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A new method of channel allocation based on clustering for multi-radio, multi-channel wireless mesh networks

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Abstract: Since the multi-channel and multi-radio networks had been widely used, the channel allocation scheme plays a crucial role in determining the performance of wireless mesh networks plays. These days many channel allocation schemes to increase performance of wireless networks has been provided. However, most existing schemes interfere links on the link of target, at one level, are considered that this will be caused a sharp drop in network performance. In this study, a new scheme for channel allocation based on clustering will be done based on category that its difference with other methods in clustering, is that this method can distinguish between Interference links and it is classified. In this method by using calculation of category the maxima at Interference graph, this scheme logically divide the network into clusters and then channel allocation in three stages to reduce interference of links that include non-synchronized Interference and synchronized Interference is done.

Keywords: wireless mesh networks, channel allocation, multi-radio multi-channel, Interference

1. Introduction

Nowadays, wireless mesh networks have found extensive attention because of the many advantages, such as high-capacity, high data rate, low costs and good extensibility. Wireless mesh networks is a communicative network that includes the radio nodes that have been organized in a mesh topology. Wireless mesh networks based on bilateral cooperation between mesh nodes that by moving multi-hop wireless are provided access to the Internet to end users [1]. The main advantage of wireless networks is their inherent ability in formation of a strong network. When mesh nodes be lighter, the nodes hear each other's voices and establish a network that so see what happens when a node fails and how the routing nodes discover the alternative route this improving and repair is fully automatic. Over the years, wireless mesh networks achieved unique three features based on radio technology: any combination on the basis of more scalability and higher performance of the network upgrades throughput and delay time frequently. This initial stage before the IEEE standard known as first generation is development of wireless mesh technology. That based on this feature the various settings of the first generation of wireless networks have been described briefly. Wireless mesh network is a wireless technology promising for a number of commercial applications and emerging, such as home networking, broadband, community and neighborhood networks, synchronized network management, intelligent transportation systems. Mesh networks is a powerful and reliable solution to create and access to wireless broadband services for Internet service providers and end users with cost are reasonable and hence are highly regarded. Wireless mesh networks include mesh routers and mesh clients. In this architecture, the routers are static and fixed mesh, that formed the backbone of the networks and clients through these routers have access to the network (Internet), as well as these clients are directly connected to each other (or so have been woven or meshed). In contrast to traditional wireless networks, wireless mesh networks dynamically, are self-organizing and self-configuring. In other words, the nodes in the mesh network automatically establish and maintain their connection. This feature provides many advantages for end-users; Such as the cost of prepayment less Easy maintenance of network, powerful and reliable coverage. In addition, the use of advanced radio technologies, such as multiple radio interfaces and smart antennas, network capacity has been increased significantly. Also, Gateway and bridge functions in mesh routers, provides possibility of merging wireless mesh network with wireless networks, such as wireless sensor networks. Subsequently, through such wireless mesh network as merged, end users can to benefit from the advantages of multiple wireless networks. Some of the benefits and features of wireless mesh networks have been listed below. Increased reliability: In wireless mesh networks, wireless mesh routers create additional routes between sender and receiver of the wireless connection. This has been eliminated the only component failures and potential bottleneck links means links that are prone to becoming the bottleneck and led to a significant increase in the reliability in communications. against potential problems of the networks, such as nodes failure and route failure due to radio wave interferences or obstacles

network's ability with other selectable multi-path, is guaranteed. So by using wireless mesh networks technology, networks can continue to operate in more additional times; Even if an element of the network has been corrupted or congestion of communications would have existed. Low installation costs: In recent years, the main method of providing connectivity for end-users to create wireless network based on the 802.11 standard and to support the Wi-Fi-based access points. In areas where in urban scale to ensure that the relative coverage of network in large number of access points is required, because the access points have limited send range.

