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A Review on Channel Allocation Schemes in Mobile Ad Hoc Networks

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***Abstract*— Mobile Ad Hoc networks are the networks that has no centralized control in it. The Ad Hoc network consists of mobile nodes that exchange packets by sharing a common broadcast radio channel. Bandwidth that is available for communication to be shared is limited and thus there is a need to control the access to this shared medium. Due to this, bandwidth can be used very efficiently. In MANET's, MAC layer protocol plays a very vital role in efficient utilization of shared media in a distributed manner. There are three contradicting requirements at the MAC layer and they are: maximize channel utilization, minimize control overhead and ensure fairness. In this paper, we have studied about channel allocation schemes in mobile communication and have also studied various reuse partitioning schemes, handoff's effects.**

Keywords*— Mobile Ad Hoc networks, channel allocation, channel allocation schemes, frequency reuse, interference.

I. INTRODUCTION

The networks in cellular communication divide a geographical area into small regions those are hexagonal in shape. These are called cells. Each cell has a mobile service station and a number of mobile hosts. To establish a communication, a mobile host sends a request to the mobile service station in its cell. But the session of communication is possible only if a wireless channel can be allocated for the communication between the mobile host and the mobile service station. There is a need of reuse of frequency channels as the frequency spectrum is limited. This will also increase demand for wireless communication. But unless and until the geographical distance between two different cells is less than a threshold called minimum channel reuse distance, they cannot use the same channel for communication. If they use it, there will an interruption caused between their communication sessions and this is called as channel interference [1] [3].

A channel is available for a cell if its use in the cell does not interfere with that of other cells. Whenever there is a need of a channel by a cell, it acquires one available channel using a channel allocation algorithm. A channel allocation algorithm contains two parts in it. They are a channel acquisition algorithm and other is the channel selection algorithm. The channel acquisition algorithm collects information from other cells and make sure that two cells within dmin do not use the same channel. Further, the channel selection algorithm chooses a channel from a large number of available channels in order to achieve better channel reuse. Performance of a channel acquisition algorithm is measured by message complexity and acquisition delay. The number of messages exchanged per channel acquisition gives the message complexity and the time required for a mobile service station to allocate a channel is termed as an acquisition delay. Call blacking rate gives the measurement of performance of the channel selection algorithm. A call is blocked if there is no channel available for use when the call is being set up. There is another condition when the same happens and that is when it is being handed over to another cell due to host mobility [1].

A given radio spectrum is divided into a set of disjointed channels that can be used simultaneously and further will minimize interference in adjacent channel by allocating channels appropriately. Several channel assignment strategies have been suggested in the literature. They can be divided into fixed channel allocation schemes, dynamic channel allocation schemes and hybrid channel allocation schemes. In the fixed channel allocation scheme, a set of channels is permanently allocated to each cell in the network. In dynamic channel allocation schemes, all the channels are kept in a central pool and are assigned dynamically to new calls as they arrive in the system. Hybrid channel allocation schemes are the combination of above two i.e fixed and dynamic channel allocation schemes [8][9].

II. CHANNEL ASSIGNMENT IN MOBILE AD HOC NETWORKS

A. CHANNEL ASSIGNMENT

Mobile ad hoc network is a collection of radio nodes i.e transceivers located in a geographical region. Each node is equipped with an omnidirectional antenna and it has a limited

transmission power. A communication session can be established either through a single-hop radio transmission if the communication parties are close enough to each other or through relaying by intermediate nodes otherwise. A channel assignment to the nodes in a wireless ad hoc network should avoid two collisions and they are primary and secondary collisions. The primary collision occurs whenever a node simultaneously transmits and receives signals over the same channel while the secondary collision occurs when a node simultaneously receives more than one-signals over the same channel. In order to prevent the primary collision, two nodes can be assigned the same channel if and only if neither of them is within the transmission range of the other. Similarly, in order to prevent the secondary collision, two nodes can be assigned the same channel if and only if no other node is located in the intersection of their transmission ranges. The conflict-free channel assignment problem seeks an assignment of the fewest channels to a given set of radio nodes with specified transmission ranges. This happens without any primary collision or secondary collision [10]. It is a classic and major problem in mobile ad hoc networks.

