Virtual Cells: The Only Scalable Multi-Channel Deployment

As wireless LAN deployments and usage has increased, coupled with the near ubiquity of embedded Wi-Fi in laptops and smart phones, many enterprises are experiencing complaints from their users of slow or even dropped connections. Many times this is due to a high density of users all accessing the wireless LAN (WLAN) simultaneously. Unfortunately, today's wireless LAN solutions are not designed to deal with high densities of users that comes along with a pervasive[1] WLAN in a corporation and what was formerly liberating is now frustrating.

While some vendors have created WLAN switch architectures to help large deployments, they focus primarily on security management and central management of access points (APs) configuration parameters. Solving these problems is both important and necessary, but it is not enough. The key challenge is managing contention, interference and Quality of Service (QoS) in a pervasive Wi-Fi deployment with both data and voice clients. This means minimizing the problems of co-channel interference, inter-AP handoff, as well as wireless network fidelity (for reliable communication) even with the limitation of few available channels. Meru Networks has created a Wi-Fi certified system designed from the ground up to account for co-channel interference and allow single channel or Virtual Cell operation creating the only truly scalable deployment architecture available today.

Why Traditional WLANs Fail in High Density Situations

Traditional wireless LANs are analogous to an Ethernet hub. As the 802.11 protocol is a shared medium, all users contend for the same bandwidth delivered by a single Access Point (AP). As higher numbers of users access the wireless LAN, the collision avoidance protocol used by 802.11 to manage contention increases each individual client's time to access the network. As the number of users increases, more and more delay occurs resulting in slower speeds for each user and even application timeout.

To solve these issues, conventional wisdom is to deploy more access points at a closer spacing. The reasoning behind this practice is, in summary, that if one access point provides 54 Mbps of bandwidth (802.11g or 802.11a), then additional APs will increase the capacity. This is true only to a limited extent. A number of reasons including only three non-overlapping channels[2] and co-channel interference as more than three APs are deployed limit the effectiveness of this approach. Reducing cell size by reducing the output power of the AP from the default 100mW to somewhere on

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[1] Pervasive Wi-Fi deployments are defined as deployments whose intent is to provide wireless voice and data access throughout a building or campus

[2] 802.11b and 802.11g

the order of 30mW (a practice also known as creating “Microcells”[3]) is often mentioned as a way to mitigate this, but when it comes right down to it, the solution is still inadequate for pervasive deployments. The more APs deployed in close proximity, the more contention there is, resulting in even more problems with throughput and connectivity for high numbers of users. And with a limited number of channels it is impossible to avoid having some APs on the same channel (particularly in a multi-story building).

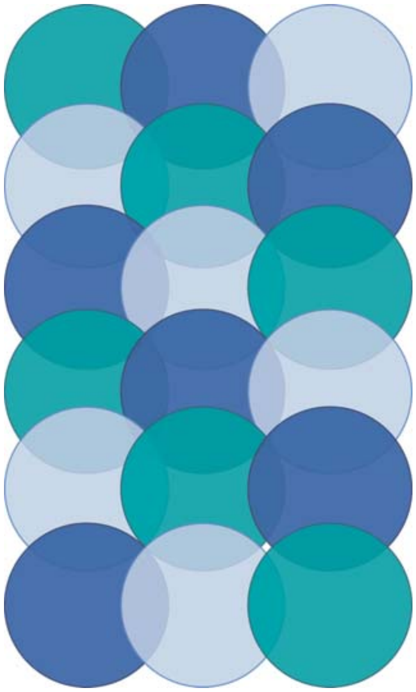

Figure 1: As the 2.4 GHz spectrum only supports three non-overlapping channels, overlapping occurs in pervasive WLAN deployments causing significantly increased interference.

In fact, because of the nature of the 802.11 protocol, with only three to five simultaneous contenders 802.11 throughput dramatically decreases because of the increased collisions and the subsequent backoff caused by contention among the users.

