Interference Mitigation in WiFi Networks using Multi-sector Antennas

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ABSTRACT

Sectorized antennas provide an attractive solution to increase wireless network capacity through interference mitigation. Despite their increasing popularity, the real-world performance characteristics of such antennas in dense wireless mesh networks are not well understood. We demonstrate our multi-sector antenna prototypes and their performance through video streaming over an indoor wireless network in the presence of interfering nodes. We use our graphical tool to vary the sender, receiver, and interferer antenna configurations and the resulting performance is directly visible in the video quality displayed at the receiver.

Categories and Subject Descriptors

C.2.1 [**Network Architecture and Design**]: Wireless Communication; C.4 [**Performance of Systems**]: Measurement Techniques

General Terms

Experimentation, Measurement, Performance

Keywords

Interference Mitigation, Sectorized Antenna, Sector Selection

1. INTRODUCTION

Interference is a major issue in wireless networks. In WiFi-based networks, all wireless devices that operate on the same frequency and are located within each others sensing range share the wireless medium. Sectorized antennas can mitigate interference in dense wireless networks by limiting both the transmission and reception to certain directions. These antennas thus promise increased wireless network capacity through higher spatial reuse. Despite their increasing popularity and extensive studies in theory and using simulations, their performance characteristics when deployed in real networks are still not well understood. While the concept of sectorization works well for outdoor line-of-sight communication, indoor and dense wireless networks pose unique challenges due to its node density and reflection rich environment [3, 1].

MobiCom'09, September 20-25, 2009, Beijing, China.
ACM X-XXXXX-XX-X/XX/XX.

We have developed a demonstrator that complements our previous measurement campaigns [3, 4] and its primary goal is to demonstrate the operation, the challenges, and the resulting performance of sectorized antennas in real-world dense 802.11 wireless mesh networks. We have designed a four-sector antenna [2] for operation in the 5GHz band with off-the-shelf 802.11 wireless cards. We equip a number of wireless nodes with these antennas and place them in vicinity of each other. We stream video content from a sender to a receiver in the presence of an interfering node while varying antenna configuration (i.e., sector activation) at these nodes. The perceived video quality is affected by changes of the antenna configurations. We thus demonstrate the impact of sector selection on network performance through the perceived video quality at the receiver. In addition, we complement the qualitative video performance evaluation by collecting and graphically displaying quantitative link characteristics.

2. EXPERIMENTAL SETUP AND OPERATION

We detail our demo architecture and its operation and specific requirements.

Sectorized Antennas. We use Thomson multi-sector antennas as the one shown in Figure 1. This antenna consists of four Vivaldi sectors, each covering one quarter of the azimuth plane. These sectors can be simultaneously activated in any combination, and when all four sectors are active, it represents omni-mode. Sector activation is controlled by a switch integrated on the antenna system, which we control from the parallel port of the host computer (for more details on the antenna system, see [2]).

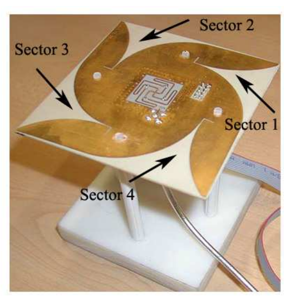

Figure 1: A prototype of the Thomson multi-sector antennas used in our demo.

Wireless Deployment. Our demo configuration consists of three nodes deployed in an indoor environment (see Figure 2). These three nodes have the roles of sender, receiver, and interferer, respectively. Each node is a regular Dell laptop running Linux and is equipped with an Atheros IEEE 802.11a/b/g mini-PCI wireless card, to which we connect the multi-sector antenna. The Atheros card is controlled through the Madwifi driver, which we have modified to obtain detailed measurements of signal strength, per-retransmission bit rate, and packet loss. We set the wireless card to operate in Ad hoc demo mode to facilitate ad hoc communication between nodes. We perform the demo experiments in any of the channels in the 5GHz band of 802.11a, without external interference.

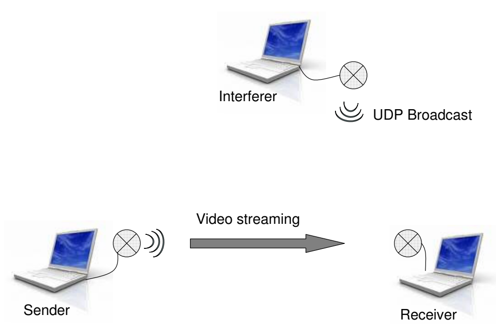

Figure 2: Experimental setup: Three nodes with sectorized antennas (circles with cross). We stream a video between sender and receiver while the interferer broadcasts UDP packets. We vary the active sectors at all nodes and evaluate the impact on performance.

Demo Operation. We use the VideoLAN client to continuously stream video content from sender to receiver. Simultaneously, the interferer node broadcasts backlogged UDP traffic. Depending on the antenna configurations at all nodes the interferer will have different impact on the video stream.

In the basic configuration, all nodes have omni-mode antenna configuration. In this case, all nodes carrier sense each other and are forced to share the medium. This thus leads to low performance. We then explore different antenna configurations and the resulting performance. We remotely vary the antenna configuration on the nodes using a graphical tool we developed. The impact of these changes is directly visible on perceived video quality at the receiver. We demonstrate how an optimal antenna configuration lead to good performance and in addition we explore the difference between the geographically pointing sector and the best sector. We also demonstrate how sub-optimal antenna configuration may lead to performance degradation due to the directional hidden terminal problem. In addition to the subjective video quality at the receiver, we display detailed information about the link between sender and receiver which allow us to correlate this information. In conclusion, by varying the antenna configurations on the nodes we can both qualitatively and quantitatively investigate the impact of sectorization on the network performance in dense indoor wireless environments.

3. REFERENCES

[1] X. Liu, A. Sheth, M. Kaminsky, K. Papagiannaki, S. Seshan, and P. Steenkiste. DIRC: Increasing Indoor Wireless Capacity Using Directional Antennas. In *Proc. ACM SIGCOMM*, Aug 2009.

[2] P. Minard, J. Robert, and A. Louzir. Multi-beam Antenna System for Mesh Network with Omnidirectional Mode. In *In Proc. IEEE Antennas and Propagation Society International Symposium (AP-S)*, 2008.

[3] A. Subramanian, H. Lundgren, and T. Salonidis. Experimental Characterization of Sectorized Antennas in Dense 802.11 Wireless Mesh Networks. In *Proc. ACM MobiHoc*, May 2009.

[4] A. Subramanian, H. Lundgren, T. Salonidis, and D. Towsley. Topology Control Protocol Using Sectorized Antennas in Dense 802.11 Wireless Networks. In *Proc. IEEE International Conference on Network Protocols (ICNP)*, Oct 2009. *To appear.*