Adaptive Broadcast Scheduling in Mobile AD HOC Networks

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ABSTRACT

The topology of the Mobile Ad Hoc network changes dynamically. The initial slot assignments may cause interferences among the nodes while transmitting. Many heuristics methods have proposed in [1] – [19]. In this paper, describes an adaptive distributed broadcast scheduling for spatial time division multiple accesses in mobile ad hoc networks that computes the slot assignments according to the changes in the topology like new node joining / leaving the network. No central node has maintained to calculate such schedules. Each node gathers information from its local neighborhood to reconstruct the slot assignments.

Keywords : Packet Radio Network (PRN), Time Division Multiple Access (TDMA), Carrier Sense Multiple Access (CSMA), Frequency Division Multiple Access (FDMA)

1. Introduction

A Mobile Ad Hoc Network consists of a collection of inter connected nodes. These nodes had geographically separated over a broad region. Each node is equipped with a transmitter / receiver and a control unit. All the nodes share a common radio channel over which the communication takes place. Hence, all the neighboring nodes may receive the transmission of a node. Hence, the TDMA protocols assign time slots to the nodes, so that collisions are resolved.

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The goal of the TDMA is

1. To find a Minimal TDMA length, without any conflict.
2. To maximize channel utilization.

Two types of interferences are possible in Mobile Ad Hoc Networks

1. Primary Interferences occur when a node receives from two different nodes at the same time or performs transmission and receiving at the same time. This is shown in Fig 1.
2. Secondary interferences occur when a transmission from a neighboring node unwittingly interferes at the receiving end. This is shown in Fig 2.

A Graph (V, E) represents a Mobile Ad Hoc Network where V denotes the set of nodes in the network, and E denotes the set of edges. If nodes a, b $\in$ V are within the transmission range of each other then they can receive the packets transmitted from each other. Then primary interference occurs. Let a, b, c $\in$ V. If (a, c) $\in$ E, (c, b) $\in$ E and (a, b) $\notin$ E then we say that secondary interferences occurs at node c.

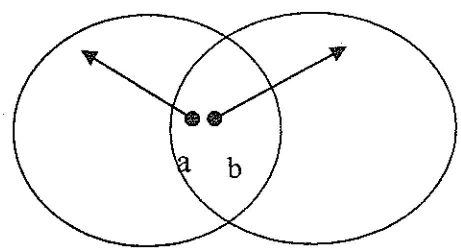

Figure 1 : Type 1 : Interferences

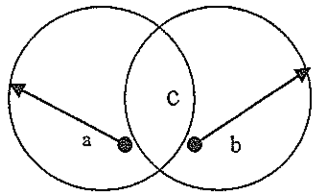

Figure 2 : Type 2 : Interferences

Hence, to avoid the above said interferences, the following constraints must be satisfied.

- A node cannot have transmission and reception status simultaneously.
- A node cannot receive two or more transmissions simultaneously.

In short, a node and its 1-hop, 2-hop neighbors have to transmit in different time slots. The broadcast schedule problem is identified as a distance – 2 coloring problem where a node and its 1-hop, 2-hop neighbors are assigned with different colors/slots

In [1] – [19], many transmission-scheduling methods had discussed. All of them are to find a collision-free transmission assignment in Mobile Ad Hoc Networks. The Lyuis's algorithm [6] assigns time slots for the nodes. In this paper, a new distributed method for adaptive broadcast scheduling in Mobile Ad Hoc Networks is proposed. This method performs better for heavily loaded networks and it is efficient in the assignment of collision-free transmission slots.

The remainder of the paper organizes as follows.

Section 2 describes the scheduling methods in Mobile Ad Hoc Networks. Section 3 describes the basics of broadcast scheduling concepts. Section 4 discusses the distributed adaptive broadcast scheduling method, Section 5 discusses a new slot assignment protocol, and section 6 presents the conclusions.

2. Scheduling Methods In Mobile Ad Hoc Networks

The protocols for Mobile Ad Hoc Networks are generally divided into two classes.

- Static Channel Access Classes
- Dynamic Channel Access Classes.