Obviously, hence, is not cost-effective and requires extensive cabling to connect anywhere access to the Internet backbone. In contrast, the construction of a wireless mesh network, reduces infrastructure costs; Because at least in limited points for connecting to a wired network (like the Internet) needs. Thus, wireless mesh networks possibility of rapid implementation and make changes in network provided at a cost acceptable, and this in today competitive market is very important. Extensive coverage areas at present, Data rate wireless local area networks by using efficient modulation schemes, has increased (like data rate as 802.11a and 802.11g networks to 54 megabits per second has reached). Although data rates in wireless local area networks is increasing, but for a given transmission power and when users are away from points of access, coverage and continuity of wireless local area networks is reduced. In contrast, multi-step and multi-channel communications that with the help of mesh routers is done, And also a long send range WiMAX towers in wireless mesh networks have been expanded, Remote communications without a significant reduction in efficiency, making possible. Auto-connect of network: Wireless mesh networks, as mentioned before, are self-organizing and self-configuring. In other words, the clients and mesh routers, network connect automatically create and maintain; The multi-step communications between networks will be exist seamlessly. For example, when new nodes are added to the network, these nodes meshing functions to such use to automatically discovered all possible routes and optimal routes for Internet connection (wired network), to determine. In addition, the mesh routers available, the new routes are created in the network has identified and so, network develops in a simple manner. The reduction in capacity because of the interference wireless link wireless mesh networks is the biggest challenge. Nowadays multi-channel and multi-radio wireless mesh networks by nodes equipped with multiple radio interfaces have been proposed for using that can be reduce the interference and to improve network performance. by using the system features multi-channel and multi-radio nodes can simultaneously send and receive information with their neighbors. Channel allocation scheme is one of the key technologies to increase the efficiency of multi-channel and multi-radio wireless mesh networks by reducing interference. Now the channel allocation schemes have been provided to increase network performance [2]. Some of these plans are usedthe clustering method for reducing the complexity of channel allocation [3] [4] [5]. They are divided into cluster of networks and channel allocation are become to local problems within the cluster. They use benefits of reuse channels in the various clusters to enhance networks performance.

2. Background of reserach

Some of the channel allocation's algorithms have been proposed in recent years. Alicherry et al proposed the method of allocating focused aware of load channel and routing. This method uses from traffic load for measuring interference. Ramachandran et al proposed a focused channel allocation's algorithm that use from efficiency and quality of channel for determining interference quantity. Marina et al proposed exploration focused static channel allocation algorithm that uses some radio interference for measuring interference. Although, none of these scales do not destroy the effect of non-harmonic links, efficiently. In contrast, in this survey we consider the effectiveness of allocation channel with giving priority to the non-harmonic interference than harmonic interference and give importance to non-harmonic interference as a more destructive agent on the network [4]. Ko et al assume that a nod can transfer on a channel but can listen to the all existing channel in its local area at the same time. In this method nodes select a channel that minimize the interference from set of node its interference area [8]. Shin et al allocated many single channels if possible, to node for improving efficiency. Channel allocation to a specified inference of wireless network is done accidently [8].

There are two methods that are near to our presenting method: Tabu-based و CLICA-SCE. Subramanian et al designed an algorithm based on focused Tabu-based and a distributed greedy algorithm. Both algorithms allocate the channel to interference of wireless networks with the purpose of minimizing network interference. Tabu-based algorithm have included of two levels. The first level tries for finding a good solution with minimum interference from set of accidental allocation. Although, this solution may reverse, the limitation of interface which is done in first level, but increases that interference. Besides, tabu-based work well when numbers of radio interface is limited [8].

Channel allocation scheme based on cluster (CCAS)

This scheme in the main idea of this survey and proposed with considering the defects that this scheme have and creating changes in that proposed scheme. This scheme logically divides the network to clusters

without overlap that each node has a range of carrier sensor. All of the nodes of inside a cluster can communicate to each other through a same channel. The neighbor's clusters use from orthogonal channels, therefor non-harmonic interferences decrease. Clustering approach decrease the complexity of non-harmonic interference in this method effectively. Although this method decreases non-harmonic interferences but all the existed links in cluster of tolerant to interference coordinate and this are the disadvantages of this method. To decrease harmonic interference this method uses from orthogonal channels that have not used for non-harmonic interference.

This method [6] is a focused and static scheme that runs in wireless mesh network. Server of this method can runs in gate nodes. An interface of each node has designed as default interface, while the remaining interfaces define as non-default interfaces. Default interface defines all the nodes inside a cluster as common channel. This method assumes that the specified nodes of wireless mesh network define as head cluster. These nodes are selected as follow during the development of wireless mesh network. The whole area of wireless mesh network logically divides in hexagon network with length of the edge of hexagon that is equals to range of carrier sensor. Closer located node to the center of each hexagon determines as head cluster that this is the difference of clustering of this method with proposed method. Note that physical settlement of wireless mesh network does not need to perform regularly, for this purpose divides into a logical hexagon network. In addition note that channel allocation's server, allocate only default channel to the clusters while head clusters allocate the channel to the non-default interfaces of the nodes. After clustering with this method it is time to reduce non-harmonic and harmonic interferences and finally algorithm is finished. The difference between this method and proposed method is first clustering method and then channel allocation.

