NETGEAR®

Best Practices for High Density Wireless Network Design In Education and Small/Medium Businesses

WHITE PAPER

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EXECUTIVE SUMMARY

As usage of smart phones and tablets continue to gain in popularity, the trend towards BYOD (bring your own device) continues to gain momentum. Wireless networks that were once designed to support a few laptop computers must now routinely host a wide range of mobile devices including smartphones, tablet computers, and e-readers, often with these devices running bandwidth-intensive applications such as video. As a result, IT administrators are increasingly faced with the challenge of how to design and deploy a wireless network that can accommodate the exponential growth in network devices and applications.

This whitepaper is intended to help IT administrators understand some basic guidelines for determining access point (AP) throughput, bandwidth requirements and best practices for wireless deployment in high density environments such as schools and small/medium businesses.

INTRODUCTION

There are two basic types of deployment models in wireless: coverage and capacity based. In a **coverage** based wireless design, the goal is to provide good quality of service (in terms of RF signal strength) in as much of the area as possible with a single or multiple access points. Examples of coverage based deployments include sites where there is a relatively large area with few Wi-Fi devices per user such as:

- Elementary school classrooms
- Warehouses
- Nursing homes, hospitals and clinics
- Hotels
- Office cubicles

In most of these deployments, the number of access points needed to cover the area is determined by the AP signal strength, which is a combination of AP output power and antenna gain. Other factors to consider when designing coverage based networks are:

- **Type of site -** office, cubicle, warehouse, single room motel/hotel, etc.
- **Floor plan and ceiling height –** e.g. office (10 ft./3 m), warehouse (20 ft./3m), gym (30 ft./9m)
- **Construction materials and obstructions -** e.g. concrete, brick, drywall, elevator shafts
- **Number of floors**
- **Exclusion areas –** locations where coverage is not needed/wanted

The second type of wireless deployment is referred to as **capacity** based. In this type of deployment, the goal is to provide good quality wireless service to a concentrated set of concurrent users in a confined area. Examples of capacity based deployments include sites such as middle or high school classrooms, lecture halls, auditoriums, libraries, stadiums, and office conference rooms. Factors to consider when designing capacity based networks are:

- Number of users in a specific area covered by a single AP
- Number of Wi-Fi devices per person
- Percentage of users that are expected to be active
- Types of applications and throughput needed
- Mix of applications
- Type of clients in the network (2.4 GHz vs. 5GHz)
- Legacy vs. .11n client protocols

Within an enterprise or school, there may be a mix of areas that require both coverage and capacity based wireless deployments. When you have a large number of users accessing Wi-Fi and demanding throughput at the same time, it is considered to be a high density area. As a general rule of thumb, when there are 25 to 30 active users in a coverage area served by a single AP (approximately 500 to 1,000 square feet), then you will need to design your wireless network using some of the high density best practices that are outlined in this guide.

DETERMINING ACCESS POINT THROUGHPUT

It is a common sizing mistake to use the theoretical maximum to estimate how much throughput an AP can actually support, For example, the theoretical throughput for an access point with a 2x2 dual band radio that can support up to 300Mbps per radio would be 600 Mbps (300Mbps x 2). Assuming there are 25 concurrent Wi-Fi users in the area, you could mistakenly calculate that each access point can support 24Mbps per user (600Mbps/25 users).

In practice, there are several factors that will significantly reduce AP throughput vs. the theoretical limit:

- **Protocol and packet overhead -** can reduce throughput by 40 - 50%
- **Slow or "far away" clients -** clients that are further away or in an area of weaker signal strength must step down the transmission physical rate (PHY) rate to send the packet (e.g. a client sending a packet at 1 Mbps will take 100 times longer than a client sending the same packet at a PHY rate of 100Mbps), potentially causing an additional 50% degradation of throughput.
- **Uneven distribution of clients -** in a dual band concurrent AP, both bands can simultaneously support client traffic. However, not all clients are dual band and there is no guarantee that even the dual band clients will evenly distribute themselves between 2.4 and 5GHz. Network effectiveness may be reduced by another 50% due to the behavior of the clients.
- **Control traffic –** control traffic exchanged between the AP and various clients at low PHY rates can further reduce available bandwidth by 25%.
- **Other –** co-channel and adjacent channel interference, network re-transmissions, and bad behavior clients will further reduce AP throughput.

As you can see in Figure 1, end users in schools and small/medium businesses are only left with 2 -3 Mbps/user to run mission critical applications after taking into account the various factors constraining AP throughput. Note that these values are offered as an example based on experience with past solutions and actual performance may vary based on situational conditions.

