Interference Avoidance and Power Management in Hybrid Wireless Networks

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Abstract — *With the advancement in Networking and Telecommunication technologies and the increase in mobility necessities, Wireless Networks and its related technologies are becoming more popular nowadays. Since, Wireless and Mobile Networks are still evolving, the technology requires much more optimizations. The traditional Base Station (BS) based Wireless networks and Ad-hoc Wireless networks, apart from having their unique advantages, have some disadvantages too. So, we are working towards a new type of Wireless Networks called Hybrid wireless networks incorporating the advantageous features of both BS based and Ad-hoc wireless networks enabling the wireless end terminals to work in different modes based on the necessities and availabilities. The existing literature in Hybrid Wireless Networks does not include much work in overcoming the performance deterioration due to Interference and also the Power drain incurred because of retransmissions. We propose a novel method for Interference Avoidance and Power Management in the presented work.*

Index Terms — Hybrid Wireless Networks, Interference Avoidance, Proximity Vector, Dynamic Channel Assignment, Activity Scheduling.

I. INTRODUCTION

1.1 Base Station based wireless networks:

The traditional Base Station (BS) based wireless networks are of single-hop type since the data transmissions need to be either from Base Station to Mobile node or from Mobile Node to the Base Station. The mobile nodes in this type of networks are solely dependent on the Base Stations for communication. These Base Stations are usually connected by a wired infrastructure. This architecture is highly reliable and is versatile to almost all geographic locations.

The design of BS based networks is such that, the geographical area is virtually divided into a number of cells and Base stations are established in these cells. The selection of the location of a Base Station within a cell is an endeavoring task. The main problem with BS based networks is frequent hand-off because of the small size of cells. Another important problem is Location maintenance of the mobile nodes.

1.2 Ad-hoc wireless networks

These are special types of wireless networks that do not require any prior infrastructure. Base Stations are absolutely absent in these networks. The mobile nodes form a network among themselves and then start communicating with one another by building some essential data structures like routing tables etc., for efficient communication. The information about the constituent nodes in these tables need to be regularly updated since the nodes are highly mobile in nature. Ad-hoc networks are highly flexible because of their plug-and-play property (These networks can be formed whenever and wherever necessary). This flexibility makes these networks more applicable in military bases and during the times of disasters during which base stations may not survive. Some of the disadvantages may be the small size of these networks, unreliability and route maintenance.

1.3 Hybrid Wireless Networks

Hybrid wireless networks [1] are new type of networks incorporating the advantageous features of both BS based and Ad-hoc wireless networks enabling the wireless end terminals to work in many modes based on their necessities.

The traditional BS based wireless networks are prone to failures at the time of catastrophes like earthquakes, war periods etc. This failure of a base station deprives some of the wireless nodes within that cell of communicating with the outside world. In such situations Ad-hoc networks play a very vital role in communication. The nodes which are in close proximity form a wireless network and communicate among themselves and even with the mobile nodes in the nearby cells.

This switching of Base Station to Ad-hoc mode can even be done in many other different scenarios. In general, BS based communication involves two-hops. Let us consider a scenario in which a mobile node A wants to communicate with mobile node B and the distance between them is lesser when compared to the distance of either of the nodes A and B from the corresponding base stations as shown in the Figure 1. Here, it would incur more cost when communication takes place using Base Stations. Hence, another alternative is to make the nodes A and B communicate among them directly. This mode of communication is known as **One-hop direct transmission mode.**

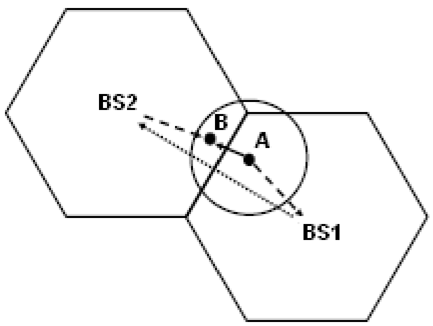

Fig.1 One-hop Transmission mode

Another mode of communication in Hybrid wireless networks is **Two-hop direct transmission mode** [6]. Let us look at this mode of transmission with an example. Let X, Y and Z be the three mobile nodes and node Y is in the transmission range of both the nodes X and Z and also node Z is not in the range of node X. When node X wants to communicate with node Z, the communication can take place via the node Y.

