graph shows that the failure probability decreases for large wake periods as well as for a large number of nodes in a given area.

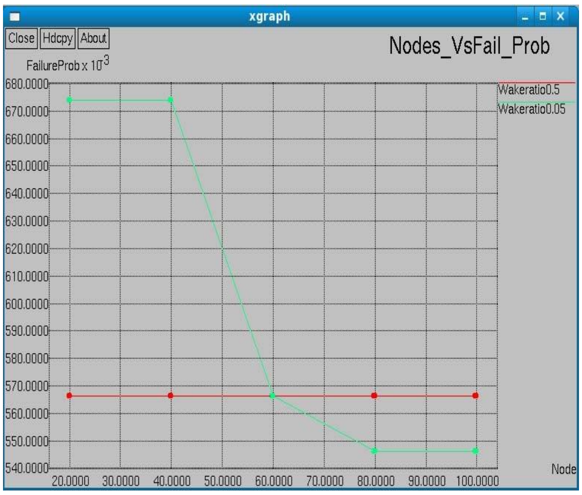

Fig. 5 Node versus Failure Probability

The following table is a comparative analysis showing the energy consumption for different number of nodes for with synchronization and for without synchronization.

No. of Nodes	Energy Consumed With synchronization	Energy Consumed Without synchronization
20	99.976850	92.894834
40	99.980875	93.022889
60	99.982239	93.066279
80	99.982925	93.088109
100	99.983338	93.101251

Table 1 Energy Consumed with Synchronization & without Synchronization

From the table values, it is seen that the energy consumed in the case of with synchronization is almost 100 and this value is higher compared to that of the without synchronization mechanism.

V. CONCLUSION

It is concluded from the observed graph and table that the proposed mechanism for power saving without synchronization reduces comparatively the power consumption in multi-hop scenario. As a result, it can also extend the lifetime of the nodes in the ad-hoc network. This multi-hop scenario also enables good connectivity properties. Future work will focus on the improvement and detailed evaluation of the multi-hop scenario by considering some adaptive mechanisms.

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