B. CHANNEL ASSIGNMENT STRATEGIES

Channel assignment affects the performance of the system, especially when it comes to handoffs. There are several channel assignment strategies and two basic are Fixed Channel Assignment and Dynamic Channel Assignment [9].

Fixed Channel Assignment

In this type of assignment strategies, channels are pre-allocated to different cells meaning that each cell is assigned a specific number of channels and further the frequencies of these channels are set. Following are the aspects. Any call attempts in a cell after all channels of that cell become occupied gets blocked i.e the caller gets a signal indicating that all the channels are occupied. These strategies are very simple and require least amount of processing. Borrowing strategy is a variation of this method. In borrowing strategy, cells are allowed to borrow channels from adjacent cells if their channels are fully occupied while adjacent cells have free channels. Mobile Switching Centre monitors the process and gives permission to borrowing cell to borrow channels. But donating cell should not be affected by the borrowing process and no interference should occur by moving the channel from one cell to another [5][6].

Dynamic Channel Assignment

In this type of channel assignment strategies, channels are not pre-allocated to any cells. This means that any channel can be allocated to any desired cell during the operation of the system. Such a channel assignment has some aspects. They can be described as further. Mobile Switching Centre monitors all cells and all channels. Each time a call request is made, serving BS requests a channel from the mobile switching centre. This further runs an algorithm that takes into account the possibility of future blocking in cells, frequency being used for channel and the reuse distance of the channel. MSC assigns a channel only if it is not used and if it will not cause co-channel interference with any cell in range. This algorithm provides less blocking that gives higher capacity. MSC collects real-time data of channel occupancy, traffic distribution and radio signal strengths indicators [5][6][8].

III. CHANNEL ALLOCATION SCHEMES

Channel allocation schemes are divided into various categories depending on the comparison basis. Channel assignment algorithms when compared based on the manner in which co-channels are separated; they can be distinguished as Fixed Channel Allocation, Dynamic Channel Allocation and Hybrid Channel Allocation. i.e FCA, DCA and HCA, respectively [3].

In Fixed Channel Allocation i.e FCA schemes, the area is partitioned into a number of cells and a number of channels are assigned to each cell according to reuse pattern. This pattern depends on the desired signal quality. These schemes are very simple but they do not adapt to changing traffic conditions and user distribution. In order to overcome these drawbacks of FCA schemes, dynamic channel assignment i.e DCA strategies have been introduced.

In Dynamic Channel Allocation schemes, all channels are placed in a pool and they are assigned to new calls as needed. At the cost of higher complexity, DCA schemes provide flexibility and traffic adaptability. But, DCA strategies are in less efficient than FCA under high load conditions. For that, Hybrid Channel Allocation i.e. HCA techniques were designed that combines FCA and DCA schemes together [8].

Channel assignment schemes can be implemented in many different ways. For an example, a channel can be assigned to a radio cell based on the coverage area of the radio cell and its adjacent cells such that the minimum carrier-to-interference ratio is maintained with high probability in all radio cells. Channel assignment schemes can be implemented in centralised or distributed fashion. In the centralised schemes, the channel is assigned by a central controller and in distributed schemes a channel is selected either by the local base station of the cell from which the call is initiated or selected autonomously by the mobile. In a system where a cell based control is present, each base station keeps information about the current available channels in its vicinity. The channel availability information is updated by exchange of status information between base stations. In the autonomously organized distributed schemes the mobile chooses a channel based on its local co-channel interference ratio measurements without the involvement of a central call assignment entity. The channel assignment based on local assignment can be done for both fixed channel allocation schemes and dynamic channel allocation schemes [1][4].