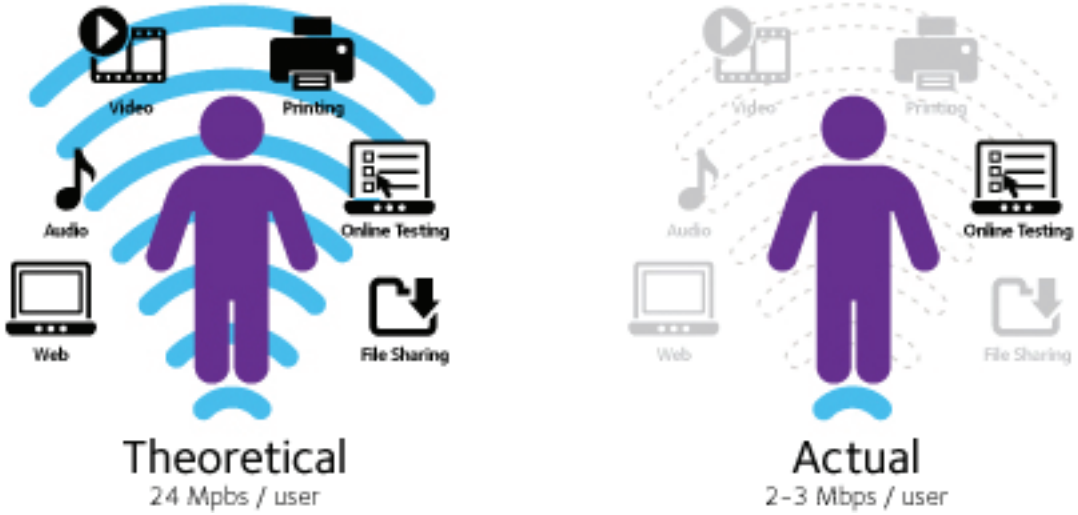

Figure 1: Realistic User Throughput

ESTABLISHING BANDWIDTH REQUIREMENTS

When designing high density wireless networks, it is critical to understand which applications will be used and how much bandwidth each application will consume in terms of throughput per user. The chart in Figure 2 below provides some general references on how much throughput is needed for common applications such as internet, audio, video, printing, file sharing, and online testing. More and more schools are using online video applications such as knowmia.com and youtube.com as a daily teaching tool. As you can see from the chart, throughput requirements can vary from 2 to 4Mpbs per user depending on the video resolution. Once the bandwidth per application is known, this number can be used to calculate the bandwidth required per user.

