LPCA: Low Power Coordination Algorithm in Ad-hoc Network Environment**

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Abstract

This paper identifies the necessary features of a minimum energy protocol and suggests schemes for their implementation in mobile ad-hoc networks. In this paper, we propose a method for saving power consumption in mobile ad-hoc network. We reduce the active time in coordinator node depending on the number of forwarding packets. We use the structure of busy and wait coordinators to improve power saving. Our simulations are carried out to illustrate the effectiveness of the proposed power saving algorithm.

Key words: ad-hoc network, mobile, routing, low-power

1. Introduction

Mobile ad-hoc network is an emerging area of research and it continues to experience increasing popularity. As mobile networking is embedded in our natural movements, the need to connect large numbers of wireless devices will become more prevalent.

Mobile ad-hoc network consists of a collection of geographically distributed nodes that communicate with one other over a wireless medium. It allows nodes to form temporary networks and communicate beyond transmitter range by supporting multi-hop communication through IP routing. It consists of a set of mobile hosts and data is transmitted via multi-hop communication. mobile ad-hoc network differs from cellular networks in that there is no wired infrastructure and the communication capabilities of the network are limited by the battery power of the network nodes.

The battery power is very limited within each device and cannot be refreshed simultaneously. If one of the mobile devices in mobile ad-hoc networkis consumed its energy completely, the entire network will be broken. In this paper, we address and analyze the problems of Span's coordinator[2] and propose the new scheme for efficient power saving.

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2. Related works

Existing works have approached the problem of power consumptions in Ad-hoc networks by proposing mechanisms to improve power saving over such networks. IEEE 802.11[1] uses a handshake consisting of RTS(Request To Send) and CTS(Clear To Send) before transmission of a data. In IEEE 802.11, carrier sensing range for RTS-CTS is the same as that of DATA-ACK since transmit power does not change. PCM[3] proposes a power control MAC protocol for Ad-hoc networks. When a destination node receives an RTS, it sends a CTS message at maximum power level. When a source node receives the CTS, it calculates desired power level based on received power level and also maximum power level. The source nodes transmit data using a desired power level. To avoid a collision with the ACK, PCM periodically increases the transmit power during data transmission. COMPOW[4] selects the smallest common power level at which the network is still connected. Each node runs routing daemons, each at a different power level. If the optimum power level was found, then the routing table is installed as the master routing table, which is used by the kernel. Their power control protocol guarantees bi-directionality of links and connectivity of the network, asymptotically maximizes the traffic carrying capacity, reduces MAC contention, and can be used with any proactive routing protocol. The ATIM window size critically affects throughput and energy consumption. If the ATIM window is too small, there may not be enough time available to announce buffered packets which potentially degrade throughput. Large ATIM windows will result in higher energy consumption since all nodes remain awake during the ATIM window and degrading throughput at high loads. Thus, it proposes a DPSM[5](Dynamic Power Saving Mechanism) for choosing an ATIM window size for power-saving. DPSM is based on PSM, but a node can dynamically adapt its ATIM window size according to observed network conditions. In DPSM, a node can also change its wireless network interface into idle state whenever it finishes packet transmission for the announced packets.

The basic idea of an asynchronous power management protocols[6] is twofold. First, the protocol enforces PS hosts to send more beacon packets than the IEEE 802.11 standard does. Second, the protocol arranges the wake-up and sleep patterns of PS hosts. Thus, it guarantees to detect between two neighboring hosts in finite time. They proposed three power-saving protocols for IEEE 802.11 based, multi-hop, and unsynchronized mobile ad-hoc networks. The protocols can guarantee an upper bound on packet delay if there is no collision in the beacon window.

SPAN, a power saving technique, elects a group of coordinators. Coordinators are changed periodically and stay awake to perform multi-hop packet routing within Ad-hoc network, while other nodes remain in power-saving mode and periodically check if they should awaken and become a coordinator. The amount of energy saving that Span provides increases only slightly as density of the network increases. This is largely due to the fact that the current implementation of Span uses the power saving features of 802.11, since nodes periodically wake up and listen for traffic advertisements.

3. Power saving scheme for coordinators

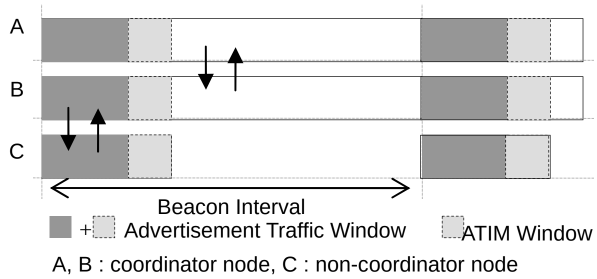

Fig. 1. Structure of Coordinator and non-coordinator node in SPAN.

The Span has two types of nodes: coordinators and normal nodes, as shown in Fig. 1. The Span in Ad-hoc network is more efficient for power-saving than 802.11 and 802.11 PSM.

Although the coordinator have not forwarded packet, the coordinator node should stay awake for packet forwarding after the end of advertisement traffic window. It is very expensive to wait for packet forwarding during the wake state because the devices in the network have limited batteries and the occurrence of packet forwarding is uncertain.

