Power Optimization In Mobile Ad Hoc Network

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***Abstract-* A mobile ad hoc network is a collection of mobile nodes that are dynamically and arbitrarily located in such a manner that the interconnections between nodes are capable of changing on a continual basis. Mobile ad-hoc networks are the autonomous systems of mobile nodes forming network in the absence of any centralized support. This is a new form of network and might be able to provide services at places where it is not possible otherwise. Absence of fixed infrastructure poses several types of challenges for this type of networking. Almost devices in mobile Ad hoc network run on lithium-ion rechargeable batteries, these batteries have a lifetime of few hours of active lifetime. To solve this problem researcher tried to optimized power consumption in every aspect of mobile devices. Power consumption can be reduced at device level, at transmission level or may be by using optimized power aware routing protocol. In this paper we have given a brief description of basic aspects of mobile ad hoc network and studied various power saving techniques in mobile ad hoc network & given a comparative analysis of these techniques.**

Keywords-Mobile Ad-hoc network, Transmission power, Routing protocol, Power saving.

I. INTRODUCTION

A mobile *ad hoc* network (MANET) is a network formed without any central administration, which consists of mobile nodes that use a wireless interface to send & receive packet data. Since the nodes in a network of this kind can serve as routers and hosts, they can forward packets on behalf of other nodes and run user applications. Ad- hoc networks [8] are formed where there is no existing infrastructure and there is a need for communication. Examples of ad hoc networks include soldiers on enemy terrain, workers in a disaster area, or a group of executives at an outdoor location. Figure 1 shows a typical ad hoc network.

What differentiates ad hoc networks from traditional wireless networks is the absence of a centralized base station. In traditional wireless networks, nodes wishing to communicate with each other have to first contact the nearest base station, which forwards their requests to the base station closest to the destination node. All packets are routed through the path established by the base station. The base stations perform the tasks of tracking, routing and route maintenance. In ad hoc networks, all these tasks are performed by the nodes themselves, in addition to their personal tasks. This

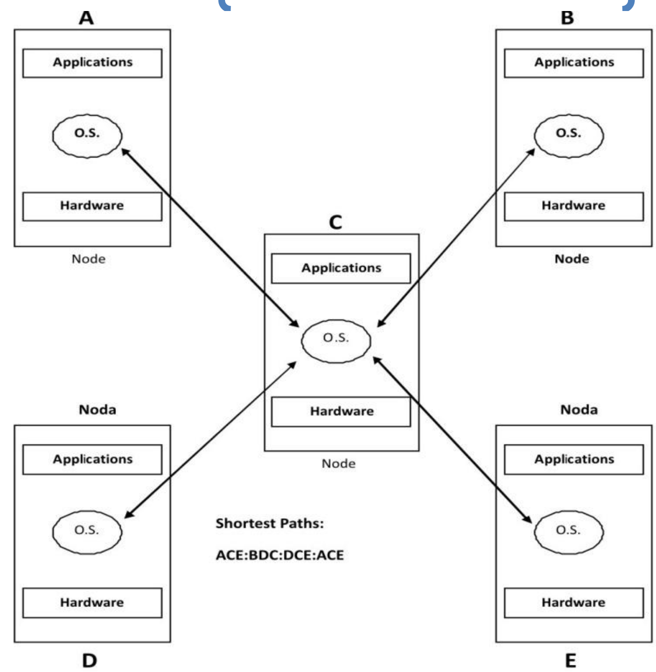

Figure 1. Ad hoc networks

causes additional drain on the batteries leading to a diminished lifetime. Power utilization can be optimized by employing routing algorithms that avoid nodes with less battery power remaining while trying to minimize the total power consumed in transmitting a packet.

II. MANET EVOLUTION

The whole life-cycle of ad-hoc networks could be categorized into three generations.

The first generation goes back to 1972. At the time, they were called PRNET (Packet Radio Networks). The PRNET used a combination of ALOHA[5] (Areal Locations of Hazardous Atmospheres) and CSMA (Carrier Sense Medium Access), approaches for medium access, and a kind of distance-vector routing. PRNET were used on a trial basis to provide different networking capabilities in a combat environment.

The second generation of ad-hoc networks emerged in 1980s, when the ad-hoc network systems were further enhanced and implemented as a part of the SURAN (Survivable Adaptive Radio Networks) program. This provided a packet-switched network to the mobile battlefield in an environment without infrastructure. This program proved to be beneficial in improving the radios performance by making them smaller, cheaper, and resilient to electronic attacks.

