# Channel interference effect on throughput in Wireless mesh network

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*Abstract:* - Wireless mesh network (WMN) has evolved significantly in the recent years and become a very important and valuable method to deliver robust internet backbone to places that wouldn't be feasible running the conventional cables. Although still far from perfect, recent development and decrease in manufacturing costs, more advanced equipment are used to route data using intelligent wireless mesh network. One of the aspects which limit the performance of WMN is the interference. Interference became major issue with new devises being equipped with more than one radio interface. This work focuses on effect of interference on WMN's throughput as a result of utilizing dual radio in a WMN node.

*Key-Words:* - Wireless Mesh Network (WMN), Access point (AP), Netperf, Signal to Interference Ratio (SIR), Non-overlapping channels, UDP throughput

## 1 Introduction

"Wireless Community Networks" is a term used to describe wireless mesh networks that aims to deliver high speed internet to places where running cables is not cost effective of due to terrain limitations. Low cost, ease of deployment, ability to self-organize, auto-configure, Self-healing and scalability are some of advantages that made the wireless mesh networks very attractive to be an alternative solution to be a backbone in providing internet access to deserted areas [1]. Despite these advantages, Wireless Community Networks is still far from being a reliable method to provide a high speed internet due to many challenges such as, unpredictable delays, and number of packet dropped.

This paper is divided into two main parts. The first part focuses on the evolution of multi-hop multi-radio wireless mesh network along with its limitations such as the interference problem. The second part concentrates on investigating interference effect on throughput through multiple experiments such as Signal to Interference Ratio (SIR) measurement and a comparison between single and two radio wireless mesh network nodes.

### 1.1 Multi-hop Multi-Radio Wireless Mesh Network (WMN)

IEEE 802.11 MAC layer protocol utilizes CSMA/CA mechanism for medium access. This mechanism is based on medium sharing and a single hop transmission [1]. In general, the multi-hop networks experience long transmission delays and route break. Throughput is also affected with the increase in the number of hops. This problem becomes even more severe with single radio since it has to do all the transmitting and receiving data by itself.

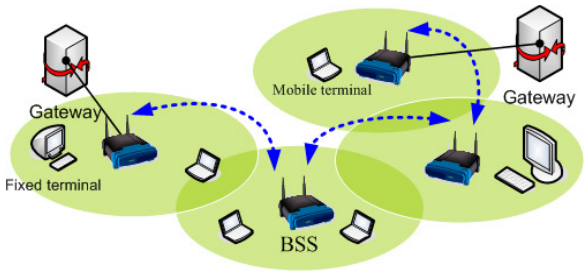


Fig. 1 Wireless Mesh Network

However, since multi-hop is key issue to form a wireless mesh network [5], there was a need to improve the performance of the network by adding multiple radios to the mesh points. With the rapid decrease in the cost of IEEE 801.11 radios, it became feasible to equipped nodes and access points with multiple low cost radios. This enables the node to transmit and receive simultaneously [3]. As a result,

the capacity is increased in compensation with the utilization of bigger portion of the radio spectrum[2]. As shown in Fig.1, the multi-radio wireless mesh network can consist of stationary nodes or minimally mobile [3].

### 1.2 Non-overlapping channels

According to IEEE 802.11 standard, 2.4GHz 802.11 can achieve up to three non-overlapping (non-interfering) [4] channels as shown in Fig. 2 These non-overlapping channels can operate simultaneously with minimal interfering. Even for these non-interfering channels, the Inter-channel interference cannot be completely eliminated [2].

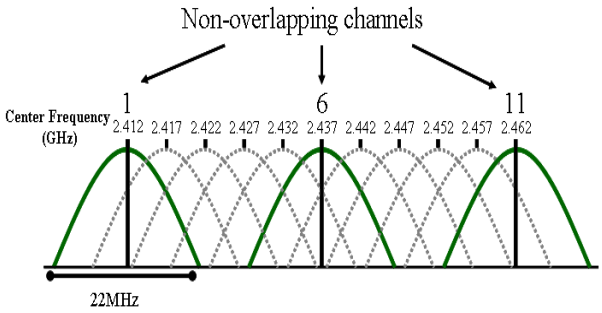


Fig. 2 IEEE 802.11 Non-overlapping channels

. The system capacity and throughput is affected by this channel interference which will be illustrated in our experiment results.