A. Fixed Channel Allocation

In this, the channels can only be used in designated cells. Different groups of radio channels may be assigned to adjacent cells, but the same groups must be assigned to cells separately by a certain distance that is termed as reuse distance to reduce co-channel interference [9]. In this allocation strategy, every cell is permanently assigned a set of nominal channels according to the traffic constraints and interference. To decide which channels should be assigned to which cells, there is a need of an assignment policy before we activate the system. In other words, an FCA algorithm allocates the same number of channels to every cell and for this the channel set is partitioned into a number of subsets of equal cardinality and these sets are assigned to cells accordingly to some possibly regular scheme. For an example, consider a hexagonal tiling. If the set of available channels is partitioned into three subsets, numbered 1,2 and 3, then the regular pattern shows a possible assignment for a reuse distance equal to 2. When a reuse distance of two hops is needed, the whole channel set must be partitioned into seven subsets, numbered from 1 to 7 [6]. This is the easiest assignment technique but it provides the worst channel utilization. Advanced Mobile Phone System works with this strategy. If the total number of available channels in the system S is divided into sets, the minimum number of channel

sets N required to serve the entire coverage area is related to the frequency reuse distance D and is given by

$$N = D^2 / 3R^2$$

Due to short term fluctuations in the traffic, FCA schemes do not maintain high quality of service and its capacity is not attainable with static traffic demands. This can be addressed by borrowing free channels from neighbouring cells.

Simple Channel Borrowing Schemes (CB)

In Simple Borrowing schemes (SB), acceptor cell that has used all its nominal channels can borrow free channels from its neighbouring cell i.e. donor cell to accommodate new calls. Borrowing can be done from an adjacent cell which has largest number of free channels and this is called borrowing from the richest (SBR). An improved version of SBR strategy takes channel locking into account when selecting a candidate channel for borrowing. This scheme tries to minimize the future call blocking probability in the cell that is most affected by the channel borrowing (BA). Basic Algorithm with Reassignment (BAR) provides for the transfer of a call from a borrowed channel to a nominal channel whenever a nominal channel becomes available. Borrow First Available i.e. BFA selects the first candidate channel it finds [6][8].

B. Dynamic Channel Allocation

Channels are temporarily assigned for use in cells for the duration of the call. After the call is over, the channel is returned and kept in a central pool. There is no fixed relationship between channels and cells in DCA. All channels are kept in a central pool and are assigned dynamically to radio cells as new calls arrive in the system. After a call is completed, its channel is returned to the central pool [4]. To avoid co-channel interference, any channel that in use in one cell can only be reassigned simultaneously to another cell in the system if the distance between two cells is larger than minimum reuse distance. This scheme needs more transceivers for each base station. They give worse performance than FCA under heavy loads. DCA is partially suitable for Microcellular systems and in conditions of light nonstationary traffic.

The main idea of DCA scheme is to evaluate the cost of using a candidate channel, and select the one with the minimum cost provided that certain interference constraints are satisfied. The selection of the cost function differentiates DCA schemes. In DCA schemes, all channels are kept in a central pool and are assigned dynamically to new calls as they arrive in the system. After each call is completed, the channel is returned to the central pool. It is fairly straightforward to select the most appropriate channel for any call based simply on current allocation and current traffic, with the aim of minimizing the interference. DCA scheme can overcome the problem of FCA scheme; however variations in DCA schemes center around the different cost functions used for selecting one of the candidate channels for assignment. DCA schemes can be centralized or distributed [6] [8] [9].

