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Balancing Radio Range and Capacity with An Interference Aware Joint Channel Assignment Scheme in Wireless Mesh Networks

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Abstract-Wireless mesh networks are being increasingly used in a variety of applications such as surveillance and traffic monitoring, industrial automation, and communication. However, due to the number of devices operating in the same area, interference can be an issue and can reduce network reliability. To address this problem, researchers have proposed an interference aware joint channel assignment scheme for multi-channel, multi-radio wireless mesh networks. It takes into account both radio frequency (RF) characteristics and interference issues when assigning channels. The goal of this scheme is to improve network reliability by minimizing interference between nodes while maintaining sufficient throughput for each node.

Introduction

A Wireless Mesh Network (WMN) is an inexpensive, multihop wireless network composed of mesh routers and Internet gateways. It's a subset of ad hoc networks characterized by their inherently static topology. When it comes to power consumption, mesh routers are unlike traditional ad hoc networks. There are several applications for WMN in the building automation industry, including security monitoring, remote medical care, and smart grids. In a wireless mesh network, the mesh routers play a vital role. Through these services, mesh clients' network traffic is directed. Routers in a mesh network might include many radios to improve coverage and reduce interference. Because of its modular design and wide range of possible applications, IEEE 802.11 is a great candidate for wireless mesh deployment. Networks based on 802.11 standard provide wireless connectivity in places like campuses, airports, and hospitals affordable, versatile, and simple to implement. Backhaul links in an 802.11 WMN can be operated on any of the non-overlapping channels. Furthermore, the low cost of network interface cards allowed for the use of numerous radios and channels, hence increasing throughput.

Different radio setups give you access to all of the stations. Wireless backhaul connections between multi radio mesh routers use a wide variety of non-identical channels. Network access links are the means by which mesh clients connect to mesh routers. Clients in a mesh network are user-created entities that do not participate in network routing. For the rest of this article, "link" will refer to a backhaul link. A gateway, or mesh router, connects nodes within a mesh to networks beyond the mesh.

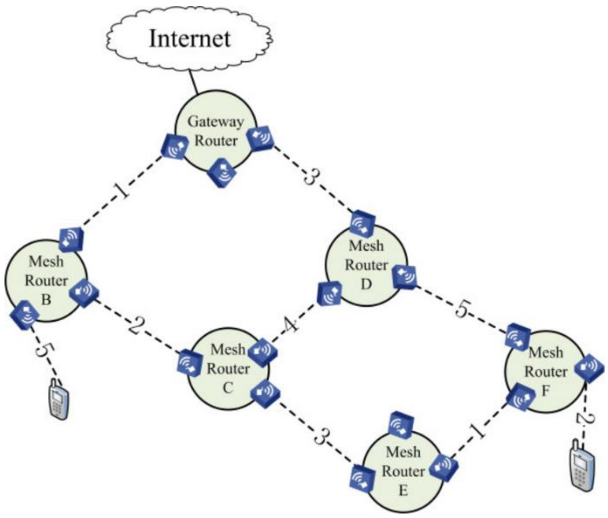

Figure 1. Multi-channel, multi-radio wireless mesh networks

As a network topology, a mesh consists of numerous interconnected nodes. Common components of wireless mesh networks include mesh clients, mesh routers, and gateways. Occasionally, nodes may be repositioned. If nodes are often or constantly changing locations, the mesh will waste time recalculating routes rather than transmitting data. Stable topology is characteristic of a wireless mesh network, which is necessary for the convergence of route computation and the successful delivery of data packets. As such, this type of wireless ad hoc network exhibits centralization and permits only limited mobility. Because it sometimes requires stationary nodes to operate as gateways, it is also not a genuine all-wireless ad hoc network. With cheap operational and management expenses, wireless multi-radio multi-channel mesh networks can provide ubiquitous and high-speed broadband connectivity in both urban and rural areas, for both stationary and mobile users. By utilizing geographic diversity with numerous radio interfaces in mesh nodes (each using a different channel) and directional antennas, these networks can outperform their single-radio single-channel counterparts. Mesh clients are often wireless devices like smartphones and laptops. The gateways, which may or may not have Internet access, are connected to the rest of the network via the mesh routers. Mesh clouds refer to the combined coverage area of a network of radio nodes. In order to gain access to this mesh cloud, a radio network must be established between the various radio nodes. When it comes to network uptime and availability, a mesh network is the way to go. When one node fails, the others can continue communicate with one another either directly or via a relay node. It is possible for wireless mesh networks to spontaneously generate and self-heal. There is no need to limit wireless mesh networks to a single technology or protocol because they are compatible with a wide range of wireless standards.

Multi-Channel, Multi-Radio Wireless Mesh Networks

Multi-channel, multi-radio wireless mesh networks are a type of communication infrastructure that can be used for data transmission and other applications such as quality of service (QoS) support, traffic engineering, network monitoring and security. This type of network is composed of multiple radio interfaces (called radios) linked to different channels.

This architecture presents several advantages over traditional wireless mesh networks. The most significant one is the ability to significantly reduce interference between neighbouring radios. By shifting certain wireless channels away from each other, the network can mitigate interference to the point where it no longer impacts the performance of the network.