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The third generation of ad-hoc networks emerged in the 1990s, when the concept of commercial ad-hoc networks arrived with notebook computers and other viable communications equipment. At the same time, the idea of a collection of mobile nodes was proposed at several research conferences. In the meanwhile the IEEE 802.11 subcommittee had adopted the term "ad-hoc networks" and the research community had started to look into the possibility of deploying ad-hoc networks in other areas of application.

III. Features of Mobile Ad Hoc Network

In general, mobile ad hoc networks are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using the existing network infrastructure or centralized administration. The nodes are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger network. Mobile ad hoc networks are infrastructure-less networks since they do not require any fixed infrastructure, such as a base station, for their operation.

Mobile Ad hoc network has the following features:

A. Autonomous and infrastructure-less

MANET does not depend on any established infrastructure or centralized administration. Each node operates in distributed peer-to-peer mode, acts as an independent router and generates independent data. Network management has to be distributed across different nodes, which brings added difficulty in fault detection and management.

B. Distributed operation

As there is no background network available for the central control of the network operations, the control and management of the network is distributed among the terminals. The nodes involved in a mobile ad hoc network should collaborate amongst themselves and each node acts as a relay as needed, to implement functions e.g. security and routing.

C. Multi-hop routing

In these kind of networks no default router available, every node acts as a router and forwards each others' packets to enable information sharing between mobile hosts.

D. Dynamic network topology

Since the nodes are mobile, the network topology may change rapidly and unpredictably and the connectivity among the terminals may vary with time. The mobile ad hoc network should adapt to the traffic and propagation conditions as well as the mobility patterns of the nodes. The mobile nodes in the network dynamically establish routing among themselves as they move about forming their own network on fly.

E. Variation in link and node capabilities

Each node may be equipped with one or more radio interfaces that have varying transmission/receiving capabilities and operate across different frequency bands [1, 2]. This heterogeneity in node radio capabilities can result in possibly asymmetric links. In addition, each mobile node might have a different software/hardware configuration, resulting in variability in processing capabilities. Designing network protocols and algorithms for this heterogeneous network can be complex, requiring dynamic adaptation to the changing conditions (power and channel conditions, traffic load/distribution variations, congestion, etc.).

F. Network scalability

Currently, popular network management algorithms were mostly designed to work on fixed or relatively small wireless networks. Many mobile ad hoc network applications involve large networks with tens of thousands of nodes, as found for example, in sensor networks and tactical networks [7]. Scalability is critical to the successful deployment of these networks. The steps toward a large network consisting of nodes with limited resources are not straightforward, and present many challenges that are still to be solved in areas such as: addressing, routing, location management, configuration management, interoperability, security, high capacity wireless technologies, etc.

G. Light-weight terminals

The nodes of ad hoc network are mobile devices with less CPU processing capability, small memory size, and low power storage. Such devices need optimized algorithms and mechanisms that implement the computing and communicating functions.

H. Energy constrained operation

Because batteries carried by each mobile node have limited power supply, processing power is limited, which in turn limits services and applications that can be supported by each node. This becomes a bigger issue in mobile ad hoc networks because, as each node is acting as both an end system and a router at the same time, additional energy is required to forward packets from other nodes.

IV. Power Saving Techniques

Since ad hoc networks do not assume the availability of a fixed infrastructure, it follows that individual nodes may have to rely on portable, limited power sources. The idea of energy-efficiency therefore becomes an important problem in ad hoc networks. Most existing solutions for saving energy in ad hoc networks revolve around the reduction of power used by the radio transceiver. At the MAC level and above, this is often done by selectively sending the receiver into a sleep mode, or by using a transmitter with variable output power (and proportionate input power draw) and selecting routes that require many short hops, instead of a few longer hops [4].
In mobile Ad hoc network there can be three aspects to reduce the power consumption.

- Power saving at mobile device level
- Power saving by controlling transmission level of packet
- Power saving by using optimized power routing protocol

A. Power saving at mobile device level

Mobile devices consume power even in their sleep mode For example, in mobile phones, even if they are not in use, there is a constant power drain because the trans-receiver is constantly hearing for signals to itself. A lot of efforts are currently going on to reduce the power consumed in each & every aspect of a mobile device. Now we give a brief description of some of these methods

- Disk scheduling

The operating system of a machine is responsible for using hardware efficiently — for the disk drives, this means having a fast access time and disk bandwidth. Access time has two major components seek time & Rotational latency. Seek time is the time for the disk arc to move the heads to the cylinder containing the desired sector. Rotational latency is the additional time waiting for the disk to rotate the desired sector to the disk head. Disk bandwidth is the total number of bytes transferred, divided by the total time between the first request for service and the completion of the last transfer.