Though, this type of communication can be further extended to three or more hops, the throughput obtained is worse than the throughput obtained when communicating using Base Stations.

1.4 Interference: Sources and its detection

Since Radio spectrum is a scanty resource, proper sharing of these resources need to be considered with great care. This sharing of resources can also result in various problems one of which may be intentional or non-intentional access of the channel resources of others, which results in a phenomenon called **Interference**.

Interference [3] may be due to external devices like Cordless phones, Microwave Ovens or Radar devices which may sometimes make use of the unlicensed part of wireless spectrum. There can also be Interference between the upstream and downstream flows of nodes in the same network itself. Another chance of Interference occurring within the network itself is that the multiple nodes within the range of one another can attempt to transmit simultaneously, resulting in collisions.

Interference is said to occur if the calculated value of carrier to interference ratio on the receiver side is lower than the threshold value.

1.5 Power Management in Wireless Networks:

The real use of a true wireless network is to have the freedom of roaming everywhere within the range of the network. The users of wireless terminals like PDAs, Mobile Phones etc. do not want to be bound to a place. At the same time, this mobility should not incur excessive or inefficient battery usage. Thus power management plays an important part in Wireless and Mobile computing.

II. PROPOSED METHOD

In Wireless networks, the transmission power determines the range of a mobile device or a Base Station and therefore transmission power has a direct impact on the performance. If we make use of high power, the transmission range is large. However, more interference due to large power will tend to limit the throughput. If we decrease the power, the interference also decreases, as does the transmission range. As a result, handoff becomes more frequent and critical in this situation.

Consider the case where there is a failure of a Base Station. Now all of the mobile nodes within the coverage area of that Base Station are deprived of communication. Now the mobile nodes start operating in One-hop transmission mode. The nodes increase their range by increasing their power and start communicating with other nodes in this mode. The various problems that might arise are excessive usage of available power when compared to the power consumed in normal Base Station based operation and Interference occurring due to the presence of a large number of mobile nodes within the transmission range when compared to those in conventional BS based networks. Here we would like to compensate the power loss by some other means.

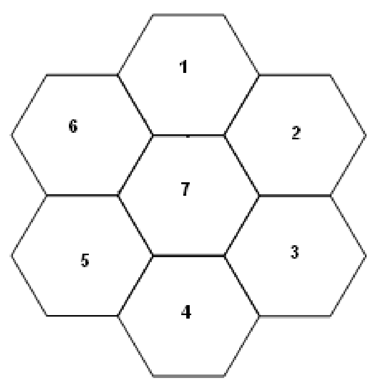

Fig.2 Basic cell structure

Interference results in poor quality of data transmission and the overhead of retransmission is also incurred. So we would like to avoid interference as far as possible by proposing various methods for each and every mode of operation of the nodes of Hybrid Wireless Networks.

2.1 Interference avoidance in BS mode of operation

The best method for Interference avoidance [4] is to make the nodes communicate at different frequencies. We would like to adopt the conventional methods presently used for interference avoidance in the base station mode of operation.

The general virtual partition of the geographical area for establishment of Base Stations [5] is as shown in Figure 2. This type of arrangement is known as a C**luster.** The conventional method of achieving interference avoidance within a cluster is by allotting and providing license for a set of channel frequencies for each and every cell. But, this may not be a suitable method since wireless spectrum is a scarce resource. As a result of this there might be unavailability of resource when most of the users within a cell need to be served at the same time. To overcome this problem, a method called **Channel borrowing**, in which the free channels in the neighboring cells are borrowed for use, is employed.

Consider the cell labeled 7 in the cluster shown in Figure 2. The cell is neighbored by the cells labeled 1 to 6. In a similar way, in real-time, each and every cell is neighbored by some number of cells.

i) When the Base station of a cell, say 7, allots a channel to a user, it need to convey this information to the base stations of its neighboring cells labeled 1 to 6.

ii) The base stations upon receiving the channel allotment information from their neighbors, should store them for future use.

iii) When a cell in a cluster runs out of communication channels, it borrows from any of its neighboring cells. This is Channel Borrowing.

