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Delay Efficient Algorithm for Adhoc Wireless Networks

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Abstract: Wireless technology has advanced tremendously over the past decade, introducing a wide array of devices with networking abilities. Adhoc networks are dynamically created and maintained by a group of wireless enabled devices (gargets) with out the assistance of pre-existing infrastructure like Base Station (BS) for communication purposes. In this study, we consider the issue of performance enhancement of wireless networks in terms of 'overhead messages per node and power consumption'. Minimizing power consumption is an important challenge in mobile networks. Wireless network interface is often a device's single largest consumer of power. To fulfill the above requirements, we have designed a topology management scheme for Adhoc wireless networks. In our topology management scheme, MARI(Mobile Agents with Routing intelligence) nodes are selected in such a way that, the MARI nodes have maximum power level among their one hop neighbors and all non-MARI nodes are with in the transmission range of MARI nodes. These MARI nodes have the routing intelligence i.e. they make all decisions relating to routing. The gateway nodes having sufficient power level are selected so that they can forward packets between MARI nodes. Gateway nodes do not have routing intelligence. These MARI and gateway nodes stay continuously awake to route the packets of other member nodes.

Key words: Adhoc networks, MARI nodes, gateway nodes, power consumption, node delay

INTRODUCTION

Several problems will occur in managing of wireless Adhoc networks, because of the domain in which such networks are used. The sample of Adhoc network (Perkins, 2001) is shown in Fig.1. Some of the properties of Adhoc networks (Feeney and Nilsson, 2001) that make them difficult to manage well are:

Complexity of nodes: The nodes used in the Adhoc network can range from simple sensors located in the field to fully functional computers (laptops). An implication of this diversity is that not all nodes will be able to contribute equally to the management task.

Message over head: In wireless networks, very frequently changes in the topology (i.e., new nodes gets added, failure of node, addition or deletion of sub network etc) will occur. Thus management station needs to collect connectivity information from nodes periodically, which indicates an increased message over head for collecting topology information.

Power consumption: Almost all the nodes in the Adhoc network run on batteries. Thus we need to ensure that the networks management overhead is kept to a minimum so that the power is conceived.

Mobility: The node may power them selves off to conceive energy resulting in partitions or a node may move out of transmitting range of other nodes. Similarly, a node may die when its battery run out of power. In all these cases, the partitioned sub networks need to continue running independently and management protocol must be robust enough to adapt.

Minimizing of power consumption is an important challenge in mobile networking. Wireless networks interface is often a device's single largest consumer of power (Jamieson *et al*., 2002). Since the network interface may often be idle, this power could be saved by turning the radio off when not in use. The requirement of co-operation between power saving and routing protocols is particularly acute in the case of multi-hop Adhoc wireless networks (Rodoplu and Meng, 1999; Blough *et al*., 2003), where nodes must forward packets for each other. Here we are proposed a MARI protocol for topology management to save the power in the Adhoc wireless networks. There are several proposals under this area, but ours is a new one and which is giving better results.

The objective of this study is to design a topology management scheme for Adhoc networks for power saving. The characteristics of it are:

It should allow as many nodes as possible to turn their radio receivers.

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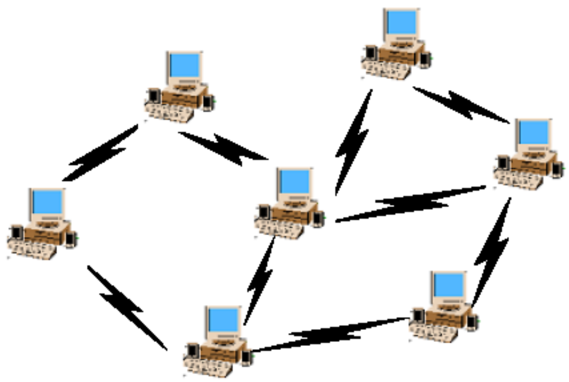

Fig. 1: Adhoc wireless network

It should forward packets between any source and destination with minimally more delay than if all nodes were awake.

The picking of backbone should be distributed, so that each node should make a local decision.