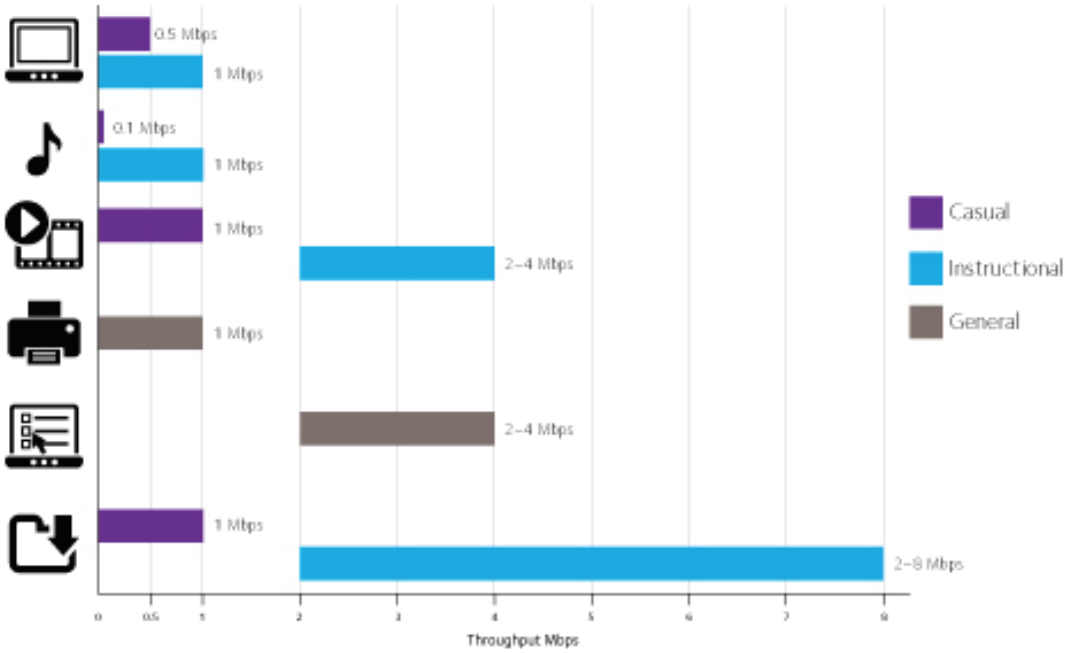

Figure 2: Average Bandwidth Requirements by Application Type

In addition to the type of applications to be used, bandwidth requirements will vary based on the number of expected users on the wireless network. As more users access the network, throughput per user goes down causing slower transmission rates. If the network consists of mixed clients (11a, b, gand 11n modes), the average throughput per client will also go down with the greater the number of legacy clients

Once the types of applications are identified and the bandwidth per type of application is determined, you can establish the aggregate bandwidth required by multiplying the total Mbps by the number of expected users in the coverage area.

TOP 10 HIGH DENSITY DESIGN RECOMMENDATIONS

The following design recommendations are best practices based on many successful installations and should serve as guidelines for proper design, planning, and deployment of a wireless network in a high density environment.

1) **Identify High Density Areas –** start the design process by using a live RF tool such as AirMagnet planner to identify areas of high density.

2) **Use Dual Band APs –** use dual band concurrent access points (2.4GHz and 5 GHz radios) to maximize available throughput for users. Always enable both radios.

3) **Design AP Overlap –** design the AP placement in high density areas such that each client always sees two to three access points. If one or two access point is overloaded at any given time, the client can be load balanced to another access point without any negative impact to the end user.

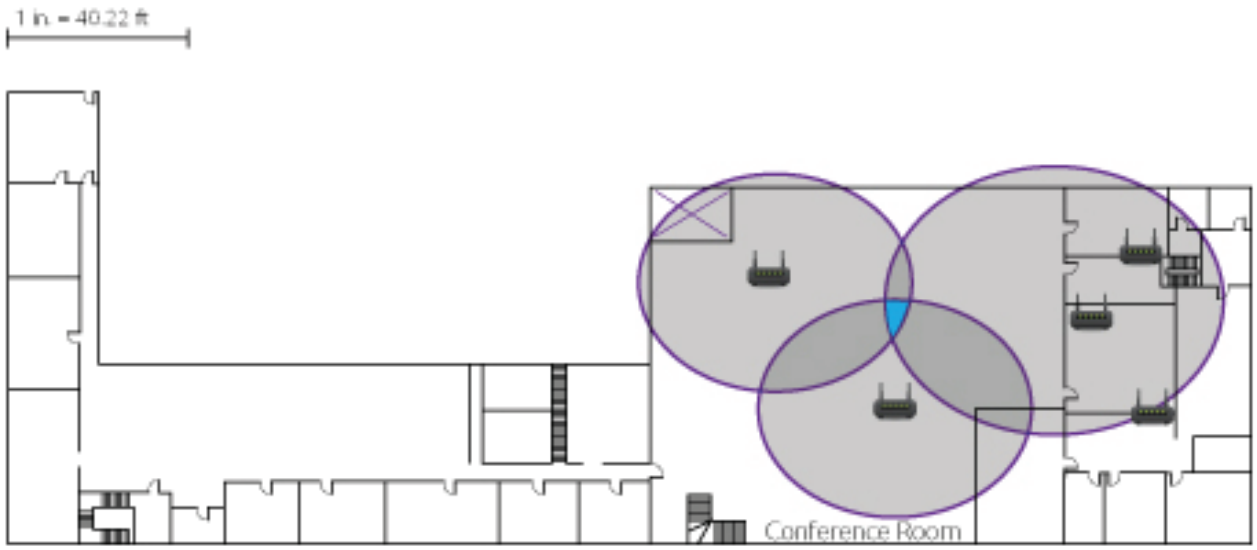

Figure 3: Design AP Overlap for High Density Areas

4) **Load Balance Traffic –** set the threshold on the AP to effectively utilize an over the air resource to ensure that you load balance the traffic to all of the access points that can be seen by clients. Based on Netgear's internal testing, we recommend setting the maximum number of clients to 25 to 30 for high throughput applications and the minimum RSSI threshold of (-73dBm). This means that any particular AP will serve a maximum of 25 to 30 clients with good reception.