[3] For more information on the problems associated with Micro-Cells see the Meru Paper “MicroCell Deployments: Making a Bad Problem Worse”

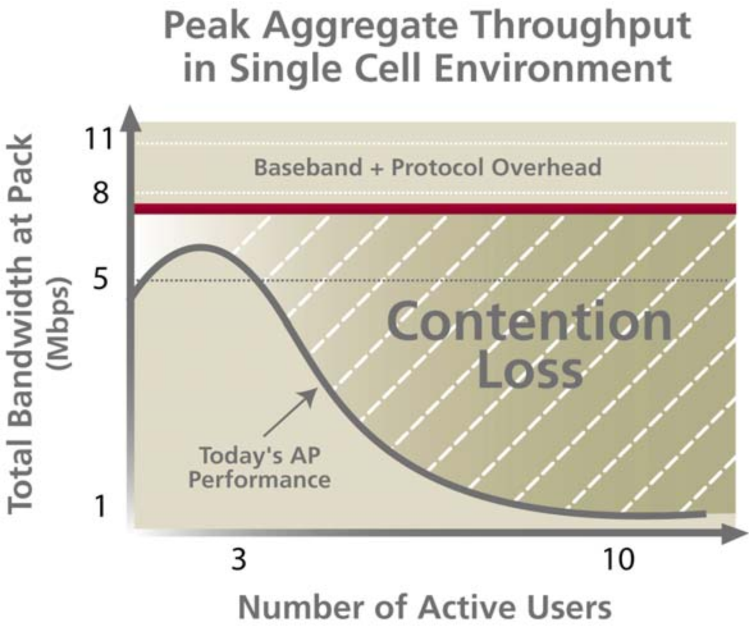

Figure 2: With only three to five active contenders, the total bandwidth available from a single AP dramatically declines.

With the power reduced on the AP you also artificially increase the signal to noise ratio (the interference level doesn't change but the AP signal is lower). This further increases the chances of corrupt packets and retransmissions and lowers the quality and fidelity of the wireless network Significantly.

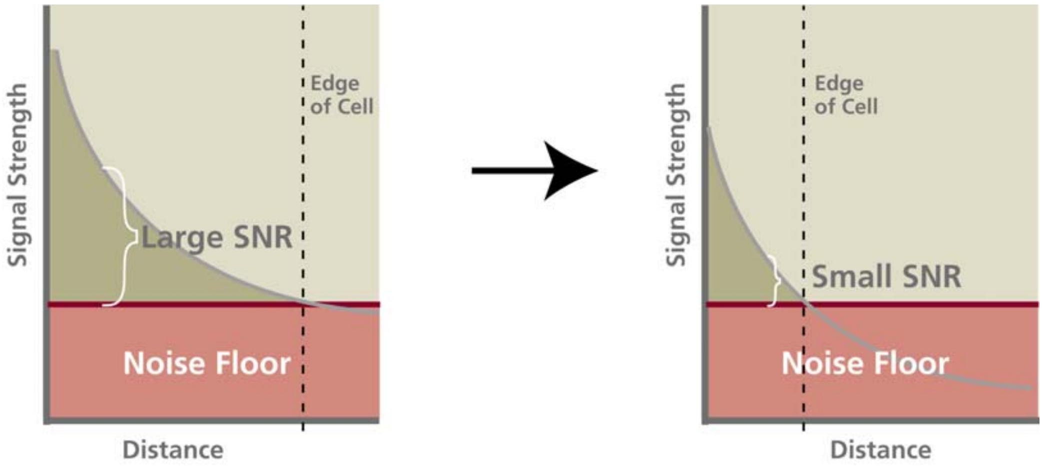

Figure 3: As the transmission power of the access point is decreased, it becomes more and more difficult for the AP to discern between noise and other interferers, decreasing the overall performance.

Voice Applications Aggravate the Problem

The challenges described above are even worse as voice clients enter the WLAN environment. Voice traffic requires low latency, low jitter, and fast handoffs. The traditional method for increasing client density – using more APs - has exactly the opposite intended effect. More access points will increase latency, increase jitter and create more handoffs. All of these combine to make most pervasive WLAN deployments unusable for voice at all. The significant contention in such an environment will cause such a high packet loss that voice calls will be unintelligible.

Technology to Scale WLANs

Managing Contention

With the foresight that Wi-Fi will become the primary enterprise network connection in the years to come, the Meru WLAN System uses advanced techniques within the 802.11 protocol to *schedule* client access to the network. Patented Air Traffic Control technology makes channel access more deterministic to eliminate the contention problem that occurs when a high density of clients connected to a single access point compete with each other for channel access. In this way, throughput for the network stays high and consistent, even as many more than five simultaneous clients contend for the same channel.

