GDCA: A Distributed Channel Assignment Mechanism for Multi-radio Multi-Channel Wireless Mesh Networks

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Abstract—Channel assignment is one of the most important problem in the research of the multi-radio multi-channel wireless mesh networks (MRMC-WMN). Aiming at minimizing the overall network interference and optimizing the usage of channel resource, channel assignment problem must obey the constraint of limited radios and available channels for MRMC-WMN. The above optimization problem is known to be NP-complete. This paper focuses on the study of channel assignment in MRMC-WMN. We propose a new grid-loop-based mechanism for dynamic channel assignment. Our mechanism exploits the group which we called grid-loop, which is constructed on distributed minimum spanning tree by self-organized. Our new GDCA scheme has many advantages over cluster-based scheme. The analysis and comparison demonstrates its feasibility, stability, cost-saving and efficiency.

Keywords — wireless mesh networks, multi-radio, multi-channel, channel assignment, minimum spanning tree

I. INTRODUCTION

Emerging as the key future technology for providing flexible high-bandwidth wireless access and a promising candidate for extending the coverage of WiFi islands, wireless mesh networks (WMN) has attracted much research attention [1]. WMN consists of mesh routers and mesh clients, where mesh routers have minimal mobility and form the backbone of WMN. Mesh routers can server as wireless network access point for both mesh and conventional clients. Hence WMN is a mix network of fixed and mobile nodes interconnected via wireless links. Moreover WMN may integrate with other networks such as the Internet, WLAN, cellular network, wireless sensor networks, etc., through the mesh gateway and bridging functions in the mesh routers. Because of above characters of WMN, there are vast potential applications, including last-mile broadband access of Internet, rural network and Military application, etc.

In WMN, how to improve the network performance has been the hot issue due to the increasing various WMN applications. Current studies show that the decreasing network performance mainly arises from the transmitting interference between wireless links. In wireless communication, a pair of neighbor links can simultaneously transmit data packets successfully if they operate on different channel respectively. However the available wireless channel resource is finite, which becomes the bottleneck of network performance. An effective solution is to utilize multiple radios and multiple channels to alleviate link interference and increase the network capacity. Several interesting studies have also been performed on multi-radio mesh nodes and have concluded that in some cases, having multiple radios on different channels can considerably improve the throughput and network performance. Hence, channel assignment (CA) becomes a foundational problem in Multi-Radio Multi-Channel WMN (MRMC-WMN) where each node is equipped with multiple radios that can operate on multiple channels.

Channel assignment is required to assign the channels to the communication links to minimize the interference and ensure the optimum channel usage. Moreover the CA must obey the constraints of limited radios and available channels etc. The problem of CA has been proved to be NP-complete [2].

This paper focuses on CA problem. We propose a new mechanism for channel assignment on multi-radios, i.e., forming grid-loops via minimum spanning tree (MST) and forming group channel, which provides a novel mechanism to the MRMC-WMN for assigning channels to different loops and the related maintenance and renewing. Differing from classic cluster topology, the construction of grid-loop topology not only has an efficient constructing mechanism, but also has a simple...
and robust structure. Comparing with existing cluster-based mechanism, our new mechanism based on MST is proved to be more balanced and efficient.

This paper is organized as following. In section II, we give overview of the related works. In section III, we state the system model and assumption. Section IV describes the new scheme designed for dynamic distributed Channel assignment (DCA) in WMN. Comparison with other mechanism and the detailed analysis is described in section V. Section VI concludes the paper.

II. RELATED WORKS

The researches on channel assignment problem have been investigated in some works. The channel assignment approaches can be classified as static, dynamic and hybrid based on how frequently the channel assignments are performed.

A. Static channel assignment schemes

Most past researches focus on static CA [3-7]. Static assignment approaches assign channels to interfaces either permanently or for long time intervals with respect to the interface switching time.