5) **One AP Per Classroom –** for middle or high schools that have 25 to 30 students per classroom and have high throughput traffic as part their daily classroom teaching due to 1:1 programs or HD video streaming, use one AP per classroom and an additional AP in the hallway.

6) **Set AP Power Lower –** turning AP power up could cause additional co-channel and adjacent-channel interference. The recommended method is adding a third AP while setting the output power to one half or one quarter for the 2.4GHz AP and to one half for the 5 GHz AP.

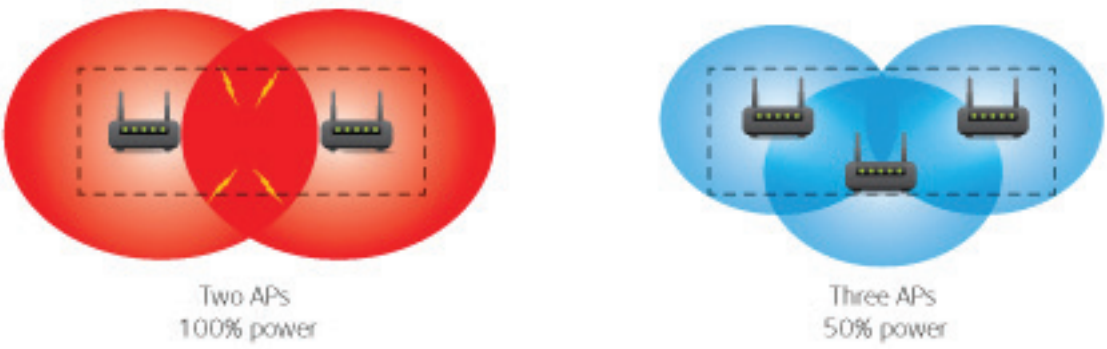

Figure 4: Tuning AP Output for Maximum Power

7) **Upgrade the Wired Network –** ensure that there is sufficient bandwidth on the wired network to support higher throughput APs by deploying PoE Gig switches at the edge and 1G or 10G switches at the aggregation/core layer.

8) **Go Onsite –** conduct a physical site survey to identify and trouble shoot any potential forms of interference from Wi-Fi or non-Wi-Fi sources.

9) **Stress Test –** prior to live deployment, fully load the network to validate the ability of the network to handle the amount of traffic generated by a BYOD implementation.

10) **Share Knowledge –** high density wireless design is still a relatively new topic among IT administrators in K-12 education and SMBs. Sharing knowledge of best practices from other successful deployments can be a valuable resource.

CONCLUSION

As BYOD becomes a way of life, not just in business environments but in facilities like schools, hospitals and even government buildings, wireless networks must be-designed to accommodate significant increases in the amount of traffic generated . In high density environments, the demands on throughput are often exacerbated by users carrying two or three devices using multiple applications that consume network resources simultaneously. The key to a successful wireless deployment is first understanding whether your environment is coverage or capacity based. Once you assess the parameters based on the deployment scenario, following the design recommendations outlined in this document should ensure sufficient bandwidth capacity to deliver a positive experience for end users. Sharing best practices with colleagues who have implemented or are in the process of implementing wireless networks in other schools and small/medium businesses can also be a valuable resource.

ABOUT NETGEAR

NETGEAR is a global networking company that offers reliable, affordable and easy to use solutions that have been specifically designed to meet the needs of small businesses and educational institutions. NETGEAR Access Points and Wireless Controllers give schools a powerful, cost-effective wireless solution that can fulfill the promise of connected learning simply and quickly. With NETGEAR Education Solutions, schools and small businesses gain:

- Lower Total Cost of Ownership for size of deployment (5-20 AP)
- A simple web-based UI for easy management and access
- Partner support and planning
- A full portfolio of Access Points and Wireless Management Controllers

Whether you are in the exploration, project definition, implementation, or expansion stage for coverage or capacity based wireless, NETGEAR can provide guidance and advice to help design robust, secure and flexible networks through our extensive and experienced reseller channel. For more information, go to *www.netgear.com*.

ABOUT DEBRA CHIN

Debra joined Palmer Research in 2006 as Senior Vice President. Her background includes over 15 years of experience in executive level marketing and research positions for leading consumer packaged goods and high tech companies. She holds an MBA from Columbia Business School and a BSE in Economics from the Wharton School of Business. Founded in 2001, Palmer Research delivers the information and intelligence IT decision makers and high tech companies need to better understand market dynamics and meet their business objectives. The company is located in Los Altos, CA. For more information, go to *www.palmerresearchgroup.com*.