Managing Interference

Interference from overlapping AP channels and co-channel interference raises the level of noise, which reduces performance of the network. Meru avoids this problem by managing the APs in the system with cellular-like coordination algorithms that account for co-channel interference and mitigate its affects. This cellular network architecture coordinates contention across cells as well eliminating hidden node issues. For an added level of quality, clients that require Quality of Service, such as a smart phone, are scheduled such that there is no interference when they are on the air, even from other clients in neighboring cells. This creates the ultimate high fidelity wireless network the radio spectrum can provide.

Delivering Upstream and Downstream Quality of Service

Latency sensitive applications, such as voice over Wi-Fi, require quality of service to work properly in even a lightly loaded network[4]. While IEEE is introducing 802.11e to solve some of the quality of service issues, this standard does not address several important areas. Meru uses 802.11e and builds upon it to provide a much more robust system. 802.11e delivers downstream Quality of Service performance but leaves the upstream transmission up to the clients. This means that client communications upstream to the Access Point are not managed and contention is even more likely in a dense environment because of the aggressive nature of 802.11e clients. Contention is

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[4] Network World "Clear Choice Test – Voice over WLAN", January 2005

destructive, especially to voice applications as even the dropping of a single packet every 200 seconds will result in clipping and lost speech. Meru's patented call flow intelligence determines which streams are voice applications and automatically manages quality of service in both directions.

In addition, 802.11e does not provide Quality of Service on a per application basis. This means that if a laptop is simultaneously running a soft phone for a voice over Wi-Fi call as well as checking email, the device receives the high priority assigned to it, not just the voice over Wi-Fi application. This situation worsens contention. Meru's Quality of Service capability is on a per-application basis, not per-device, so each application receives the correct QoS settings.

Last, 802.11e does not address the critical issue of handoff between APs. Handoff can take up to several seconds[5], which will destroy the quality of the voice call. Because Meru's WLAN infrastructure removes co-channel interference problems through coordination it can allow many APs to operate on the same channel in close proximity to each other. These APs on the same channel in close proximity transmit the same physical address to the client that to the client appears as one AP with extensive coverage. This operating mode is known as Virtual Cell – a coverage cell that, while comprised of many physical APs, appear to the client as one single, pervasive AP. By eliminating co-channel interference problems and creating a Virtual Cell, the Meru WLAN infrastructure takes over control of handoff and eliminates all client handoff so no handoff delay or re-authentication is needed as the client roams.

A New Approach Radically Changes the Playing Field

Now that the main challenges of contention, interference and Quality of Service have been addressed, new approaches can be made to deal with the scalability of a WLAN. Meru's WLAN technologies radically alter the bleak scenario described earlier when trying to use traditional WLAN architectures in a pervasive deployment. While still using the standard 802.11 protocols and providing full interoperability to any Wi-Fi certified client, Meru is changing the game when it comes to WLAN deployments.

Designing for Scalability with Meru Networks' WLAN System

With these technologies in place the Meru WLAN System takes WLANs out of the dark age of planning RF spectrum, deploying APs, and subsequently replanning RF spectrum and re-deploying APs in a continuous cycle and rings in the age of simple network device deployment – no RF issues to deal with or try to predict. Wireless network deployment has radically changed forever.

[5] Network World "Clear Choice Test – Voice over WLAN", January 2005

Single channel deployment – Virtual Cell

With the infrastructure managing RF problems, the number of channels and which channel to use where becomes a moot point. The only thing you need to know is the following:

1. What throughput do you require for your network?
2. Where do you want coverage?

The network is now free of co-channel interference issues so determination of throughput simply gives you the threshold of the distance between APs (as data rate decreases with distance from the AP). With the Meru WLAN System you can simply space APs every 60' to 80' in the areas where coverage is needed and receive full-rate[6], pervasive wireless access. With the APs on the same channel, the Meru WLAN System will create a Virtual Cell and the network will be ready for high fidelity, handoff free access.

Virtual Cell – The Industry's Most Scalable Wireless Network Really Is that Easy

The question often is asked "with all the access points operating on the same channel how can it possibly scale? Don't you get more capacity if you alternate channels and have a 'multi-channel' approach? Don't all the APs share the same capacity in a single channel configuration?" The answer is simple – yes, using multiple channels does provide more capacity. That is why Virtual Cells can be deployed simultaneously on multiple channels in the same area creating the most scalable multi-channel WLAN in the industry through overlaying blankets of capacity.