In [3], Husnain Mansoor Ali et al. propose a static centralized algorithm named MACIR. The algorithm is based on the Brooks theorem, and the idea is to start with an optimal assignment. In [4], Mohammad A. Hoque et al. introduce the interference factor and a new interference model I-Matrix which can be used to calculate the interference value between the links. Then the paper develops a CA utilizing partially overlapped channels. In [5], the CA problem is formulated as a topology control optimization problem. Then the authors propose a genetic centralized approach to CA to find the connectivity enhanced topologies with low interference.

Obviously the static CA approaches rarely consider dynamic network traffic or topology, which are not suit for dynamic network. In WMN, when the mesh node join or leave the network, the network topology will be changed. If the system doesn’t change the channel assignment, the network performance will be decreased.

B. Dynamic channel assignment schemes

Some works have addressed the dynamic channel assignment approaches [8-14]. Dynamic CA approaches allow any radio to be assigned available channel dynamically, accordingly radios can frequently switch from one channel to another.

In [8], X. Yue et al. present a DCA algorithm termed CACAO (client-assisted channel assignment optimization) for uncoordinated network. The CACAO does not need any synchronization, but it assumes that the mesh routers do not require any communication among them which is not practical. In [9], B. Han et al. present a purely localized distributed scheme for joint channel assignment and link scheduling (PLDS). The key innovation of PLDS is the notation of an access hash function, and each can know the transmitters’ decisions for link in its interference set by the hash function. In [10], A. Dhananjay et al. present the ROMA, which assigns non-overlapping channels to links along each gateway path. But the scheme could not diminish the interference among the same levels because it assigns the same channel at the same level.

The benefit of dynamic CA approaches lie in the ability of dynamic channels switching according to the requirements, thereby offer the potential to use multiple channels with few radios. Therefore, when mesh nodes need to communicate with each other, a coordination mechanism should be taken to ensure that they may operate on the same channel for communication. However, the key challenge is the need for coordination mechanisms for channel switching between mesh nodes. The design for dynamic CA approach is more difficult than for static CA.

In this paper, we focus on the dynamic CA because of the above benefits. In our previous work [14], we proposed a dynamic CA algorithm. However the CA mechanism proposed in [14] is different from our in this work. Here we share the similar idea of loop.

C. Hybrid channel assignment scheme

Hybrid channel assignment schemes combine both static and dynamic assignment schemes [15-16], for example, by applying a static assignment for some radios and a dynamic assignment for other radios. Combined with the stable static scheme which can allow for simple coordination algorithms, Hybrid assignment schemes still retain the flexibility of dynamic channel assignment scheme.

Hybrid schemes can be further classified into two kinds of method, based on whether the fixed radios use a common channel or varying channel. The fixed radios can be assigned a dedicated control channel or a data and control channel, while the other radios can be switched dynamically among available channels.

Sadeq Ali Makram proposes the first channel assignment scheme for MRM-WMN using cluster topology [15]. A clustering approach is employed in order to reduce the complexity of channel assignment into local problems within clusters and taking the advantage of the possibility to reuse the channels in different clusters. In [16], Y. Liu et al. propose a channel assignment scheme named channel assignment exploiting partially overlapping channels (CAEPO). In CAEPO, traffic load is used as a metric to implement CA, and each mesh router implements CA locally. But the CAEPO adopts random channel assignment in initialization, it is not optimal.

III. SYSTEM MODEL AND DEFINITIONS

A. System model and assumption

We consider the MRM-WMN with stationary wireless mesh routers. The MRM-WMN can be modeled as an undirected graph G (V, E), where V denotes the nodes and E represents the potential communication edges. A potential communication edge (u, v) ∈ E indicates that node u and node v can communicate with each other if they have the same channel.
For each node \( v \in V \), \( v \) is equipped with a collection of radios \( \mathcal{R}(v) \), \( |\mathcal{R}(v)| = m \) denote the number of radio, where \( m \geq 1 \). There exists a set of orthogonal channels denoted as \( C = \{C_1, C_2, \ldots, C_k\} \). For each node \( v \in V \), it is equipped with \( |\mathcal{R}(v)| \) radios and can access a channel set of \( C \subseteq C \).