2.2 Interference Avoidance in One-hop transmission mode

In ad-hoc mode of operation, the mobile stations communicate among themselves without the help of Base stations. Hence the communicating nodes need to co-operate among themselves to avoid the possible interferences.

In the proposed method for interference avoidance, each and every node constituting the network need to maintain some details about its neighboring nodes in a data structure called **Proximity Vector**. The details maintained about the neighboring nodes are Address of the neighboring mobile node, List of channels currently in use by that mobile node. The nodes maintain separate proximity tables for each and every neighboring node. These proximity vectors are updated periodically.

The nodes make use of this Proximity Vector for deciding upon the channel through which the communication is about to occur. The steps involved in transmission are as follows:

i) At first, the sender builds a list of free channels by combining the information obtained from all of its Proximity vectors, the channels carrier-sensed to be free and also by eliminating the channels that are previously found to be more prone to Interferences.

ii) Now, the sender sends a Request To Send (RTS) with a list of free channels on which communication can take place possibly.

iii) On receiving the Request, the intended recipient also builds a list of free channels in a similar way that the sender followed for building.

iv) Now the intended recipient sends a Clear To Send (CTS) signal along with the information of the channel [2] on which communication is about to occur.

2.3 Power Management in Hybrid Wireless Networks

The excessive power consumption incurred when the transmission range is increased need to be compensated by some other means. The battery conservation technique needs to be applied at the MAC layer. Large amount of power is consumed in listening the radio channels even when the mobile node has no data to receive. Thus, scheduling the duration during which the mobile node needs to be active helps in achieving higher throughput with less battery consumption. This is known as **Activity Scheduling**.

Here we propose two types of activity scheduling methods namely **Synchronous** Activity Scheduling and **Asynchronous** Activity Scheduling.

2.3.1 Synchronous Activity Scheduling

Synchronous Activity Scheduling requires synchronization of clocks between all the nodes in the network and also the sender and receiver nodes should have knowledge of each one's **Activity Time**. The remaining duration, during which there is no activity, the nodes spend their time in sleep. Figure 3 shows the **Activity diagram** of a transmitter and a receiver pair.

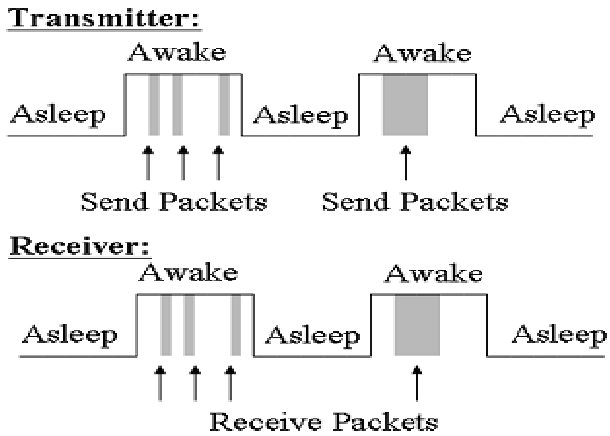

Fig. 3 Activity diagram of a Transmitter-Receiver pair in Synchronous mode

2.3.2 Asynchronous Activity Scheduling

In Asynchronous mode, the nodes can involve in packet transfer whenever they need. However, the nodes need to wake up in periodic intervals to check whether any other node is waiting to communicate with it. In this mode, in order to achieve proper communication without any loss of data, initially some bytes of synchronization data need to be sent till the intended recipient node wakes up and starts listening. In the worst case, the sender tries to transmit immediately after the receiver goes to sleep. In this case, the sender needs to send the synchronization data during the whole of the sleep time of the receiving node. Once the receiver has come to the activity, proper data transmission starts. The Activity diagram of Transmitter and a receiver in Asynchronous mode is shown in Figure 4.

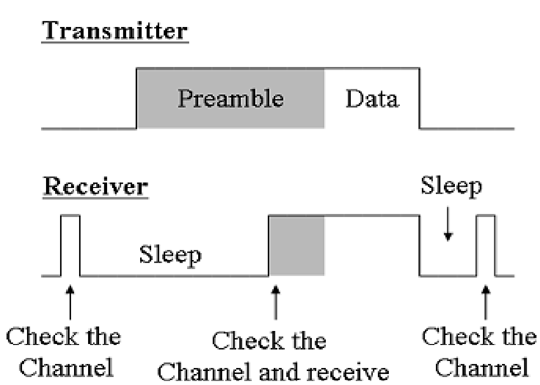

Fig. 4 Activity diagram of a Transmitter-Receiver pair in Asynchronous mode

III. EXPERIMENTAL RESULTS

The performance evaluation parameter “Total number of Bytes lost”, both in traditional Base Station based networks and Hybrid wireless networks incorporating the proposed interference avoidance features, is analyzed and the graphs are plotted.