## 2 Field experiment

The environment is carefully checked for any possible interference form outside source prior to performing the experiment. The equipment utilized through out the experiment are, IPN-W100AP Trinity Security Systems, Inc [8]. Access points with dual radio module 2.4GHz and Netperf [6] is used to measure UDP throughput.

### 2.1 Signal to Interference (SIR) Ratio Measurement

In this scenario, the aim is to plot the relation between the throughput and Signal to Interference ratio (SIR) for one hop mesh network.

Fig.3 illustrates the experimental setup. It consists of two networks interconnect with an isolator. The upper section consists of one hop mesh network. Cables are used in this experiment instead of wireless to avoid any unwanted interference from outside source. 30dB attenuators are utilized at the access points to guard the access point.

The lower section of the experiment (indicated by the blue devices), acts as interference to the upper network. While operating at the same frequency channel, the signal from the lower section will be fed into the upper network while changing the transmission power of the interference network. The isolator will allow a single direction signal pass to prevent affecting the interference circuit with the signal from the upper network.

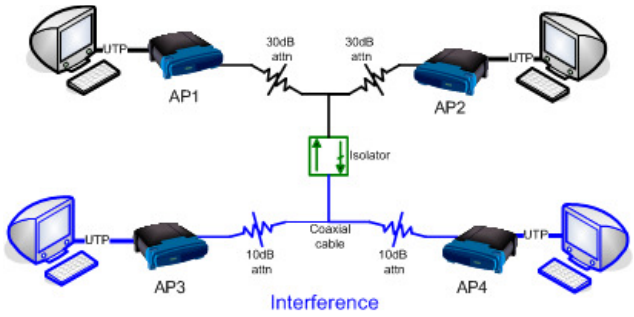


Fig. 3 SIR measurement using two interfering networks.

The results obtained are shown in Fig. 4. We can conclude that severe channel interference occurs at low Signal to Interference Ratio (SIR) values. In order to avoid the interference effect, the SIR values at the reception radio must be more than 25dB [7].

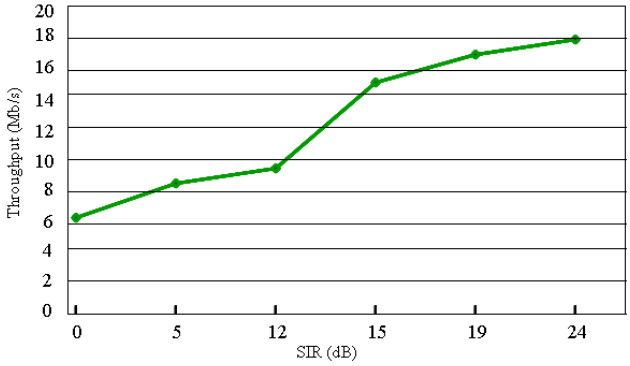


Fig. 4 Throughput vs. SIR (adopted from [7])

It is also noticed that the network didn't arrive to a state where the throughput is zero even with 1 SNR which indicates that the interference is equal to the signal. That is because the signals are timely sharing the channel medium between them. So the

communication not be completely halted regardless the intensity of the interference,

## 2.2 Single radio vs Multi radio WMN node Experiment

The aim of this scenario is to examine the interference effect in a multi-radio access point. The introduction of the second radio in access point is expected to improve capacity, connectivity and better utilization for the frequency band. However, the two radios may interfere with each other's transmission. To examine this interference effect, Fig. 5 indicates the two WMN that were tested in this scenario.

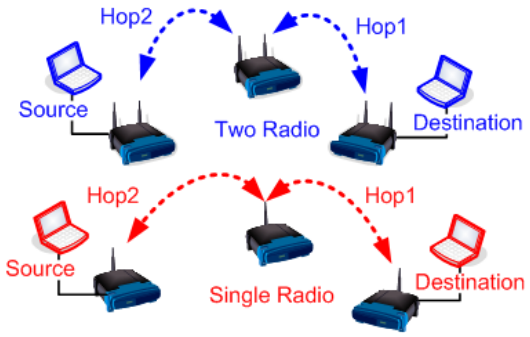


Fig. 5 Single radio vs. Multi-radio

The upper network in Fig. 5 utilizes two radios at the middle access point to route the data between the source and destination. The red network on the other hand utilizes only a single radio to do the routing. For this simple two hop WMN, it was expected to achieve better throughput with the two radio setup since they utilized different channel for the two hops. However, the results summarized in Table 1 show that the single radio setup achieved slightly higher throughput than the two radio setup.