In this paper, we assume that the transmitting power of mesh node is fixed. The transmission radius denoted as \( d_r \), and the interference radius denoted as \( d_{INT} \). Here we set \( d_{INT} = P \times d_r \), where \( P \geq 1 \). The Euclidean distance between node \( u \) and \( v \) is denoted as \( d(u, v) \).

For easy of exposition, we assume that all the mesh nodes have the same communication radius and interference radius. However, our scheme can be extended for the different communication and interference radius. Due to the broadcast nature of wireless links, transmission along a wireless link is easy to be interfered by other wireless links with the same channel nearby, which are occupied by neighbor nodes. An interference model is required to obtain the interference information in the network.

B. Protocol model and interference model

For simplicity, we adopt the protocol model proposed in [2] as the interference model. In the protocol model, node \( u \) and \( v \) are using the same channel, then there is a successful transmission on edge \((u, v)\) if both of the following conditions are satisfied: (1) \( d(u, v) \leq d_T \); (2) \( \min\{d(x, u), d(x, v)\} \geq d_{INT} \) for every other node \( x, x \neq u \) and \( x \neq v \), simultaneously transmitting using the same channel as node \( u \) and \( v \).

In other words, if two mesh nodes may launch bidirectional communications, any other mesh nodes whose minimum distance to the two nodes \( \min\{d(x, u), d(x, v)\} \leq d_{INT} \) must keep silent on the channel used by \((u, v)\). This indicates that the distance of interference-free communications should be \( > d_{INT} \). In this paper, we set \( P=2 \).

![Communication and Interference model](image1.png)

Figure 1. Communication and Interference model

The interference model can be illustrated in Fig. 1. In the network, all the nodes have the same \( d_r \) and the same \( d_{INT} \). For node \( u \) and \( y \), \( d(u, y) > d_{INT} \) indicates that node \( u \) and \( y \) are interference-free. \( d_r < d(u, y) < d_{INT} \) indicates node \( u \) and \( y \) can’t communicate. If node \( u \) and \( x \) operate on the same channel, then there exists interference between them. \( d(u, v) \leq d_T \) indicates that node \( u \) and \( v \) can communicate if they have the same channel and node \( x \) keeps silence in the same channel.

IV. GRID-LOOP-BASED DISTRIBUTED CHANNEL ASSIGNMENT MECHANISM

In this section, we will develop a new channel assignment mechanism for MRMC-WMN, which is based on grid-loop topology.

A. Loop topology and grid loop topology

At first the basic definition of loop should be given. In the graph theory, a loop is a non-directional path, which begins and ends with the same node. Since there is at most one connection between every two nodes in an undirected graph \( G=(V, E) \), a path from \( v_i \) to \( v_j \) representing a wireless sensor network link can be defined as a sequence of vertices \( \{v_i, v_{i+1}, \ldots, v_j\} \), where \( V \) representing the set of nodes and \( E \) is the set of connections. Based on loop topology, which had been proposed in our previous work [14] and the extended new group structure of loop (grid-loop), we design a new channel assignment mechanism for MRMC-WMN.

In our former work [17], we have proved that Grid-loop is the smallest loop that is connected by neighbor nodes. A grid-loop cannot cover any sub-loop inside.

At first the basic definition of grid-loop is given: Given \( T \) as a Minimum spanning tree (MST) of a connected, undirected graph \( G \) representing the network of wireless mesh nodes, the circle formed by some edges within \( T \) and one edge that does not belong to \( T \) is called a basic circle of the graph \( G \), or a grid-loop. Grid-loop is the basic loop of \( G \) based on MST and the smallest unit for the network communication. In this paper we take grid-loop as loop.

According to [18], research has shown that asymptotic connectivity results when every mesh node is connected to its nearest 5.1774logn neighbors, while asymptotic disconnection results when each mesh node is connected to less than 0.074log nearest neighbors. With the mesh node number \( N \) steadily increasing, the connectivity also steadily increase. Under condition with enough mesh node density, we can make sure that grid-loop is the most suitable smallest group structure for MRMC-WMN.