TDMA, FDMA, and CDMA are examples of the static channel access protocols. In static channel access protocols, a fixed amount of time/ frequency /code of the transmission medium is assigned to each node.

ALOHA and CSMA are examples of dynamic channel access protocols.

In TDMA, time has divided into fixed length time slots, where each slot has assigned to one node. Two or more non-conflicting nodes can share the same slot.

The primary objective of the PR network is to provide high throughput and secondary objective to maximize the total number of transmissions.

Most of these studies dealt with the construction of two different types of schedules

1. Broadcast schedules
2. Link schedules.

These schedules have two different types of interferences namely primary interference and secondary interference. In a broadcast schedule, each transceiver has scheduled to ensure collision free transmission, to all the transceivers within its range. In link scheduling, the transmission of a station has intended for only one specific transceiver within its range. This schedule needs to ensure that there are no collisions.

3. Adaptive And Non-adaptive Broadcast Scheduling

In the basic scheduling methods, a central computing center had maintained. This center maintains the complete information of the topology of the PRN. When a node is transmitting, no other nodes have permitted to transmit. These types of scheduling methods are not optimal as they produce lengthy frame lengths. Because of this, long delays had introduced to distribute the transmission schedules.

The topology of a PRN changes dynamically. Nodes join /leave the network frequently. Hence, the initial slot assignments may cause interferences among the nodes while transmitting. Hence in the non-adaptive broadcast scheduling the schedules should be recomputed when ever the topology changes. Until such a new schedule computed and distributed, the communication have stopped, which is not suitable for realistic environments. Hence, adaptive broadcast scheduling is preferred.

In adaptive Broadcast, scheduling a central computing center does not exist. Instead, each node maintains the state information record. Each node constructs this record from collecting information from its 1-hop, 2-hop neighbors.

The sate information record contains the following details

- Node id.
- List of 1-hop, 2-hop neighbors (local State Information).
- The transmission slots assigned to 1-hop, 2-hop neighbors.
- The list of neighbors out of its transmission range.
- The current frame size.
- The current maximum slot number.
- The Max degree of the network.
- The max hops distance of the network.

4. A New Distributed Method For Adaptive Broadcast Scheuling NDAB

The two primary issues in distributed adaptive scheduling method are

- Node joining the network.
- Node leaving the network.

The distributed adaptive scheduling method runs the scheduler whenever the topology changes. It collects information from the 1-hop, 2-hop neighbors, re-computes the new schedule and runs the new schedule without interrupting the nodes that are transmitting. Whenever the node leaves the network, the schedules too have to compute again. NDAB uses its own slot assignment protocols called the time_slot_allocation protocol and time_slot_adjustment protocol to find such new schedules.

4.1 Joining of the Network

There are two issues to consider when a node joins the network

- Registration
- Resolution

The purpose of the registration process is to make the new node known to all its 1-hop, 2-hop neighbors. If more than, one node joins the network and if they are within in the transmission range of each other, then only one of them succeeds through the registration process.

Resolution is the process of collecting the local information prepares a conflict-free schedule and runs this schedule in the network.

Time slots have divided into two parts called as identification interval and a payload interval as shown if figure 3. Each terminal decides whether to transmit an identification packet. A new node have to transmit an identification packet, otherwise it remains in receiving mode only. When a node receives an identification packet, it understands that it has a new neighbor.

The identification interval again consists of four mini-slots.

1. Broadcast mini-slot
2. Request mini-slot
3. Collision mini-slot
4. Monitor mini-slot

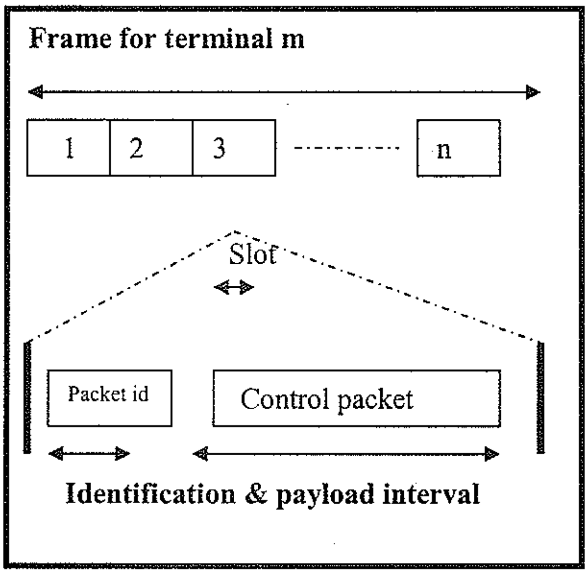

Figure 3 : Frame Structure

A node that successfully completes the registration process was called a monitor node to its 1-hop neighbors.