To fulfill the above requirements, each node in the network makes periodic, local decisions on whether to sleep or stay awake and as a MARI node, participate in the forwarding backbone topology. The MARI nodes have the maximum power level among their one hop neighbors and all non-MARI nodes are within the transmission range of MARI nodes. These MARI nodes have the routing intelligence i.e. they make all decisions related to routing. The gateway nodes are selected which are having power so that they can forward packets between MARI nodes and they don't have routing intelligence. Here both MARI nodes and Gateway nodes are continuously awake to route the packets to the other member nodes with in the transmission range. All the member nodes will go to sleep mode, if they do not have to transmit or receive data and they wake up a 'n' number of times in a beacon period 'T'. The wake up time for each node is calculated from a pseudo-random manner, such that the MARI node and neighbor nodes know the wake up of that node time. Thus the member node can remain in power saving sleep mode (Regavendra and Singh, 1998; Ramanathan and Rosales, 2000) most of the time, if it is not actively sending pr receiving packets. The packets are routed over the backbone consisting of MARI nodes and gateway nodes. The routers are found with the help of mobile agents (Hass, 1999).

MATERIALS AND METHODS

This work was carried at different places, mainly at IIT, Mumbai. In the present study several parameters are considered but delay and power consumption are the major issues.

TOPOLOGY MANAGEMENT IN Adhoc WIRELESS NETWORKS

The topology management in Adhoc wireless networks is decided at every node

- Which node to turn on
- When the node to be turn on
- What should be the transmit power
- So that network connectivity is maintained under the conditions of mobility.

Most of the algorithms proposed for Topology Management which are based on the first two points or the third point i.e. switching between active (transmit, receive or idle) to the transmission power. They are:

- Power On-off scheduling algorithms
- Power scheduling algorithms

In on-off management scheme, few nodes are having more power, which are called as cluster heads and gateways. These are selected distributively in such a way that each node in the Adhoc wireless network is either cluster head or connected to cluster head. The gate way nodes are selected such that they forward packets between cluster heads. Here any node can send packets to any other node in the network through cluster heads and gateways. Thus the cluster heads and gateways form a virtual backbone to the rest of nodes. The packets destined to the nodes in the sleep mode can be buffered at its cluster head. When the node wakes up cluster head can deliver the packets to the node. The cluster node and gateway nodes are always in awake mode. Some proposed on-off scheduling topology management schemes are Span (Borbash and Jennings, 2002) and TMPO (Topology Management by Priority Ordering) (Bahl *et al.*, 2002).

In the power scheduling topology management schemes, each node adjusts its transmission power in such a way that it has few neighbors. In this typology management scheme all nodes take part in the routing, it is called as flat topology management scheme. Few power scheduling topology management schemes are CBTM (Cone Based distributed Topology Management) (Rohl *et al.*, 1997) and K_Neigh Protocol for symmetric topology control (Bao and Garcia-Luna-Aceves, 2003).

The proposed topology management is power on-off scheduling scheme.

MARI TOPOLOGY MANAGEMENT SCHEME

This topology management scheme runs above the MAC layer and interacts with the routing protocol. If a

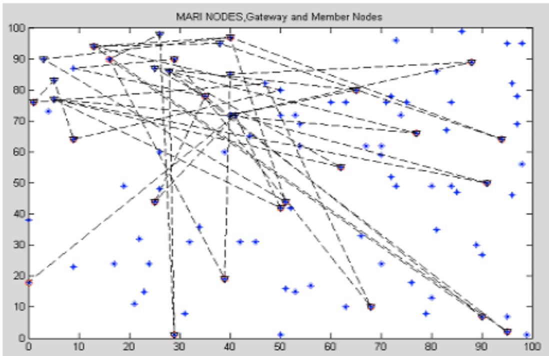

Fig. 2: Sample of 100 nodes with MARI, Gateways and member nodes (shown with O, Δ and * symbols, respectively).

node has been asleep for a while, the packets destined for it are not lost but are buffered at a neighboring MIRA node. When the node awakens, it can retrieve these packets from the buffering MIRA node. This scheme makes the routing simple, width minimum number of entries as only those entries in a node's routing table that correspond to currently active MIRA nodes can be used as valid next-hops.

Definition 1: MARI nodes are the nodes such that all non-MARI nodes are connected to any one of the MIRA node and route packets for any other nodes with the help of Mobile Agents. The route consists of Source node, Corresponding MARI node, Gate way nodes and intermediate MARI and Gateway nodes and destination node.

Definition 2: Sleep cycle period is the time period during which member nodes remain in the power efficient sleep mode and wake up once in fixed time duration in one beacon period.

