A Blueprint for Multimedia-Grade Wi-Fi

Multimedia-Grade Working Group

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A new age of handheld mobile devices and multimedia applications is driving the need for a new Wi-Fi infrastructure. This emerging demand for mobile multimedia represents a whole new scale for consumption of wireless resources and capacity. The enormity of this issue led a number of cross-industry networking professionals to form a working group dedicated to defining documenting, and making recommendations to address the requirements for building and operating a "Multimedia-Grade" Wi-Fi infrastructure, whether in Greenfield environments or building on an existing network deployment.

This paper represents the collective experience of the working group for the first 60 days as they explore what it means to become Multimedia-Grade by scaling their own environments and sharing those experiences. Before launching into solutions, the group felt it important to first characterize their environments for each other. In particular, they wanted to share the "drivers" for enablement of mobile multimedia that existed or were emerging in their wireless LANs in order to gain a better perspective on the demands for capacity and resources. After laying this foundation the group began by defining then exploring the critical components of Multimedia-Grade Wi-Fi infrastructure:

- Wi-Fi Infrastructure Scaling
- Access Provisioning
- Network Integration
- Client Integration
- Management & Monitoring

The following is a summation of these five discussions resulting in recommendations relevant for anyone building or scaling up to a Multimedia-Grade Wi-Fi infrastructure.

Multimedia Drivers

The following represents the group's collective experience with the major factors that are driving their environments towards a Multimedia-Grade infrastructure.

Increase in the number and types of multimedia devices

The University of Washington presented one of the best collections of statistics depicting the drivers for a Multimedia-Grade network. Their experience was echoed by the group in terms of trends and scale and provides a good summary of the drivers experienced by everyone. In the spring 2010 the University of Washington documented roughly 78,000 unique devices connecting to their Wi-Fi network. Of those 78,000 47% were Windows, 25% were Mac OS, 24% were IOS (iPhone & iPad) and 2% were Android. Of that mix, they saw their most rapid growth from handheld devices such as iPad, iPhone and Android devices. Together these accounted for over 18,000 unique devices. For the last four and a half years, they've experienced steady growth on wireless with the number of devices and usage roughly doubling every 18 months. These stats are updated regularly at: http://www.freshlymobile.com/ Another recent study by the Educause Center for Applied Research shows that 89% of students own a laptop and 48.8% own a handheld device such as a smartphone or tablet from which they access the Internet: http://www.educause.edu/ecar/.

It's interesting to note that everyone in the working group is beginning to see many users bring two to three multimedia Wi-Fi devices. Typically this includes at least one converged device (iPhone, Droid, iPod, iPad, etc.) and a laptop. In addition, and especially in college campuses, many bring Vonage and/or a Netgear or Linksys Skype phone, plus X-Box, Wii and PS3 network-ready gaming consoles for networked, multi-player gaming. Some environments are supporting specialized mobile VoIP appliances such as Vocera and Wi-Fi enabled video cameras like Axis for targeted applications. It should also be noted that these devices range in capability and intelligence. This can play a factor in their ability to actively participate in various authentication and quality of service (QOS) schema. Less intelligent devices may require different methodologies that require little or no participation on their part, thus placing more requirements on the wireless infrastructure. For an ever-expanding list of wireless, multimedia devices, refer to the "Devices" page on the working group's website: http://www.multimediagrade.com/.

Moves towards video, voice, and other real time applications

Multimedia services such as Microsoft OCS, GoogleVoice, iChat, Facetime, Netflix, Hulu, AppleTV, Skype, and others are increasingly common on the group's networks. In the education environment, applications such as Blackboard, MS OneNote, DYKnow have expanded their multimedia capability for teaching and learning. Standard media servers from Microsoft and Apple are being used in ever increasing numbers to distribute local and reference (library) multimedia content. The use of podcasting and streaming has also skyrocketed. With the emergence of the mobile, converged, multimedia devices previously described, increased use of multimedia inside as well as outside of the classroom has become commonplace. Due to the pervasiveness of wireless in some environments, the smart classroom has now become virtualized allowing its capabilities to be delivered anywhere as long as the wireless infrastructure is Multimedia-Grade. Enterprise working group members cited similar experience for the workplace. Video and audio are used extensively in meetings but are no longer relegated to the conference room. Meetings can be virtual as well allowing participants geographic freedom of choice. In addition, and perhaps most critically, Unified Communications (UC) applications are becoming more prevalent.