Centralized DCA

The centralized DCA involves a single controller selecting a channel for each cell. For a new call, a free channel from the central pool is selected that would maximize the number of members in its co-channel set. It minimises the mean square of distance between cells using the same channel. First Available (FA) is the simplest of all. In this, the first available channel within the reuse distance encountered during a channel search is assigned to the call. FA minimizes the system computational time. In Locally Optimised Dynamic Assignment (LODA), the channel selection is based on the future blocking probability in the vicinity of the cell where a call is initiated. Selection with Maximum Usage on the Reuse Ring (RING) – A candidate is selected which is in use in the most cells in the co-channel set. If more than one channel has this maximum usage, an arbitrary selection among such channel is made to serve the call. If none is available, then the selection is made based on FA scheme. The Mean Square (MSQ) scheme selects the available channel that minimises the mean square of the distance among the cells using the same channel. 1–clique scheme uses a set of graphs, one for each channel, expressing the non co-channel interference structure over the whole service area for that channel [4] [9].

Distributed DCA

Distributed schemes are simpler for implementation in the micro-cellular systems due to its simple assignment algorithm in each base station. This scheme is based on one of the three parameters and they are Co-channel distance; Signal Strength Measurement and Signal to Noise Interference Ratio.

C. Hybrid Channel Allocation

Hybrid Channel Allocation (HCA) schemes are a combination of the FCA and DCA schemes. In this, the total number of channels available for service is divided into fixed and dynamic sets. The fixed set contains a number of nominal channels that are assigned to cells as in the FCA and in all cases are to be preferred for use in their respective cells. The second set of channels is shared by all users in the system to increase flexibility. When a call requires service from a cell and all of its nominal channels are busy, then a channel from the dynamic set is assigned to the call. The channel assignment procedure from the dynamic set follows any of the DCA strategies. The call blocking probability for an HCA scheme is defined as the probability that a call arriving to a cell finds both the fixed and dynamic channels busy. HCA schemes have variants which add channel recording i.e. switching channels assigned to some of the calls in progress to maintain a nearly optimum separation between coverage areas by simultaneously using the same channel in order to reduce inefficiency at high load [4]. For an example, when a call requires service from a cell and all of its nominal channels are busy, a channel from the dynamic set is assigned to the call.

In Hybrid Channel Allocation, request for a channel from the dynamic set is initiated only when the cell has exhausted using all its channels from the fixed set. Optimal ratio is the ratio of number of fixed and dynamic channels. 3:1(fixed to dynamic) ratio provides better service than fixed scheme for 50 percent traffic. Beyond 50 percent, fixed scheme perform better. For dynamic, with traffic load of 15 percent to 32 percent, better results are found with HCA [6] [8] [9].

D. Other Channel Allocation Schemes

Flexible Channel Allocation

Similar to hybrid scheme with channels divided into fixed and flexible i.e. emergency sets. Fixed sets are used to handle lighter loads. Variations in traffic (peaks in time and space) are needed to schedule emergency channels. There are two types of flexible channel allocation: scheduled and predictive. In scheduled, prior estimate is done about traffic change and in predictive, traffic intensity and blocking probability is monitored in each cell all the time [9].

Reuse Partitioning based Channel Allocation

In this, each cell is divided into concentric zones. Inner zone being closer to BS would require lesser power to attain a desired channel [9].

Overlapped Cells-based Allocation

In such allocation techniques, cells are splitted into number of smaller cells as pico, micro cells in order to handle increase traffic. For fast moving MS, if channels are assigned from micro cell, number of handoffs will increase. Thus, highly mobile cells are assigned channels from the cell. MS with low mobility are assigned to micro or pico cells [9].

Flexible assignment strategies uses centralised control and they require the central controller to have up-to-date information about the traffic pattern in its area in order to manage the assignment of the flexible channels. The flexible allocation schemes reduce the processing load of the system controller as compared to DCA scheme.

IV. Conclusion

We studied different types of channel allocation schemes used in mobile ad hoc networks. We studied that fixed channel allocation is suitable for macro cellular systems with stationary traffic and a predictable propagation environment. It doesn't suits for conditions of nonstationary traffic. DCA overcomes the drawbacks of FCA strategies and it can be used for micro cellular systems and conditions of light non stationary traffic. We also studies that further these techniques can be used to reduce channel conflicts in Mobile Ad Hoc Networks.

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