1.1 Clustering based on category

Clustering algorithm based on category consists of two phases: The calculation of the category and compatibility. This algorithm consists of two stages to select Vi node to create a cluster: Creating the two-step sub-graph of the node and calculation of the maximum category in the sub-graph. The maximum Category is stored in the form of a cluster which includes cluster ID and group ID list within the cluster. Then the compatibility process for the remaining Vi nodes is run that are the remaining isolated nodes in the interference graph. Isolated nodes are added to neighbor clusters with the least number of nodes to create balance in the network load. A simple example is shown in Figure 3-4.

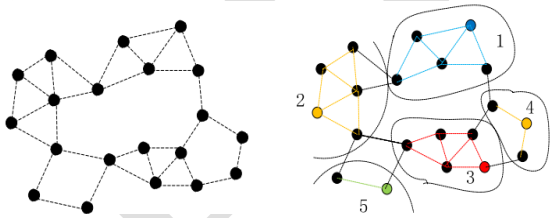

Figure 3-6 figure on the left shows the initial state of the network and the right figure shows the result of clustering.

Bold nodes are indicator of mesh router in the network and the dotted lines are indicator of the links between routers as shown in the figure above right the network is divided to five clusters.

1.2, 3-10. between clusters Channel allocation

After clustering and allocation of the default channel, between clusters Channel allocation for removing links of unsynchronized interactions must be implemented. The set of between cluster links are shown with IL. Between cluster Links are sorted by nodes' ID and are passed in order. These links with different existing channels are allocated from default neighbor network channels so as not to create non-coordinated links. Since the between cluster link may create unsynchronized interactions with high probability, it is needed to be controlled whether two-step neighboring nodes use shared channel or not. In the event that an existing channel that can meet all the needs does not exist, an unsynchronized link will be introduced to the network. Now, in this study we improve the link between the clusters to increase power between clusters that means that when a node has several neighbors in different clusters we will allocate channel to different neighbors of cluster.

After three channel allocation stages, channel for each intermediate of node in the wireless mesh network is fixed. Then delivers information gateway of the cluster to each head cluster which includes cluster ID, head cluster ID, and nodes list ID in the cluster and channel allocated to each interface after the head

clusters received cluster information, they distribute this information to their two-step neighbors to inform nodes in the cluster to establish a channel for each interface. Therefore channel allocation process ends.

3.1 Simulation and efficiency evaluation

In this part, as mentioned we conduct a set the simulation to evaluate the performance of CCCA[1] plan by using simulator NS2 [7]. We compare efficiency with single channel (SC) scheme and two other channel allocation schemes: 1. the Breadth-First Search Channel Assignment [7] 2. Channel allocation scheme based on cluster. Number of 36 mesh routers randomly in an area with the size of 1200 × 1000 square meters are located that each router is equipped with three network interface. 8 orthogonal channels are available for channel allocation. Physical layer and MAC layer simulator NS-2 for simulation According to the IEEE 802.11a standard with a maximum bit rate of 11 Mbps and transmission distance of 250 meters have been set. Constant bit rate (CBR) UDP currents with different rates were used to simulate the mesh network load packet size was set1000-byte. We ran simulation on two different traffic models as follows: One-step traffic model and multi-step peer to peer traffic model.

1.3.1 Total power output and fairness for single-step current

Total power output with power output of the system is sum of the amount of information transmitted per unit time that reaches to all terminals on a network. In the first step, we observed fairness of distributed capacity between single-step currents and total power output. In our simulation, there were 13 single-step current randomly in network. Figure 4-2 shows result of power output the network in different designs.

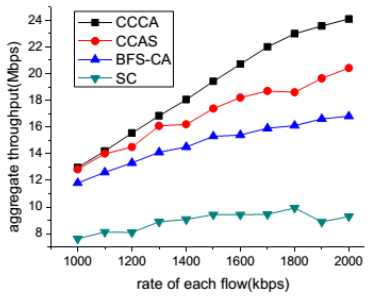

Figure 4-2 Total power output of single-step currents (13single step current)

Total power output of network when single-step current rate had increased and reached near state of saturation went up. Figure 4-3 also shows power output of network differences between these designs.