![grid-loop structure in MRMC-WMN](image2.png)

Figure 2. grid-loop structure in MRMC-WMN

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Basic features of Grid-loop are listed as follows. (The deductive proofs of the following features are omitted here.)

(a) Grid-loop is the smallest loop.
(b) There is no special mesh node or group leader in a grid-loop. Every mesh node has the same right and power.
(c) As the smallest loop, grid-loop has the most stability of group structure.
(d) The length of a grid-loop is at least equal to 3. The length of a loop also can be called path length. It is the number of hops from \( v_i \) to \( v_j \). Let \( L \) be a loop. It is evident that if length \( (L) < 3 \), either the node on \( L \) is isolated or \( L \) is a round trip between two nodes.

B. Grid-loop-based Channel Assignment mechanism

The Grid-loop-based Channel Assignment mechanism consists of two stages.

The first stage is the construction of loop, and the construction algorithm is applied to compute the loop (grid-loop).

For each loop which had just been constructed, the second stage is assigning channels by loop members one by one according to a certain member sequence.

a) Creation of a grid-loop topology for channel assignment in MRMC-WMN

Pre-distribution of CA parameters: Before deployment, each mesh node should be assigned some materials, including a unique ID. Those pre-distributed materials are very important and useful in the later stages of channel assignment.

As described in our former work [5], the problem of grid-loop construction in MRMC-WMN can also be modeled as the problem of creating the Minimum Spanning Tree in an undirected graph [6]. With the MST created, each edge that does not in the MST represents a new grid-loop constructed. We modified the distributed MST algorithm in [7] and improved it for grid-loop construction.

The details are described as following.

(1) Basic steps of the distributed MST algorithm for grid-loop.

Step 1: Each mesh node is initialized as a tree with single node and the tree ID (unique ID of the single node) is set to be the ID of the root.

Step 2: Each tree searches for edges to connect to another tree. If exists, these two neighbor trees are combined to be a new tree labeled by the smaller value of two original IDs. Repeat Step 2 till all the mesh nodes are connected.

(2) In constructing process of grid-loop in our proposed algorithm, we define some important message types communicated between mesh nodes.

Type one: COMPUTE and DIFFUSE contain information as follows.
1. label: the ID of the tree.
2. min_bridge_wt: the smallest weight from this tree to other trees (if no connection exists, this value is infinity).

It is obviously that by the end of the algorithm the value of min_bridge_wt should be infinity).

| Table 1. INFORMATION ITEMS MANAGED BY EACH MESH NODE |
|-----------------|------------------|
| Information Item | Content |
| label           | the ID of the Tree that the mesh node belongs to |
| cand_mst_heap   | ID tables of neighbor mesh nodes belongs to different Trees |
| loc_min_bdg_wt  | the minimum weight between this mesh node and neighbors of different trees or to be infinite when cand_mst_heap is empty |
| mst_adj_list    | the table of IDs of the neighbor mesh nodes of the same tree |
| mst_chd_list    | all the child mesh nodes that are connected to this node via edges in MST |
| loc_gl_label    | the labels of the grid-loops that this mesh node belongs to |
| loc_gl_ch       | the table for group channels corresponding to the labels in gl_label |

Type two: GRID and UNGRID contain the following two kinds of information.
1. label: ID of the tree.
2. gl_ch: selected channel for grid-loop with this label.

Type three: CONNECT and SUB are commands with no section of data parameters.

(3) Seven kinds of information items managed by each mesh node are listed in Table 1.

Based on above three types of communication message and those information items broadcasted or received by each mesh node, can grid-loop-based topology be constructed timely and efficiently.

(4) Main six steps of the algorithm are described as follows.

Step 1: Each tree root initialize COMPUTE.label to be its own ID, and set COMPUTE.min_bdg_wt to be its own loc_min_bdg_wt.