As discussed, legacy WLAN systems, which cannot handle co-channel interference or successfully operate APs on the same channel, require that APs are placed on alternating channels when deploying a pervasive WLAN. What this does is force a single area to only be served by a single channel at any one time. If there are only three possible channels the network is trading off 66% of its capacity in an attempt to avoid the co-channel interference problem. The inefficiency is even more dramatic when there are twelve available channels (802.11a).

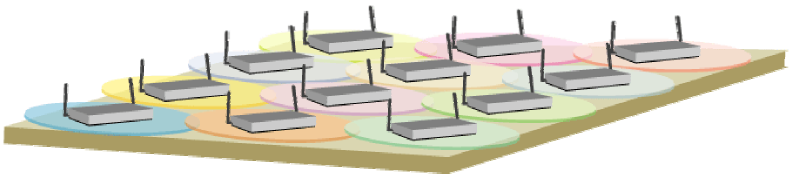

Figure 4: Traditional wireless LAN deployments are inefficient as access points must be spaced such that each area is only served by a single channel.

[6] 54Mbps for 802.11a and 802.11g; 11Mbps for 802.11b

Even more troubling with this approach is the complication of using software and other tools to try to "predict" interference and "avoid" it. Considering the radio frequency (RF) spectrum is an ever-changing environment, these prediction methodologies inevitably lead to continual exercises in re-planning and reconfiguring. This makes the cost of owning these networks to be very excessive over time[7].

With Meru's WLAN System, the capacity of a given area is maximized with the ability to overlay channels using Virtual Cells. A single channel can cover the entire coverage area while areas needing more capacity, a conference area or a crowded lecture hall for instance, can simply overlay additional channels. Naturally, the inherent capability of the network to deal with RF issues automatically removes this maintenance overhead cost from the equation. Adding capacity is accomplished without adding any complexity to the network.

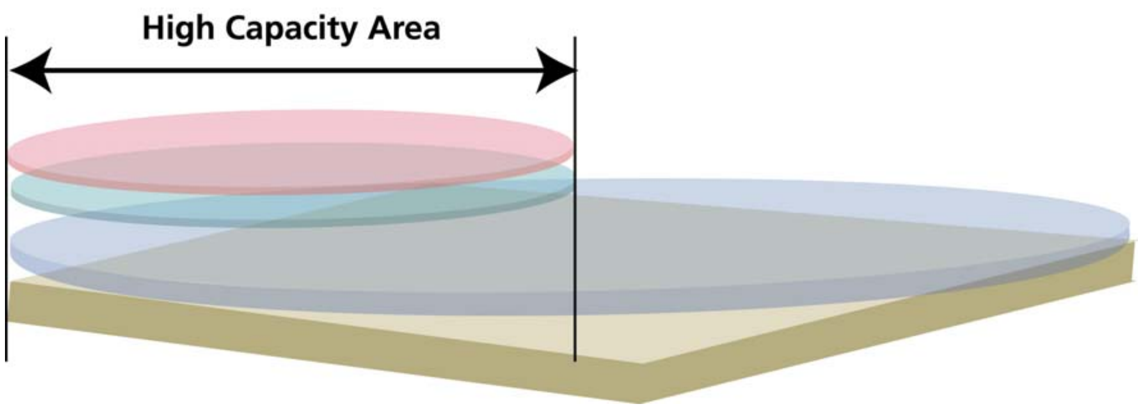

Figure 5: The Meru WLAN System increases capacity through allowing multiple blankets of coverage to be overlayed where necessary.

Scalability is accomplished with the Meru WLAN System in multiple ways. First, each controller has the ability to manage up to 150 access points. For deployments that require more than 150 access points, multiple Controllers work together to seamlessly scale the deployment to many hundreds, or even thousands of access points.

[7] Gartner estimates that 39% of the cost of owning a traditional wireless network is contained in operational costs defined as "Hourly costs for technical services, planning and process management, and service desks." - **Wireless LANs Have Higher TCO, But Can Raise Productivity, June 2004**

Summary

Traditional WLAN vendors universally recommend deploying APs on alternating channels in a reduced power output, or microcell, configuration. This is principally done to avoid co-channel interference while increasing the capacity of the network. When put to the task, yesterday's technology simply cannot produce the desired performance in a pervasive deployment. Meru's WLAN System takes into account co-channel interference and other network quality issues and was designed from the ground up to increase network capacity without increasing network *complexity* and thus delivers a solution that provides the ultimate in WLAN scalability while changing the economics of deploying and owning a pervasive WLAN.