Demonstration of Channel Assignment in a Wireless Metropolitan MESH Network *

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Abstract

We demonstrate the channel assignment in a metropolitan wireless multi-radio mesh network with directional antennas. A channel assignment approach is presented using suitable algorithms with key components the interference model, the link ordering and the channel selection metric. We have implemented and evaluated the proposed channel assignment in an actual metropolitan mesh network which covers an area of 60km^2 in the city of Heraklion and consists of 14 nodes, among which seven are core nodes with up to four 802.11a wireless interfaces each, and one for management and monitoring. Finally, we developed a Java application to demonstrate the channel assignment process in a metropolitan mesh network in a graphical environment.

1 Introduction

Wireless multi-radio mesh networks have the potential to provide ubiquitous and ultra high-speed broadband access in urban and rural areas, to both fixed and mobile users, with low operation and management costs. Such mesh networks can achieve significantly higher performance compared to single-radio single-channel mesh networks, by exploiting spatial diversity through multiple radio interfaces located in mesh nodes, each operating in different channels, and directional antennas.

Channel assignment in a wireless multi-radio mesh network influences its overall performance, since it determines the level of interference between links internal to the mesh network (intra-network interference), but also the interference from external sources. An important motivation for this work, reported in this demo and in [1], was to perform automated channel assignment in an experimental metropolitan wireless multi-radio mesh network we have deployed in the city of Heraklion [2]. We demonstrate channel assignment process in a graphical environment by a developed java application.

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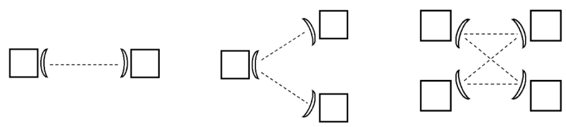
2 Multi-Point Link Conflict Graph

In this section we discuss the multi-point link conflict graph (MPLCG), which can effectively model interference in wireless mesh networks with a known wireless interface communication graph. A vertex in the MPLCG represents a multi-point communication link, i.e., a set of interfaces that communicate with each other, hence should be assigned the same channel, Figure 1. Unlike the typical conflict graph where a vertex corresponds to a link between two nodes in a mesh network, in the the multi-point link conflict graph a vertex is a set of two or more interfaces belonging to different nodes, which are connected in a point-to-point, point-to-multi-point, or multi-point to-multi-point manner, Figure 1 [1].



(a) Point-to-point (b) Point-to-multi-point (c) Multi-point-to-multi-point

Figure 1. Three types of links between mesh nodes with directional antennas

As noted above, an edge between two vertices in the MPLCG indicates that the two corresponding links interfere with each other, hence they cannot be assigned channels independently [3].

In this demo, we will assume that links interfere (hence there is an edge between the corresponding vertices in the

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multi-point link conflict graph), if wireless interfaces belonging to the two links are located in the same mesh node. Additionally, we will assume that interfering links are assigned channels with a one channel separation, i.e. there is one channel between the channels assigned to the two links.

3 Channel Assignment Procedure

The Channel Assignment procedure has three components: the interference model, the link ordering and the channel selection metric, Figure 2. The pseudo-code for the channel assignment procedure used in this demo when the multi-point link conflict graph is used for modelling interference is shown in Figure 3. Firstly, the algorithm starts putting all the vertices of the multi-point link conflict graph in a list V (line 1). Then the vertices are categorized based on the order of choice that has been defined (e.g fixed ordering). Line 6 in the algorithm considers for a link v only channels that have a one channel separation from channels that have already been assigned to other links for which there is an edge with link v in the multi-point link conflict graph. Among these channels, the one with the best metric (one-way SNR, two-way SNR, round-trip delay) is selected in line 7 [1].

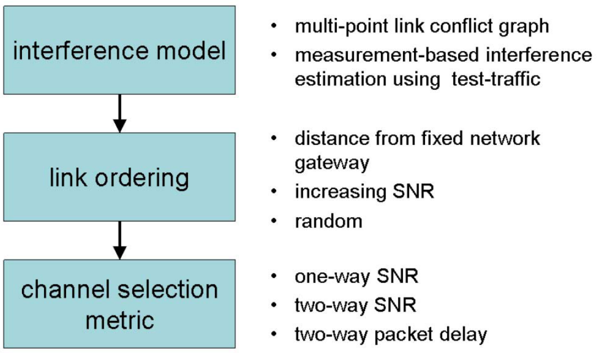

Figure 2. The three components of Channel Assignment procedure

1: Let $V = \{v | v \in$ Multi-Point Link Conflict Graph - MPLCG$\}$
2: Let $C =$ List of all available channels
3: $Order\{V\}$
4: **while** $NotEmpty\{V\}$ **do**
5: $\quad v = RemoveHead\{V\}$
6: $\quad C' = \{c \in C | c-1, c, c+1$ not assigned to u and $edge(u,v) \in$ MPLCG$\}$
7: $\quad b = \text{argmax}_{c \in C'} metric(v, c)$
8: $\quad$ Assign channel b to link v
9: **end while**

Figure 3. Channel Assignment Algorithm using multi-point link conflict graph interference model

4 Wireless Metropolitan Mesh Network

The metropolitan mesh network, that was used as a test-bed to evaluate proposed channel assignment procedure, covers an area of approximately $60km^2$ in the city of Heraklion-Crete and currently contains 14 nodes, among which seven are core mesh nodes with up to four 802.11a wireless interfaces each, and one for management and monitoring. Each wireless interface is assigned a static IP address. The mesh network is connected to a fixed network through three nodes (FORTH M1 & M2 and K4-UoC), Figure 4.