One method of energy conservation [8] in mobile devices is to spindown a disk in its idle time. The spindown delay is the amount of time the disk is idle before it spins down. [3] presents a quantitative analysis of the potential costs and benefits of spinning down a disk in its idle time. The tests were carried out using traces from both DOS machines and the Sprite File system. The conclusion was that the maximum power savings were obtained by using a spindown delay of two seconds as opposed to the 3-5 minutes recommended by most manufacturers. To justify this claim, the authors presented two points: frequency of sleep and length of sleep. They claim that, with shorter delays, the disk gets to sleep for a longer time and hence save more power.

The drawback of spinning down a disk after such short delays is the time and energy needed to spinup the disk, which results in user delay. Traces used by the authors show that the spindown occurs 8-15 times an hour. This translates to 16-30 seconds of user delay per hour, which is reasonable compared to the power savings incurred.

- CPU Scheduling

CPU scheduling is the basis of multiprogrammed operating systems. By switching the CPU among processes, the operating system can make the machine more productive. The power [8] consumed by a processor is directly proportional to the supply voltage, the switching capacitance of the various devices and the frequency of the clock. Gates in CMOS CPU’s switch state at every clock cycle, which lead to a short circuit between the power-supply and ground. As a result more power is wasted with higher frequency.

The power required by the CPU is given by CV^2F, where C is the total capacitance of the wires, V is the supply voltage and F is the operating frequency. There are various algorithms proposed for adjusting the clock frequency in idle time. The main idea behind it is to balance the CPU usage between bursts of high utilization and idle times. Task or process scheduling can be an effective way of accomplishing this.

Almost all processes have a deadline by which they need to be executed. It has been observed in [6] that even when the processor is operating at the worst case, in scheduling the tasks, there is some idle time. This idle time is called the slack time. This slack time can be used to conserve energy by slowing down the processor and reducing the voltage. These techniques are known as, static slowdown and voltage scaling. We can reduce or eliminate the idle time by reducing the voltage to operate the processor such that, the process takes longer to finish but is completed before its deadline.

- Memory Allocation

Memory is the most important resource of a mobile device In mobile devices, memory instructions are among the highest consumers of power [3]. Since many small devices do not have a secondary storage, the power consumed by the memory is very crucial and needs to be optimized. Some of the memory devices like Direct Rambus DRAM (RDRAM), have come out with a DRAM that allows the individual devices to be in different power states. These devices are in decreasing order of power states and increasing order of access times: Active, Standby, Nap and Powerdown.

Memory Placement policies for code and data can also help to reduce the power consumption. If active pages with temporal locality are grouped together and placed on the same memory chip before moving to the next, the remaining chips can be powered down [3]. This technique helps in reducing the power consumed in reading data from memory. The simulation results given in [3] show power saving of about 6% - 50% using the static, dynamic and temporal locality placement policies.

B. Power saving by controlling transmit power level

The power control problem in wireless ad hoc networks is that of choosing the transmit power for each packet in a distributed fashion at each node. The problem is complex since the choice of the power level fundamentally affects many aspects of the operation of the network like:

1. The transmit power level determines the quality of the signal received at the receiver which affects the physical layer
2. It determines the range of a transmission which affects routing in terms affects network layer.

3. It determines the magnitude of the interference it creates for the other receivers which affects the transport layer due to congestion

Transmit power control is therefore a prototypical cross layer design problem affecting all layers of the protocol stack from physical to transport, and affecting several key performance measures, including the trinity of throughput, delay and energy consumption. Cross-layer design, in general, should be approached holistically with some caution, keeping in mind longer term architectural issues . Thus arises the question of where in the network architecture should power control be located, the resolution of which requires an appreciation of the issues involved at each layer.

- Design principles for power control protocol

Power control is important in wireless ad hoc networks for at least two reasons: It can impact on battery life, and It can impact on the traffic carrying capacity of the network.

Following are the design principles for power control.
1. To increase network capacity it is optimal to reduce the transmit power level.
2. Reducing the transmit power level reduces the average contention at the MAC layer.
3. The impact of power control on total energy consumption depends on the energy consumption pattern of the hardware.
4. When the traffic load in the network is high, a lower power level gives lower end-to-end delay, while under low load a higher power gives lower delay.
5. Power control can be regarded as a network layer problem.