In addition, by taking into account external sources of interference such as cellular base stations or Wi-Fi hotspots, an interference aware joint channel assignment scheme in multi-channel, multi-radio wireless mesh networks can further increase efficiency and throughput by eliminating areas of contention. This allows for improved reliability and better utilization of resources.

Proposed Methodology

The proposed framework called Load-aware Channel Estimation (LACE). The channel assignment protocol takes information about where the routers are, how far they can transmit, how far they can interfere with each other, how many channels there are, and how many radios are on each node. It then sends the channels to the radios of each router. Link-based traffic to achieve channel allocation is the goal of this project. This will be done by analyzing the characteristics of multichannel WMN based on research that has already been done.

NS2 was used to implement LACE, and WCP (Sumit et al. 2011), GLBM (Liang et al. 2010), and Gateway Selection and Clustering in Multi-interface (GSCM) (Arash et al. 2017) were used to compare its performance. End-to-end delay (E2D), throughput, packet drop,

Table 1 Experimental Settings

No. of mesh clients	4, 6, 8, 10 and 12
Size of Area	1300 × 1300m

MAC protocol	802.11
Simulation time in seconds	100s
Traffic source	Constant Bit Rate (CBR)
Data sending rate in kbps	250
No. of channels per node	1 to 5
Propagation	Two ray ground
Antenna	Omni Directional antenna

Result

To make the network slow down, the number of clients asking for CBR traffic is raised from 2 to 10. In this section, the results are obtained by changing the number of nodes from 4 to 10.

Table 2 and Figure 2 show how the E2D changes for different numbers of nodes. It can be seen that the E2D of LACE goes up from 37.18 to 42.7 ms, the E2D of WCP goes up from 42.05 to 45.8 ms, the E2D of GLBM goes up from 46.7 to 49.6 ms, and the E2D of GSCM goes up from 48.2 to 52.9 ms. This means that the E2D of LACE is 15% less than WCP, 23% less than GLBM.

Table 2 Performance of E2D for Varying Nodes

Nodes	**E2D (ms)**			
	LACE	**WCP**	**GLBM**	**GSCM**
2	37.28	42.05	46.75	39.24
4	37.25	43.34	46.97	39.74
6	37.69	43.85	47.81	40.65
8	41.94	44.16	40.3	42.87
10	42.7	45.97	40.6	43.95

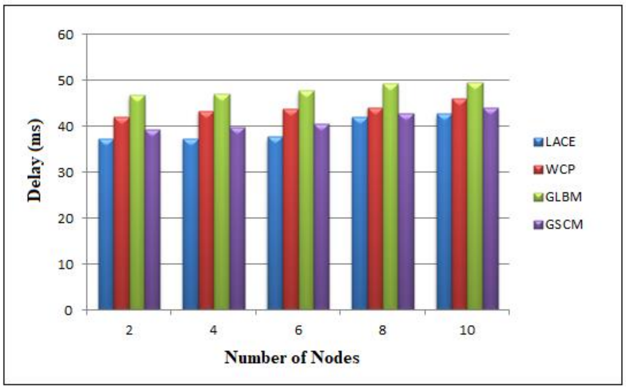

Figure 2. Results of E2D for different number of nodes

Performance of Throughput for Varying Nodes

Table 3 Performance of Throughput for Varying Nodes

Nodes	**Throughput (Mb/s)**			
	LACE	**WCP**	**GLBM**	**GSCM**
2	46.72	38.45	40.14	29.74
4	42.11	34.21	36.41	30.85
6	40.78	32.18	33.72	29.75
8	40.32	30.44	32.43	28.94
10	39.88	38.58	30.83	27.84

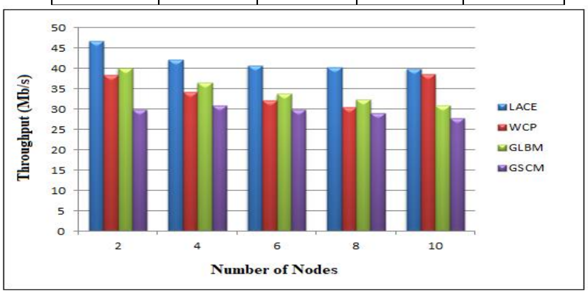

Figure 3 Results of Throughput for different number of nodes

Table 3 and Figure 3 show how much work each number of nodes can do. It can be seen that LACE's throughput goes down from 46.7 to 39.9 Mb/s, WCP's throughput goes down from 38.45 to 28.58 Mb/s, GLBM's throughput goes down from 40.14 to 30.83 Mb/s, and GSCM's throughput goes down from 29.6 to 27.8 Mb/s. This means that LACE's throughput is 23% higher than WCP, 18% higher than Tables 5.2 through 5.5 show how much better LACE is than WCP, GLBM, and GSCM, respectively.

Conclusion

The proposed method provides an approach that is suitable for heterogeneous wireless mesh networks with different radio types. The results demonstrate that the proposed scheme results in improved performance in terms of throughput and packet delivery ratio. This scheme is expected to increase the success rate in wireless mesh networks by allowing users to take advantage of the benefits of multiple channels and radios without overburdening the network. NS2 is used to test the proposed LACE protocol. Simulations have shown that, compared to other methods, the LACE protocol reduces the number of dropped packets and delays and increases the number of packets that can be sent.

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