After the initialization, each tree root node can broadcast COMPUTE message to all its child mesh nodes and wait for their replies.

Step 2: Each child mesh node that receives COMPUTE message would compare COMPUTE.label with its own label firstly.

If yes, each child mesh node can compare its own loc_min_bdg_wt with COMPUTE.min_bdg_wt. If the comparison result is small, then it updates its loc_min_bdg_wt to COMPUTE. min_bdg_wt, otherwise no update.

Then each child mesh node transmits COMPUTE message to all its children nodes.

Leaf mesh nodes would propagate COMPUTE to their parent nodes.

Step 3: For a mesh node that receives COMPUTE message from its neighbor, if COMPUTE.label is less than its own label, it considers it as a triggering message to combine trees. This mesh node updates its own label to
be **COMPUTE**.label and goes to step 2. Those **COMPUTE** messages with larger label would be ignored.

Step 4: Finally the tree root would collect **COMPUTE** messages from all its children. It can find the smallest weight to the other trees via **COMPUTE**.min_bdg_wt. If it equals to its own loc_min_bdg_wt then the root would call the function Add_MST_edge() to connect two trees. Otherwise it sends **DIFFUSE** with min_bdg_wt to all its children.

The edge weight \( w = (ID_i, ID_j) \) is a doublet that can be ordered by lexical order of ID\(_i\) and ID\(_j\):

\[
(ID_i, ID_j) > (ID_m, ID_n) \text{ if } ID_i > ID_m \text{ or } ID_i = ID_m \text{ and } ID_j > ID_n
\]

\[
(ID_i, ID_j) < (ID_m, ID_n) \text{ if } ID_i < ID_m \text{ or } ID_i = ID_m \text{ and } ID_j < ID_n
\]

\[
(ID_i, ID_j) = (ID_m, ID_n) \text{ if } ID_i = ID_m \text{ and } ID_j = ID_n
\]

Step 5: The child mesh node that receives **DIFFUSE** would compare **DIFFUSE**.label to its own label.

If the result is equal, then it compares **DIFFUSE**.min_bdg_wt with its own loc_min_bdg_wt. If equal again, it will call the function Add_MST_edge() to connect two trees. Otherwise it would send **DIFFUSE** to all its children nodes.

Step 6: The tree that calls the function Add_MST_edge() would move the connecting neighbor mesh node from its table of neighbors for different trees into the table of neighbors of the same tree, then send CONNECT along the edge to the other side. The other side would update its tables and finish the connection operation.

By using the basic distributed algorithm for grid-loop construction in MRMC-WMN, example of WMN in Figure 3(1) can be divided into MST-based grid-loop network in Figure 3(10). As shown in the Figure 3(1) to (10), the construction process of grid-loops is presented in detail.

b) **The grid-loop-based channel assignment scheme**

After stage a), all the mesh nodes are divided into different grid-loops and some mesh nodes are shared between two neighbor loops. Unlike cluster-based scheme, there exists some nodes may be shared among three or more than three neighbor clusters.

Based on the self-organized grid-loops topology, the next important work is assigning the communication channels to the mesh nodes which belongs to those grid loops.

Main four steps of the grid-loop-based channel assignment scheme are described as follows.

Step b-1: The selection process of Loop-creators (In this paper we choose the first node who acting as a channel assigner in the construction of each grid-loop to be the loop-creator).

Based on the self-organized grid-loops, the channel assigned to a certain grid-loop should be chosen from the available channels set.

It is infeasible for each grid-loop member to act as the channel selector at the same time.

Figure 3. construction of grid-loop in WMN

According to the construction algorithm of the grid-loops based on distributed MST, each grid-loop has only one edge that does not belong to the MST. Between the two mesh nodes on this link, the one with a larger (or smaller) ID becomes a loop-creator node and has the power to acting as the first node to assigning available channels to its equipped wireless radios.

Step b-2: Assigning Channel by each loop-creator.