W e assume that each node periodically broadcasts a small packet "HELLO" message, which contains:

Node id, Status (whether the node is MARI node, gateway, member or undecided), its current power level, its current MARI node, a wakeup counter etc.,

Based on the HELLO message received from the neighbors, each node constructs a table which contains the list of its neighbors, their MARI nodes, power level, wakeup counter and the information about their neighbors. A node switches form time to time between being a MARI node and being a member. A node becomes a gateway, if its MARI node chooses it as a gateway to route the packets between MARI nodes. A node is said to be kept in the undecided state, if it looses the connectivity with its MARI nodes due to mobility.

MARI placement: MARI nodes along with gateways confirm a path in the virtual backbone, which is used for routing and there is demands for additional power for transmission, reception and processing of packets. Thus the MARI nodes should be selected in such a way that they have enough/higher power level.

Algorithm is not given, but the concept of MARI placement is:

Undecided nodes periodically checks if it has a maximum power level among its node hop neighbors which have not joined to any MARI node (i.e. undecided neighbors). If a node has a maximum power level among such one hop neighbors, it becomes a MARI node and declares itself as a MARI node in the status field of next HELLO message and communicate to all its neighbors.

In the undecided node knows that its neighbor node has become MARI node from received HELLO message, it changes its status as a member. It declares its status as a member and current MARI node in its next HELLO packet.

If more than one neighbor of the undecided node becomes MARI nodes, then the undecided node select its MARI node from which it has receives HELLO packet first.

There may be undecided nodes whose one hop neighbors with power level more than the undecided node chose to join MARI nodes, as the MARI nodes have more power level than its one hop neighbors. Such undecided nodes with maximum power level among one hop undecided neighbors declares themselves as MARI nodes in the next HELLO message.

A MARI node prepares a list of its member nodes, which are joined to the MARI node, form the broadcast of HELLO messages received from one hop neighbors.

This information in the table is periodically changes as a new HELLO packet is received.

MARI node withdrawal: The MARI node will drain its energy more rapidly, as compared to member nodes. Before the MARI node loses its major part of its power, the responsibilities of the MARI node should be transferred to other node with sufficient power level. The concept is:

When a MARI node observe that its power is gone below a threshold, it will withdraw its status of MARI node. The withdrawal of MARI node is declared to its all member nodes in the next HELLO message as an undecided node. Generally the threshold will be set to 80% of power level when the node decided to become a MARI node.

When a gate way or member node comes to know that it can not contact its MARI node, it changes its status to undecided and starts MARI node placement procedure.

The Fig. 2 shows and example of a Topology formed with MARI nodes, gateways nodes and member nodes are indicated by O, Δ and * respectively.

Gate way selection: The maximum number of hops between any two close MARI nodes is two; hence gateways are required and are used to forward the packets between the MARI nodes. The gateway nodes must have sufficient amount of power, to transmit and receive the packets to and from the MARI nodes. The algorithm for selection of gateway nodes is:

To determine the gateways, MARI nodes needs information in its two hop neighborhood. This information is obtained from the HELLO packets; it has received from its one hop neighbor. But as the member of different MARI nodes are not synchronized, they may miss the HELLO packets from members of different MARI nodes. MARI node periodically sends broadcast request packet STAY_AWAKE to its members to put them in awoke mode for at least one beacon period.

MARI node finds out all the MARI nodes within two hops and MARI node selects its member as a gateway which has maximum power level, for each MARI node within two hops. Generally the gateway is taken such that it has more number of neighbors to ensure less number of gateways.

The MARI node determine the validity of the gateway node i.e., power level periodically, if the power level is below the threshold level the MARI node starts the selection procedure for new gateway.

Routing over the virtual backbone: For simplification, in this study we have not given the Scheduling of the sleepy cycle. We have designed a mobile agent based routing protocol to measure the effectiveness of the topology management scheme. It is a on demand routing protocol. This routing protocol is executed by only on MARI nodes. The gateway forwards the packets by using NEXT-HOP_DESTINATION fields. The routing algorithm is given in Algorithm-3

Algorithm 3: Sleep cycle scheduling (executed by all member nodes for each beacon period):

1. Transmit HELLO packet at appropriate time in (T, T_1)
2. for each sleep cycle period $(T_{m,} T_{m+1})$, m =1 … n do
3. if there are no packets to transmit then
4. Go to sleep mode until time t_{im}.
5. Remain in wake until time $t_{im}.+\tau$
6. if packet received at time in $(t_{im}, t_{im}.+\tau)$ then
7. Remain in wake up mode until time+ τ
8. end if
9. if time< $T_{m+1-}\ \tau$ then
10. go to sleep mode until time T_{m+1}
11. end if
12. else
13. Transmit the packet(s) at appropriate time(s)
14. if $t_{im-}.\tau <$ *time* $< t_{im}$ then
15. remain in wake up mode until time $t_{im}.+\tau$
16. end if
17. if time $< t_{im}.+\tau$ then
18. remain in wake up mode until time $t_{im}.+\tau$
19. end if
20. end if
21. if time $< T_{m+1-}\ \tau$ then
22. go to sleep mode untim time T_{m+1}
23. end if
24. end if
25. end for

Each member or gateway node S, which needs route to destination D, sends a request for route to its MARI node Ms.