So based on above design guidelines Kawadia & Kumar in [10] propose some protocols which attempt to achieve several design objectives and perform several optimizations simultaneously.

- The COMPOW protocol [10] attempts to increase network capacity, while meeting the needs of several other layers by choosing a common power level throughput the network.
- The CLUSTERPOW protocol [10] relaxes this constraint and provides a joint solution to the power control, clustering and routing problem, again with the goal of maximizing network capacity.
- The MINPOW protocol achieves a globally optimal energy consumption solution for awake nodes, but may or may not increase network capacity depending on the wireless hardware.

C. Power saving by using optimized power aware routing protocol

Routing is the process in which a route from a source to a destination node is identified and is achieved either by computing all routes before and presorting them or computing them when needed.

A routing protocol is a protocol that specifies how routers communicate with each other to disseminate information that allows them to select routes between any two nodes on a network. Typically, each router has a priori knowledge only of its immediate neighbors. A routing protocol shares this information so that routers have knowledge of the network topology at large.
In wireless ad hoc networks, every host acts both as a router and a packet sender, so the classical routing protocols used by wire linked networks are not applicable at all to ad hoc mobile networks. The routing protocols for ad hoc may be classified on the basis of following three criteria: Based on the logical organization, based on how to obtain routing information & based on how the routing path is created

- Based on the logical organization through which the protocol “describes” the network

On the basis of the logical organization the routing protocols can be divided in “Uniform” and “Non Uniform” routing protocols.

In a uniform protocol, none of the nodes take on a distinguished role in the routing scheme: each sends and responds to routing control messages the same way. No hierarchical structure is imposed on the network. Although such a protocol avoids the resource costs involved in maintaining high-level structure, scalability may become an issue in larger networks.

Non-uniform protocol attempt to limit routing complexity by reducing the number of nodes participating in a route computation. Such an approach can improve scalability and reduce communication overhead; alternatively, it can support the use of algorithms of greater computational or communication complexity than is possible in the full ad hoc network. In addition, higher-level topology information can facilitate load balancing and QoS support.

- Based on the way routing information is obtained

From the routing information point of view, routing protocols may be divided in : Proactive (Table-Driven),Reactive (On-Demand) & Hybrid

- Proactive (Table-Driven)

In Table-driven routing protocols each node maintains one or more tables containing routing information to every other node in the network. All nodes update these tables so as to maintain a consistent and up-to-date view of the network. When the network topology changes the nodes propagate update messages throughout the network in order to maintain consistent and up-to-date routing information about the whole network. This type of protocols maintains fresh lists of destinations and their routes by periodically distributing routing tables throughout the network. Example of Proactive protocols are DSDV (Destination- Sequenced Distance-Vector), WRP (Wireless Routing Protocol) etc.

- Reactive (or On-Demand)

A different approach from table-driven routing is source-initiated on-demand routing. This is type of reactive routing creates routes only when desired the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. The route is perceived by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired

In Reactive protocols a procedure is needed to establish the correct routing path only when packets are to be transmitted; in such a way signaling traffic is reduced, but with increasing delivery times.

Examples of Reactive protocols are AODV (ad hoc on-demand distance Vector), DSR (dynamic source routing) and TORA(temporally ordered routing algorithm)

- Hybrid

This type of protocols combines the advantages of proactive and of reactive routing. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding.
Examples of Reactive protocols are ZRP (Zone Routing Protocol)**,** HRPLS (Hybrid Routing Protocol for Large Scale Mobile Ad Hoc Networks with Mobile Backbones) etc.

- Based on how the routing path is created

Routing path is the track the packet will follow from source to destination. From the routing path point of view the Protocols may divided into two categories: Source Routing & Non Source Routing.
In the first ones the sending node determines the complete path to the destination, registering it directly into the packet so, intermediate nodes only retransmit packets to those addressed by directly into the packet so, intermediate nodes only retransmit packets to those addressed by the previously established path. In the latter, instead, the only routing information contained in data packets is that represented by the best neighbor node to which communication has to be forwarded; consequently, every node must be able to optimize routing decisions.

V. Conclusion

In this paper, we have given an overview of mobile ad hoc networks its features and investigated the problem of power saving in mobile ad hoc networks. We have studied current power saving techniques used at different levels .Power saving at routing protocols level is much easier as compared to, power saving at device level or transmission level. Each of these techniques saves some energy of mobile device and if we use these different techniques in a combined in a manner it saves lot of energy and increase the lifetime of network.

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