4.1.1 The Process for Registration

A node reserves the Broadcast-minislot, if none other than it is joining the network. If node B too wishes to join the registration process, it has to wait until A completes the registration process and become the monitor. If a joining node A identifies an empty Broadcast-minislot, it requests for registration by sending the Request_control packet in Request-minislot. If A did not detect any collision when it was broadcasting its control packet and if it observes an empty Collosion_minislot, then A understands that none of its 1-hop, 2-hop neighbors are making a request for registration process. Hence A reserves the Monitor-minislot by passing a monitor_h control packet. If none other than A had claimed to become the Monitor, A becomes the Monitor and the registration process ends.

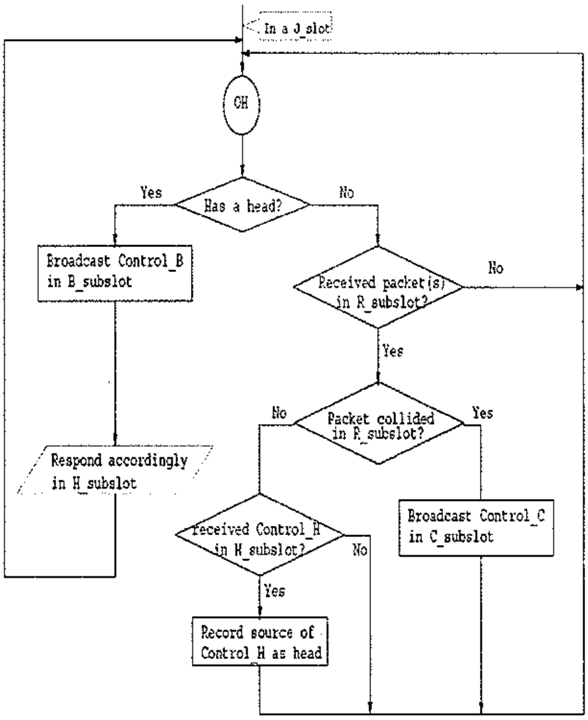

Figure 4 : Procedure for registration

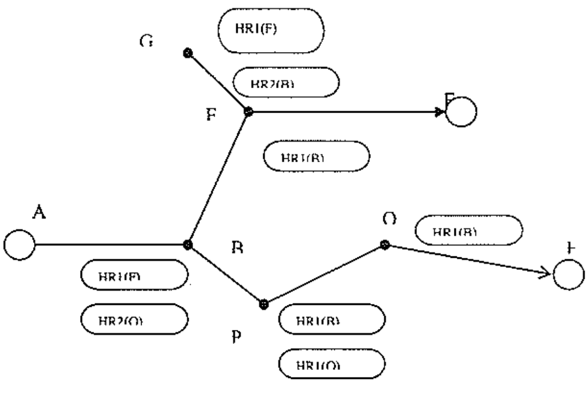

Figure 6 Information exchange between online nodes

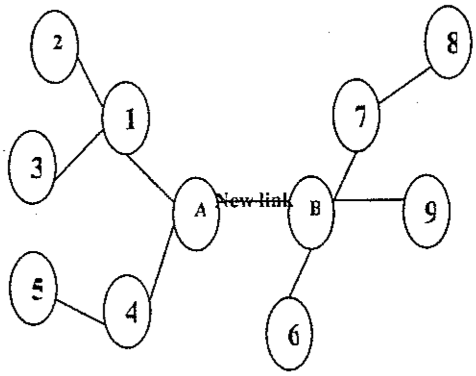

Figure 5 : B detects a new link to new node A.