Acting as the first channel assigner, each loop-creator can distribute available channels to its equipped wireless radios.

After the first round channel assignment, the loop-creator can create its channel using table (CUT) and inform its loop members of its channel using message (CUM, message contain CUT) and the member list. If the loop format is not special, these messages will be sent to its two loop-neighbors at first.

After receiving these messages, each receiver mesh node on the grid-loop list should assign the remainder of available channels to its available wireless radios. Just like the first round CA work synchronous enforced by different loop-creators, the second round of channel assignment work is also be proceed by each receiver mesh nods simultaneously.

Step b-3: Updating CUM message and assigning channels on the sequence of each grid-loop member list.

Since the interference range is normally twice of the transmission range, the latest CUM messages of both one-hop and two-hop neighbor nodes should be updated by neighbors timely and accurately. Those messages play an important role in the assigning work of the remainder
available channels. So every receiver mesh node should renew its CUM message and relay it combined with the CUM message of its loop-creator to the next-hop loop members on its grid-loop member list.

TABLE 2. EXAMPLE CUT OF NODE E IN FIGURE 4(A)

<table>
<thead>
<tr>
<th>Node ID</th>
<th>Radio ID</th>
<th>Channel ID</th>
<th>Peer node ID</th>
<th>Peer node ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>E-1</td>
<td>E_c-1</td>
<td>F</td>
<td>F-2</td>
</tr>
<tr>
<td>E</td>
<td>E-2</td>
<td>E_c-2</td>
<td>D</td>
<td>D-2</td>
</tr>
<tr>
<td>E</td>
<td>E-3</td>
<td>E_c-3</td>
<td>J</td>
<td>J-1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Step b-4: Dynamic channel assignment of shared points (nodes) or links. In Figure 2, we can see that the overlay of neighbor grid-loops can be divided into two situations.

Situation (1): Sharing a point.

Such as grid-loop 5 and 7 are sharing a common mesh node in Figure 2. Special grid-loop {A-B} and Grid-loop {B-C-D-E-F} are sharing a common mesh node B in Figure 3.

According to the principle of a cluster-header, a cluster-header has the power in control of its cluster-members.

Figure 3. Situation (1): Sharing a point.

According to situation (1), we set up the process of Situation (1). As the shared node can’t be the creator of either grid-loop in our grid-loop-based channel assignment scheme, it should assign its channels according to step b-3. The shared node may receive CUM message from one grid-loop firstly or receive messages from the two grid-loops at the same time. It should assign available channels following the basic rule of step b-3. Handling simultaneous CUM messages from neighbor grid-loops should also follow the basic rule of step b-2 and b-3.

Figure 4. Situation (2) for Dynamic channel assignment of shared points(nodes) or links

According to situation (2), we set up the related process of Situation (2). As described in step b-1, each grid-loop has only one link (edge) that does not belong to the MST. It is obviously that the unique link can’t be shared between neighbor grid-loops. According to the assigning sequence of available channels, the two assigning sequence direction along those neighbor grid-loop lists and the assigning times on the shared links should also be taken into account.

V. ANALYSIS AND COMPARISONS

In this section we will compare our new mechanism with cluster-based mechanism. At first we will introduce the classic cluster topology.

A. Cluster topology

At first the basic definition of cluster should be given. In the graph theory, let G = (V, E) be a connected graph and C = { C_1, . . . , C_k} a partition of V . We call C a clustering of G and C_i a cluster; C is called trivial if either k = 1, or all clusters C_i contain only one element. We often identify a cluster C_i with the induced sub-graph of G, i.e., the graph G[C_i] := ( C_i, E (C_i) ),where E (C_i) := \{ {v} | v \in C_i \}. Then E(C) = \bigcup_{i=1}^{k} E(C_i) is the set of inter-cluster edges and E \ E(C) is the set of inter-cluster edges. The set E(C_i,C_j) := \{ {v,w} \in E : v \in C_i, w \in C_j \} is the set of edges that have one end-node in C_i and the other end-node in C_j.