The MARI node Ms checks, if the destination D is its neighbor, if not, then it sends Mobile agent to another MARI nodes with in two hops through gateways. This will forward by all the MARI nodes until the destination node will be the neighbor of the any one MARI node Md

If the destination D accepts the route request, it acknowledges to MARI node Md. The MARI node Md waits for time Tw for mobile agents coming from various paths. After time Tw, MARI node Md selects the path over which accumulated congestion matrix and the path information is received from forward mobile agents. The congestion matrix is :

$$f_m = \alpha f_m T+(1-\alpha)f_m \qquad (1)$$

Where f_m is fraction time channel is free during past T seconds and α is weighing factor in (0,1).

Reverse mobile agent follows the path which was followed by the forward mobile agents.

The reverse mobile agent updates the routing table of the MARI node along the path. When reverse mobile agent reaches the MARI node Ms, it updates the routing table and informs node S about path establishment. Now node S can send packets over the established path.

SIMULATION MODEL

To evaluate the topology management scheme, we simulate 100 node network in a square region. Each node use a band width of 2 Mbps and each time twenty nodes send and receive traffic. Each of these nodes sends CBR traffic to another node.

RESULTS AND DISCUSSION

To measure the effectiveness of the topology management scheme, we simulated with on demand routing, several static and mobile topologies.

Delay performance: Figure 3 shows the average delay as the number of sleep cycles in a beacon period are increased. This delay was observed for packets of constant bit rate.

Power consumption: Figure 4 shows the average power consumption as node density increases. It can be noticed that, as node density increases, average power consumption per node is much less in topology management scheme as compared to flat topology network.

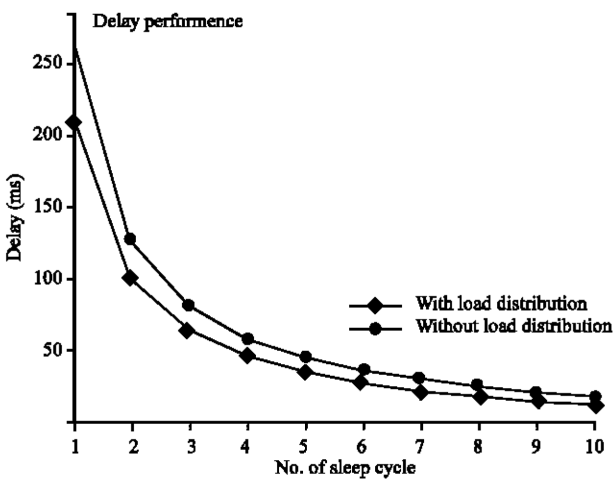

Fig. 3: Average delay for CBR traffic

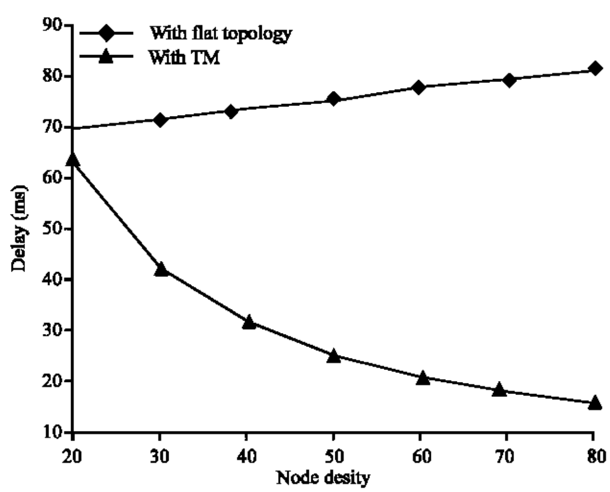

Fig. 4: Average power consumption with respect to increase in node density

From Fig. 3 and Fig. 4, we can conclude that average delay by using MATI topology is reduced and also the power consumption. The problems faced in simulation is to identify the node position because of its mobility nature.

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