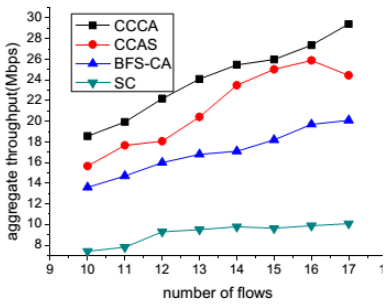

Figure 4-3 Total power output of single-step current (each current with rate of 2 Mbps)

We increased number of single-step current in the network with constant current rate of 2 Mbps. As has been shown in Fig, CCCA can bring stability increase in power output of the network more than other designs. From fair indicator of Jane [7] to evaluate the fairness of the distribution of capacity among single-step current was used for plans. The index is a value between 0 and 1, in which the larger index is indicator of a more equitable distribution of current capacity. Figure 4-4 shows Jane fair index that was obtained by various designs.

[1]Clique-base clustering channel assignment

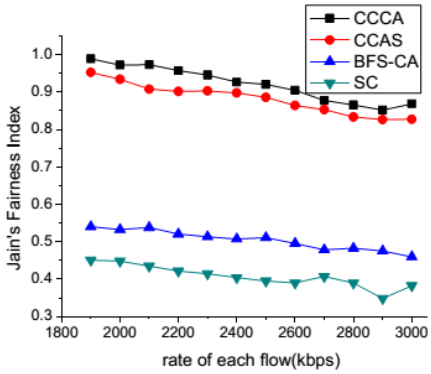

Figure 4-4 fair index of Jane (16 single-step current)

CCCA and CCAS indicators both are larger than 0.80 that means that both of them guarantee very good fairness in distribution network capacity. Meanwhile CCCA index is greater than ICCA, Which means that CCCA plan has led to a more equitable distribution of current capacity.

2.3.1, 4.5.2 Multi-step current efficiency

At this stage we review the performance evaluation of multi-step current, including end-to-end delay and end-to-end power output. Figure 4-5 and Figure 4-6 show the multi-step current efficiency.

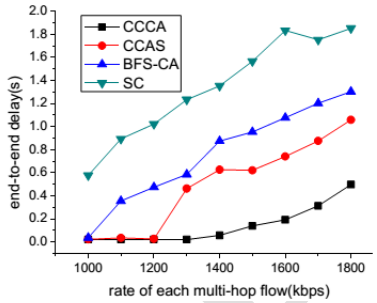

Figure 4-5 End-to-end delay (fifteen single-step interference current)

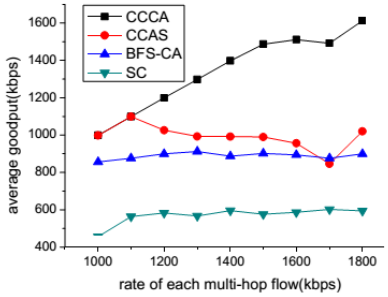

Figure 4-6 End-to-end power output (fifteencurrent interference of single-step)

There are 4 multi-step current has been developed between randomly selected pairs of source and destination and there are 15 randomly distributed single-step CBR current, each at a rate of 200 kilobytes per second as interference link. As clearly has been shown in the graph, CCCA can increase the end-to-end power output and significantly decrease end-to-end delay. As the end-to-end delay mainly depends on the to use of the channel and interface queue length, CCCA plan increases channel efficiency consequently, decreases interference between links therefore decreases end-to-end delay, and subsequently end to end power output is increased.

4.1, 4.6 Conclusion

In this study, we discussed the problem of channel allocation for wireless mesh networks by considering the different levels of interference links we suggested a clustering channel allocation method based on category for reducing interference links. CCCA has minimizing unsynchronized interference and

unsynchronized interference intention thereby improves network performance. Since this plan depends on the real connective internode relationship instead of node location information, can divide network into more logical clusters especially for networks with random topology. Since the unsynchronized interference had more devastating effect than synchronized interference, controlling it was a priority to this method. Therefore first with unsynchronized interference control and then synchronized interference control we were able to raise efficiency and productivity and thus power output and network capacity.

The simulation results show the effect of minimizing network interference for both unsynchronized and synchronized interference. Wireless mesh networks can significantly increase total power output, reduce end-to-end delay and improve the capacity fairness parameter by efficiency of this plan. As we saw in the simulation results in the previous chapter, total power output significantly increased and also end-to-end delay also significantly decreased. As the simulation results based on considered the criteria was observed, CCCA method gave far better results compared to method of SC, BFS-CA, CCAS and this expressed effectiveness of the method because of the way it used in the clustering and channel allocation. Thus, this method could enhance network performance by reducing interference and enhance the power output and network capacity.

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