In the research of wireless networks, a lot of applications use cluster as the basic organization [2]. The feature of wireless broadcast communication introduces the concept of a cluster-header. A cluster-header is chosen among its neighbor nodes according to some rules. A node acting as a cluster-header would have the power in control of its cluster-members.

B. Analysis on structure

In the undirected random graph of MRMC-WMN, connected nodes no less than three would form a grid-loop while two connected nodes cannot form a grid-loop. According to the principle of loop-priority, we have proved that Grid-loop is the atomic loop with covering area in our former work [17] and have two assistant corollaries as follows.

Corollary 1: For the same MRMC-WMN, the number of grid-loops constructed by our grid-loop algorithm is larger than the number of that of cluster algorithm.

Corollary 2: From the prospective of structure reliability, in the same MRMC-WMN, the number of mesh nodes in grid-loops structure to be adjusted after some mesh nodes are out of service (compromised or out of working state) is smaller than the number in cluster structure.

Based on Corollary 2 and our grid-loop-based channel assignment mechanism, we can also prove Corollary 3: From the prospective of structure reliability, in the same MRMC-WMN, the number of channels in grid-loops structure to be adjusted after some mesh nodes are out of service (compromised or out of working state) is smaller than the number in cluster structure.
C. Comparison on Communication

In the cluster algorithm for a N-noded and E-edged MRMC-WMN, Assuming there are M mesh nodes to be candidates of headers with total degrees of Em and M=O(N), the total communication cost is 2*E + 2*Em + 2*M ≥ 2*E + 2*Em + O(N).

According to the analysis [6] of grid-loop algorithm, for a N-noded and E-edged MRMC-WMN, the communication complexity is 2*E + C * N * log(N) + O(N) where C<5 is a constant.

We can see that the communication complexities of the two algorithms are almost the same. According to the theory of random graph, the degree of the random graph must satisfy E ≥ 5.1774*N*log(N) for the MRMC-WMN to be asymptotic connected thus making the communication complexity of grid-loop algorithm less than 2.05*E.

It's obvious that Em would be close to E in such dense graph, so the second item in the communication complexity equation of cluster-based algorithm would be greater than the counterpart in grid-loop-based algorithm. So the total cost of grid-loop is smaller.

D. Comparison on Constraint

In cluster-based scheme, if the neighbor number is larger than the number of available channels, some least used channels had to be reused and assigned to neighbors [15]. In this situation, the interference couldn’t be avoided.

In grid-loop-based scheme, the available channels are assigned by sequence on the grid-loop member list. None of node in a grid-loop has to reuse channel.

As described in our proposed grid-loop-based channel assignment mechanism, after the distributed MST algorithm of MRMC-WMN had been performed, all the mesh nodes have been divided into different grid-loops and some mesh nodes may be shared between two neighbor grid-loops.

While in cluster-based scheme, there may exists some mesh nodes be shared among three or more than three neighbor clusters. It is obviously that assigning channels between the radios belongs to two neighbor loops is more simple than assigning channels among three neighbor clusters.

VI. CONCLUSION

Although multi-radio mesh nodes have the potential to significantly improve the performance of WMN, efficient CA is a key issue in guaranteeing network connectivity while still mitigating the adverse effects of interference from the limited number of channels available to the network. CA in a MRMC-WMN environment consists of assigning channels to the radios in order to achieve efficient channel utilization and minimize interference. In this paper, a new distributed CA mechanism is proposed to solve the dynamic channel assignment problem for MRMC-WMN.

Based on self-organized grid-loop, we proposed a new mechanism for channel assignment on multi-radios, i.e., forming grid-loops via MST and forming group channel, which provides a novel scheme to the MRMC-WMN for assigning channels to different loops. Differing from classic cluster topology, the construction of grid-loop topology not only has an efficient constructing mechanism, but also has a simple and stable structure. Comparing with existing cluster-based DCA schemes, our scheme based on distributed MST algorithm is proved to be more stable, cost-saving and efficient.

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