Table 1. Throughput of Mutli-hop WMN

| **Multi-Radio** | **Throughput (Mbps)** |
|---|---|
| Channel 1<br>Channel 3 | 8.408 |
| Channel 1<br>Channel 6 | 9.094 |
| Channel 1<br>Channel 11 | 9.00 |
| **Single radio** | **Throughput (Mbps)** |
| Channel 1 | 10.25 |

The first column indicates the channel combination used for the fist and the second hops. For the multi -radio setup, we notice that as the channel separation increase, the throughput is slightly improved. The small improvement in throughput is due to utilizing non overlapping channels. In case of a single radio, the only channel 1 is utilized, and the throughput achieved was the highest among the other combination. In the two radios case, the first hop and the second hop do not interfere with each other since they utilize different frequency channels. The degradation in throughput is due to the dropped packets as a result if interference between the transmitting and receiving radios on the access point. On the other hand, the single radio case do not face such a problem since the two hops utilizes the same frequency channel. As a result, when hop 1 is using the channel, hop 2 cannot transmit until hop 1 finishes transmitting. For this reason, the dropped packet is decreased and slightly higher throughput is achieved.

## 2.3 Interference cancellation Experiment

In this scenario, we propose a solution to the interference which occurs in the access point between the two antennas. The circuit in Fig. 6 represents an interference cancellation circuit.

The circuit consists of two couplers, variable attenuator and Coaxial Line Stretchers for phase shifting.

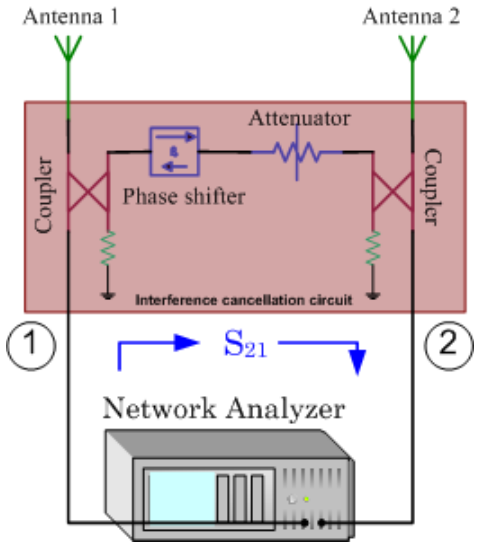


Fig. 6 Interference cancellation circuit

To evaluate the effect of the proposed circuit, the scattering parameter $S_{21}$ measured using a network analyzer with two antenna ports of AP. Fig. 6 shows a comparison in the $S_{21}$ parameter before and after applying the interference cancellation circuit. This figure indicates a decrease at 2.4GHz in $S_{21}$ parameter after applying the cancellation circuit. This decrease represents a reduction in channel interference between the two antennas.

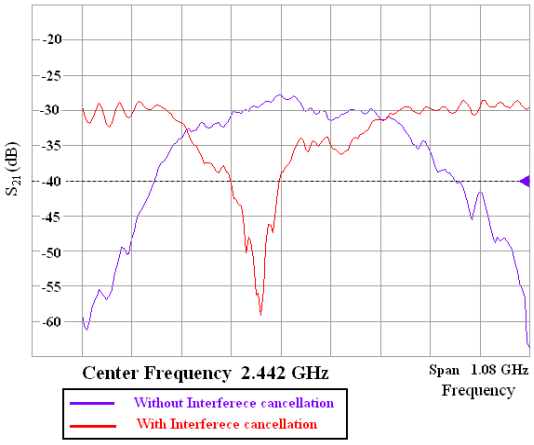


Fig. 7 $S_{21}$ Parameter

Currently the circuit is tested for its impact on throughput improvement on different indoor environments. This circuit is expected to improve the throughput of the two hops WMN for the multi-radio case.

## 3 Conclusion

In this work we investigate the effect of interference on the throughput of multi-hop multi-radio WMN. The first experiment results show that in order to avoid the interference effect, the SIR values at the reception radio must be more than 25dB. It was found that access points equipped with multiple radios can exhibit interference which can degrade it throughput.

A proposed interference cancellation circuit managed to suppress interference between two antennas with improvement of nearly 30 dB reduction in $S_{21}$ parameter.

As for future work, the circuit will be further improved to a chive higher signal cancellation and it will be implemented.

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