Figure 5 shows the plot of number of Bytes of information lost (on y-axis) vs. Time (on x-axis) in a BS based wireless network considering also the effects of Interference and abrupt base station failures.

Figure 6 shows the plot of number of Bytes of information lost (on y-axis) vs. Time (on x-axis) in a Hybrid Wireless Network incorporating the proposed interference avoidance methods.

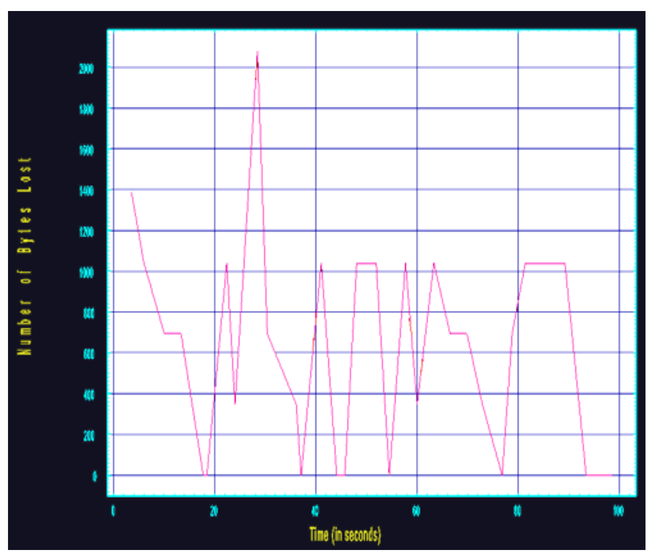

Fig. 5 Plot of Number of Bytes of Information lost vs. Time in BS based networks

Average number of Bytes lost in a BS based Wireless network is found to be 1092 for a time period of 100 seconds. The maximum number of Bytes lost during some infinitesimal period of time is found to exceed even 2000.

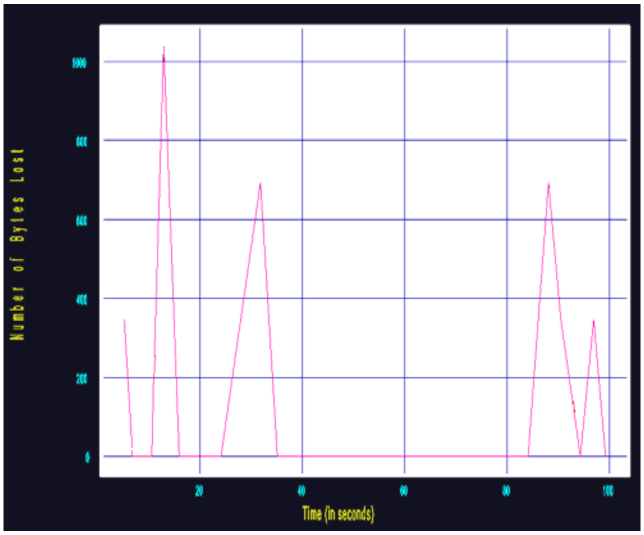

Fig. 6 Plot of Number of Bytes of Information lost vs. Time in Hybrid Wireless Networks

Average number of Bytes lost in a Hybrid wireless network is found to be 464 for a time period of 100 seconds. The maximum number of Bytes lost during some infinitesimal period of time is found to be around 1000 only during a simulation period of about 100 seconds.

IV. CONCLUSION AND FUTURE WORK

Thus, the Hybrid Wireless Networks are found to perform more efficiently after integrating the Interference avoidance schemes into the existing system. Thus, efficient power management is also achieved by completely eliminating or reducing the number of re-transmissions to a great extent. Our future works include studying the various other Power management schemes in various Wireless Networks and their relevancy with Hybrid Wireless Networks.

V. REFERENCES

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