# Applied techniques for boosting bandwidth capacity for wireless networking and last-mile protocols

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***Abstract*— Wireless technologies are finding application in numerous fields and are experiencing rapid growth in network deployments. A major obstacle for scaling of wireless networks and for effective cable-network replacement is bandwidth capacity. Typical wireless networks suffer from limited bandwidth capacity and thus suffer under significant load. Work is under way to develop and evaluate techniques for increasing available capacity. The approach will be to explore multiple methods of boosting capacity and evaluating potential performance and uptake potential. A recommendation will be made based on bandwidth gains achieved and upgradeability and compatibility with existing networks.**

***Index Terms*— Bandwidth Aggregation, Multiple Input Multiple Output (MIMO), wireless networks**

## I. INTRODUCTION

Classical wireless networks based on 802.11 technologies are able to offer a theoretical 54Mbps (802.11g/a) to the network. This represents the entire bandwidth pool for all points within the wireless coverage area for a particular channel. Protocol overheads and interference issues result in true real peak bandwidth availability of 20Mbps.

Since 802.11 networks are half-duplex and operate over a single channel, the available capacity is shared amongst all network nodes. Thus, network users are provided with a 20Mbps/n guaranteed capacity under load. It is feasible to expect an average sized office environment or hotspot wireless network to accommodate for 10 users per access point and thus per channel resulting in an effective 1Mbps peak data rate. This is overly optimistic since all users will be competing for the bandwidth which equates to mediocre performance on average.

This situation results in sub-broadband access speed which may be acceptable in a last-mile setting. However, for a an office type of application, 1Mbps and lower speeds are not acceptable for file transfers, video conferencing and other similar applications. A more acceptable bandwidth allocation would be 5Mbps or higher dedicated or rather, guaranteed bandwidth performance.

Thus, the goal is to provide a much higher bandwidth offering using the same or similar compatible technologies. This will be achieved using an extension of what is currently available. In addition, providing simultaneous access via multiple channels will provide improved performance over and above that available using half-duplex technologies including higher capacities with lower transmit/receive latencies.

## II. OVERVIEW OF EXISTING TECHNOLOGIES

### A. *Access technologies*

At present, the adopted method of wireless communications for medium range (up to a few kilometers) requirements with acceptable bandwidth capacity is using 802.11 standards based hardware and the associated protocols. These standards enjoy worldwide compatibility and thus find application in wireless networks and hotspots in almost all wireless installations.

The shortfalls for 802.11 networks are capacity and range. Requirements for efficient performance include relatively high signal quality which is difficult to achieve with the typically low power used in 802.11 hardware (due to legislatory controls on free spectrum in the 2.4 and 5GHz frequency bands).

WiMax or 802.16 standards based networks offer increased range and higher bandwidth availability. However, as this is a last mile technology and fairly new, availability of hardware and compatibility with existing 802.11 networks is a concern. Due to WiMax being a last mile technology, it is likely that access will be based on a subscription model which is the opposite of the free-to-use feature of 802.11 networks. 802.11n hardware is starting to enter the marker labeled as "pre-n" and offers a 20% boost in throughput.

### B. *Future advancements*

In the near future, 802.11a/b/g will remain the predominant wireless networking standard. 802.11n, which is due to be ratified in early 2007, will eventually take over as the primary technology of choice for wireless networks. It is possible to achieve over 100Mbps for a wireless LAN as shown by [1] using a variety of techniques similar to those used in the development of the early parts of 802.11n

## III. Objectives of Current Research

This body or research attempts to provide relatively simple expansions to existing standards using extensions of MIMO principles. The outcome can be further extended by implementing MIMO along with OFDM (orthogonal frequency division multiplexing) as shown by [1].

## IV. Approach for Research

The approach followed will be to study the principles of operation of typical wireless access networks (based on 802.11 standards). The effects of multi-channel operation in a co-existing framework will be investigated. A performance benchmark for 802.11-based networks will be set as a starting point. The outcome of the research strives to achieve a minimum of a 25% increase in throughput capacity.

As a means for comparison, the MIMO-OFDM solution for wireless LANs put forward by [1] will serve as a guideline. The authors of this work developed a testbed for an 802.11a MIMO-OFDM and discovered that while overly complex and requiring significant changes in signal processing, the effective throughput was increased by a factor of 2. The drawback of this implementation is extreme deviation from the 802.11 standard, expensive and complicated implementation as well as movement towards a new OFDM incompatible with existing modulation schemes. The work covered in this project will seek to use a combination of methods (including MIMO) to achieve 802.11-compatible gains in performance.

As explained above, OFDM methods for wireless transmissions are only applicable to 802.11a networks. Thus, OFDM will only be kept as an option but will not be the focus.

Regarding MIMO, there are 2 distinctly separate schools of thought. The first notion is that of operating the system using multiple antennas for transmitting and receiving. Systems such as these will carry a m x n rating which means m TX and n RX antennas. The second definition of MIMO implies multiple input/output channels which are combined to form a single aggregated transmission pipe.

The approach followed will be to examine the interoperability of two communication sides or nodes using a combined dual MIMO configuration. This configuration will be constituted of multiple antennas (typically limited to 3 antennas or a triple frequency or tri-mode antenna) operating over multiple channels with a combined effect.

Another aspect that will be considered is the beneficial effect of multipath signals for wireless transmissions. These multiple paths (previously a drawback in wireless transmission) can be used for multiple input and output diversity as shown by [2].

Channel effects for MIMO propagation will need to be considered. Effects such as scattering, diffraction and waveguiding will have a significant impact on performance in MIMO channels. Actual results will be based on the generic MIMO model presented by [3].

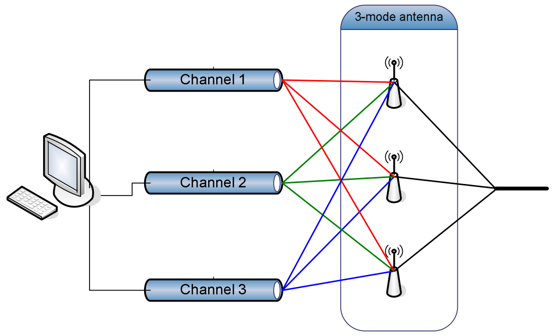


Fig. 1. Overview of the proposed model

The proposed research model shown in figure 1 shows how the nodal output (and input) transmissions are carried over multiple channels and these channels multiplexed over the 3 (or n) antennas in a mesh configuration. The three distinct outputs are considered as one single channel.

## V. Contribution

If the output of this project is useful, the performance gain will be substantial and will add to the body of knowledge regarding aggregated multiple transmission path wireless communication systems.

The benefits for the technology itself include higher throughput rates, greater transmission ranges as well as lower packet drops due to increased signal propagation and capacity or capability for error checking and correction. These features are offered by the multiple overlapping signal channels (for redundancy) and antenna diversity at the cost of increased total signal output power (technically still within legal limits if considered on a per-channel basis).

## VI. Conclusion

The benefits of greater transfer speeds and also overall wireless capacity are numerous. Application of new techniques based on MIMO technology using multiple streams and improved signal processing techniques as well as higher capacity modulation algorithms such as OFDM will become the core of future wireless access technologies. These modifications are complex to implement but the benefits will far outweigh the difficulty of implementation.

## References


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