4.1.2 The Process for Resolution

The procedure registration guarantees that no two Monitors are at a distance of 1-hop , 2-hop. However, there can be two or more monitors at a hop distance of two or more. It is the responsibility of the resolution process, to see that no two monitors run the scheduler at the same time. This is possible with the coordination of the nodes, which are not monitors.

The procedure is as follows.

Consider the figure 6. Let A, E, F are the monitors, which are at a distance more than 2-hop between each other. Each of these monitors transmits their information through theirs 1-hop neighbors. Node B observes that A is its monitor and collects the information about its monitor id, time when its monitor became a monitor. The Monitor (B)_1 is constructed, from the above information and sends it to its 1-hop neighbors. C receives this and C constructs Monitor (B)_2 and sends it to its 1-hop neighbors. This way all the non-monitor nodes get packets from their 1-hop neighbors, containing information about the active monitors. Now each of these non-monitors node, analyses the information in the packets received from their 1-hop neighbors and accepts the monitor, which has higher priority as its head. Once this conformation is received from all of A 1-hop neighbors, A sends the acknowledgement to its 1-hop neighbors.

The 1-hop neighbors reset the state information about its new neighbors and transmit the same to its 1-hop neighbors. A uses the slot assignment protocol to calculate the slots and then runs the new schedule. The remaining monitor nodes have suspended from transmitting until the resolution process completes. Once A completes the resolution process, it un-reserves the Broadcast-minislot, which enables the suspended monitor nodes to compete for the resolution process.

5. NDAB SLOT ASSIGNMENT PROTOCOLS

The topology of the Mobile Ad Hoc Networks changes dynamically. Whenever the node joins/leaves the network, the nodes cannot use the initial slot assignments. Hence, the slots have computed again whenever the node joins/leaves the network.

The joining node to re-compute the slots can use the following protocol. The joining node to all of its 1-hop neighbors distributes this new schedule.

Proc Time _Slot _Allocation(A)

Begin

// Small _conflict _set (A) is a list that contains a set of node id's

//Possible _color _set (A) is a list that contains color values

//Conflict _node _set (A) is a list that contains a set of node id'1

1.0 D-2_neighbors (A) ← Assign 3-hop, 4-hop ... n-hop Neighbors list of A

2.0 Small_ conflict _Set (A) ← Find from D-2_neighbors (A)

the largest set of non-conflicting nodes that can transmit along with A.

3.0 Let Possible _color _set (A) ← List of colors used by nodes in Small_conflict_set(A)

4.0 Sort the Possible _color _set(A) in ascending order of their color values.

5.0 Let finished ← false

6.0 For I in Possible _color _set(A) do

{

// Find whether node A fit in slot I

Conflict _node _set (A) ← find list of nodes producing conflict with A in slot I .

if [for each node in Conflict _node _set(A) are found in slots less than I]

then begin

// remove those nodes from the race

Small_conflict_set(A) ← Small _conflict _set(A) – Conflict _node _set (A)

// slot assignment is completed

Finished ← true

// exit the procedure slot assignment

Exit (true)

End //end of if

}// end of loop

7.0 if finished = false then

Increment current slot_value by 1

Assign slot_value to node A

Conflict_free_node (A) ← Find the non-interference Node set of A

Allow the nodes in conflict_free_node (A) to transmit in the current slot _value slot also.

End if // end of the if

End

The above slot_assignment protocol does not simply increment the slot_value by 1 whenever a new node joins the network. The protocol checks whether the new node produces a non-conflicting schedule with the existing schedule. If it is not possible then the slot_value is incremented by one. The primary objective of packer radio networks is to decrease the frame size and the secondary objective is to increase the total number of transmission slots. Hence, the slot assignment protocol greedily updates the slot_value for effective channel utilization. Similarly, when a node leaves the network the schedule has to compute again.

6. Conclusion

NDAB depends on the state information of all of its neighbors. When the new node joins/leaves the network, then except the monitor nodes the entire remaining nodes in the network can transmit. The new schedule have distributed without disturbing the existing schedule, which improves the performance of the network.

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