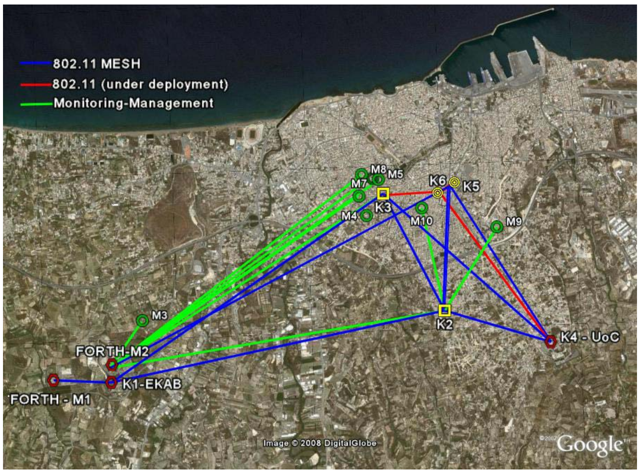

Figure 4. Heraklion Metropolitan Mesh Network

The wireless interface communication graph and the multi-point link conflict graph for the core links of the metropolitan test-bed is shown in Figure 4. Note that the current topology does not contain a multi-point connection, since the number of links is small [2].

5 Demonstration of Channel Assignment procedure

There was the need to develop an application to demonstrate channel assignment procedure in a metropolitan wireless mesh network. For this reason we developed a player application in Java that can be used for different 802.11 protocols , topologies, number of nodes and links.

The application manages three main types of input:

- Map Info - map figure and map coordinates,
- Node List - containing name, coordinates, type and number of interfaces of each node
- Link List - a list of network links including connected nodes, available excluded and assigned channels)

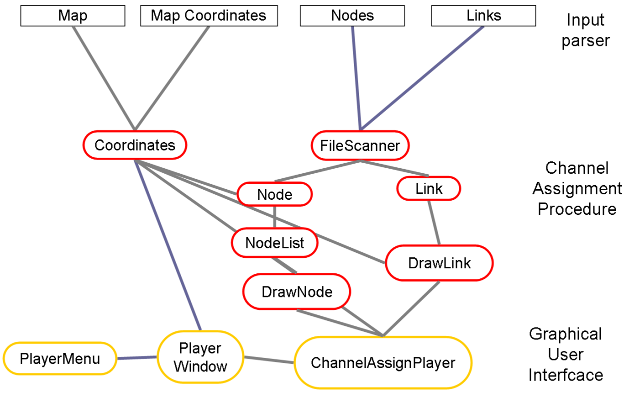

Figure 5. Structure of Channel Assignment Player

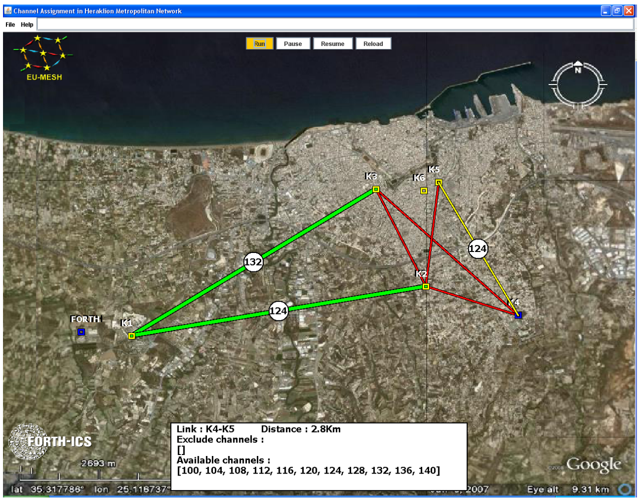

Figure 6. Channel Assignment Player

The main purpose of the player is to demonstrate the channel assignment in a metropolitan mesh network. There is a number of files that are correlated and comprise the structure of the player, Figure 5. The node list is inserted in the player and the nodes are depicted upon the inserted map by converting the geographical coordinates into pixel coordinates, storing simultaneous the imported node info. The system is dynamic, which means that if we change the map, the nodes will be placed into new positions corresponding to the new map. Then the link-list file, which includes the available, the excluded and the assigned channels, is parsed into the player. The order of the assigned channel per link is inside the file and depends on the assumed link ordering. The three different metrics (one-way SNR, two-way SNR and round-trip delay) assigned similar channels corresponding on the assumed link ordering. The selected link order of the demo was based on the distance from the fixed getaway using the two-way SNR metric.

At the beginning all the links are red. When the player scans a link, its color becomes yellow. The application checks for the best available channel, removing the excluded ones from the list, and assigns which channel gives the best results on the chosen metric. A table at the bottom of the player displays the link info such as the link distance, the excluded the available and the assigned channels in every scanning link. To preview the end of the scanning procedure and the assigned channel, the color of the link becomes green. The channel assignment procedure ends when all links have an assigned channel, Figure 6.

6 Conclusions

We have demonstrated a new conflict graph that is appropriate for wireless multi-radio mesh networks with directional antennas and a channel assignment procedure which was evaluated in channel assignment in an actual Metropolitan Mesh network which covers $60km^2$ in the city of Heraklion-Crete. The experimental results show that the proposed channel assignment procedure achieves better performance, in terms of average packet delay, that is very close to a lower bound of average packet delay and significantly better than a channel-unaware channel assignment procedure. Finally, we developed a Java application demonstrating, in a dynamic graphical environment, the channel assignment procedure.

References

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