We introduce LPCA(Low Power Coordination Algorithm), an enhanced power saving scheme for Ad-hoc network based on Span. LPCA elects

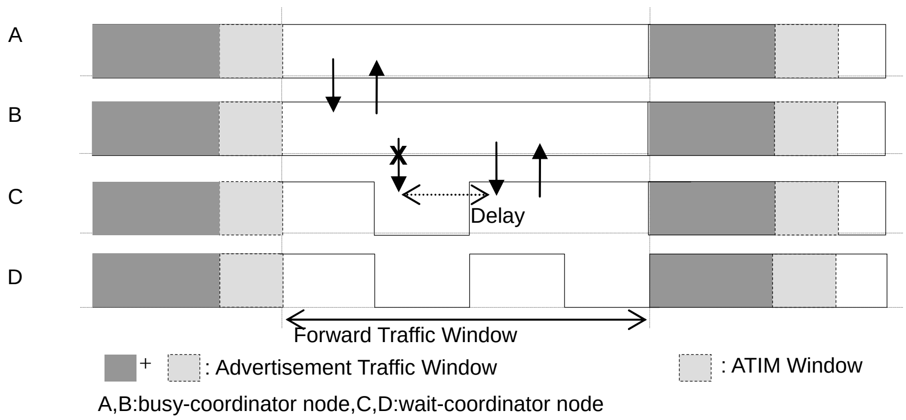

Fig. 2. Structures of busy-coordinator, wait-coordinator and non-coordinator node in our scheme.

coordinator and forward traffic for communication as Span's algorithm. The basic idea of our approach is to reduce the active time of a coordinator node in order to reduce power consumption during idle time. To accomplish this scheme, we use the structure of busy and wait coordinators as shown in Fig. 2.

The forward traffic window of busy coordinator always stays awake. In a wait coordinator, however, the forward traffic window is switched between wake and sleep states.

If a wait coordinator receives a request message from a busy coordinator in wake state, it becomes a busy coordinator. In the same manner, if a busy coordinator receives no request during 1 beacon period, it becomes a wait coordinator.

If the request has not been received from a busy coordinator in a sleep state, the transmitted packet is marked as fail and re-buffered for another try in the next wake state. If the wait-coordinator receives a packet marked as fail, a wait coordinator increases its active state time and decreases its sleep state length by one level(by 5ms in our simulations). Otherwise, if the wait coordinator receives a packet without fail flag, the wait coordinator decreases its active state time and increases its sleep state length by one level. These techniques allow each wait coordinator to have a longer sleep state. The longer sleep state increases battery lifetime of nodes.

4. Simulation Study

To demonstrate the effectiveness of our power-saving scheme, we compare the performance of Span with our protocol. We use NS-2[7] network simulator for our simulation.

In our simulations, we use a beacon period of 300ms, an ATIM window of 20ms, advertised traffic window of 100ms, an wake state in forward traffic window of 40ms(minimum length), and a sleep state in forward traffic window of 60ms(maximum length). We allowed wake and sleep state values between 40ms and 60ms, with increment of 5ms. The sums of length of wake and sleep state set to 100ms.

Fig. 3 shows the amount of energy-saving in each simulation area after 400 seconds of simulation time. The initial energy of each node is 1000 J, and it is a simulation result from 120 nodes.

In this simulation, we can find that the amount of power consumption increases as the mobile nodes are dispersed in the larger area. This is because the number of coordinator increases as the geographic region becomes larger and each coordinator stays awake.

Our Low Power Coordination Algorithm(LPCA) manifests itself when the mobile nodes are located in the relatively larger geographic area. Simulation

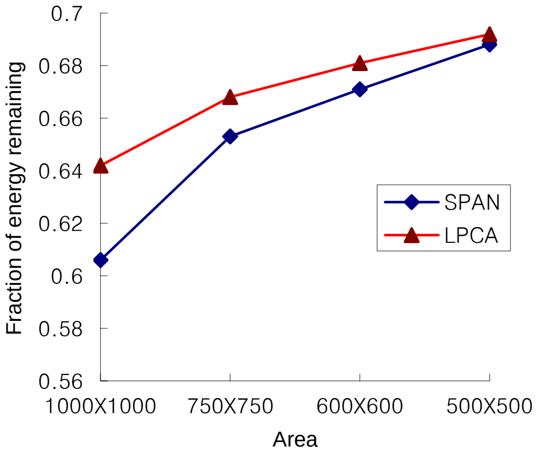

Fig. 3. Fraction of energy remaining after 400 seconds of simulation time.

results show that the LPCA algorithm outperforms SPAN.

5. Conclusion

We proposed power-saving algorithm based on multi-hop for wireless Ad-hoc network. We illustrated that our scheme increases transmission delay time and retransmission, but it improves the power-saving by increasing sleep time of the coordinators. In comparison with Span, the amount of power-saving is significantly increased when the node density in the network is decreased as well as the simulation time is increased.

6. References

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