Used mostly for entertainment, Netflix and Hulu are prime examples of how personal multimedia communications are invading the enterprise and education environments, consuming their precious resources. In fact, it's becoming increasingly difficult for IT departments to separate users' personal from sanctioned usage as the wireless devices, applications and services used are common to both worlds. However, many in the group believe this presents an opportunity. Using this traffic to test various monitoring and management techniques helps members scale and harden their Wi-Fi infrastructures to ensure they will be ready to support their business and learning goals as they grow to become Multimedia-Grade.

Many noted increased usage of Voice over Wi-Fi (VoWiFi) and accelerated convergence of cellular with VoWiFi due to poor cellular coverage within the enterprise or campus. This is especially true as enterprises adopt UC and as SIP-based applications become available for Apple iOS and Google Android. Overlaying cellular and Wi-Fi infrastructures means replicating coverage, which is an expensive capital and operational proposition. This represents a divergence from the economic advantages of network convergence, not to mention diluting value potential of converged data. Leveraging VoWi-Fi requires a single, converged infrastructure. It is evident that the carriers understand this. The rate at which they can build-out new infrastructure is about half that needed to meet the demand. Therefore, they must seek available, cost effective alternatives. That means establishing cooperative relationships with the enterprise or campus to leverage their converged infrastructure. As such, group members debated the reality of VoWi-Fi emerging as the sole voice solution within their environments. Carriers like T-Mobile are already poised to enable this option.

Many experienced increased deployments and usage in IPTV and other locally-generated video streaming. The aging cable TV infrastructure and the resources required to maintain separate networks, viewed in context of the demand to propagate locally generated content, has many considering replacing their cable systems with some variant of IPTV.

Digital signage is receiving more play as well. Once conceived as a static medium to replace paper bulletin boards, there is a move towards streaming multimedia news channels and other locally generated video clips along with their static information components.

Multimedia's Network Load

To more fully characterize the impact of the above devices and their associated applications/services, a brief look at the potential load they place on the wireless infrastructure is warranted. Audio services, be they telephony or other types of audio, need per-session bandwisth in the range of 50Kbps up to 700Kbps depending upon the desired fidelity and compression selected. Typically, a VoIP call consumes roughly 100 Kbps full duplex. While not much capacity is consumed per session, the biggest concern with VoIP is insuring the *minimum latency*. For voice calls, this is 20mS. If the latency is not kept within minimums, the audio will become choppy or possibly unrecognizable. Voice quality is typically measured with a Mean Opinion Score (MOS), which provides the perceived quality. The MOS ranking is the following

Mean opinion score (MOS)		
MOS	**Quality**	**Impairment**
5	Excellent	Imperceptible
4	Good	Perceptible but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

Video is a more complicated beast in that the capacity requirements can be more wide ranging than audio, but with latency still a critical factor. Video is almost always accompanied by audio component and optionally other latency sensitive synchronization components required for gaming or animation. The following charts provide a guide to video's potential offered load:

Video format	Picture format	Application	Approximate bit -rate for different codecs		
			Motion - JPEG	MPEG - 4 Part 2	H.264
_ CIF	176 x 120i, 30fps (NTSC)	Lower -quality NTSC/PAL analog for surveillance video	260 kbps	85 kbps	50 kbps
CIF	352 x 240i 30fps (NTSC)	Full -quality NTSC/PAL analog TV signal	520 kbps	170 kbps	110 kbps
Low - rate digital video	176x144,10 - 15 fps	Internet video on smartphone screens		100 - 200 kbps	50 - 100 kbps
SD - TV	480i	'talking head' low - motion, digital TV e.g. video conferencing		1 - 2 Mbps	700 - 900 Mbps
DVD - TV	480i; 640x480, 24p fps	movie -quality digital TV (480i)		2 - 4 Mbps	1.5 - 2 Mbps
HD - TV	720p, 1080i; 1920x1080, 24p fps	e.g. Blu - ray signals with full motion (720p,1080i)		12 - 20 Mbps	5 - 10 Mbps

Service	Bandwidth (H.264 codec)	One-way or bidirectional over the WLAN	End-to-end delay tolerance (including network and codec)	Number of channels (unique signals) available	Simultaneous viewers per channel per access point
Cable TV	1 – 4 Mbps (SD) 6 – 10 Mbps (HD)	One-way, downlink only	Channel changing affected after 300 msec	20 - 200	Occasionally
Live event video streaming	1 – 4 Mbps (SD)	One-way, downlink only	300 msec target	1	Yes!
Surveillance video	500 kbps – 2 Mbps	One-way, uplink or downlink	500 msec target	1 – 50 cameras	Seldom
Interactive video conferencing	1 -2 Mbps (SD for room-scale)	Two-way	150 - 200 msec	Typically 1 – 5 groups	No
On-demand video	1 – 4 Mbps (SD) 6 – 10 Mbps (HD)	One-way, downlink only	300 msec target	Hundreds	No

Changes in user expectations for Wi-Fi networks

Many of our Wi-Fi networks began as networks of convenience. They were intended to supplement wired connectivity. Now we are seeing a general move for Wi-Fi to replace wired networks for many types of users. This fundamental change in use brings a fundamental change in expectations. Networks must now offer not only secure access, but must also be able to support multimedia applications, the type and number of which continue to grow. They must also be highly-available, which requires not only redundancy but advanced functions like integrated spectrum analysis and adaptive RF for steering around sources of interference.

Other drivers

While not multimedia, more services are moving to IP as a transport and can ultimately impact the performance of latency-sensitive multimedia applications. Examples include physical security systems (door locks, video surveillance), vending machines, parking enforcement devices, HVAC and other sensor-based systems. The cost and convenience of convergence on Wi-Fi is creating a preference over wired access for these services, thus steadily increasing the offered load. With the openness of Wi-Fi in most environments and the lack of tools employed to effectively characterize traffic, many didn't initially realize this was happening. All agreed this increase in baseline traffic must be characterized and taken into consideration when deploying a Multimedia-Grade environment.

Defining Multimedia-Grade

The following recommendations represent the group's collective experiences scaling their Wi-Fi infrastructures to meet the demands of mobile multimedia.

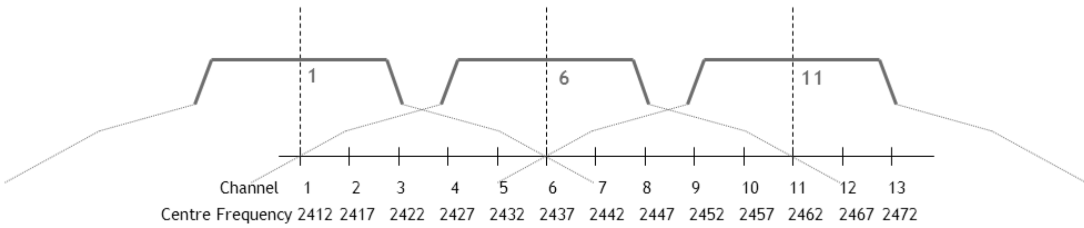
Scaling Capacity

For the most part, a Wi-Fi infrastructure's scale is defined by the number of AP's deployed and the number of clients each serves. When scaling the infrastructure, several factors must be considered. These include:

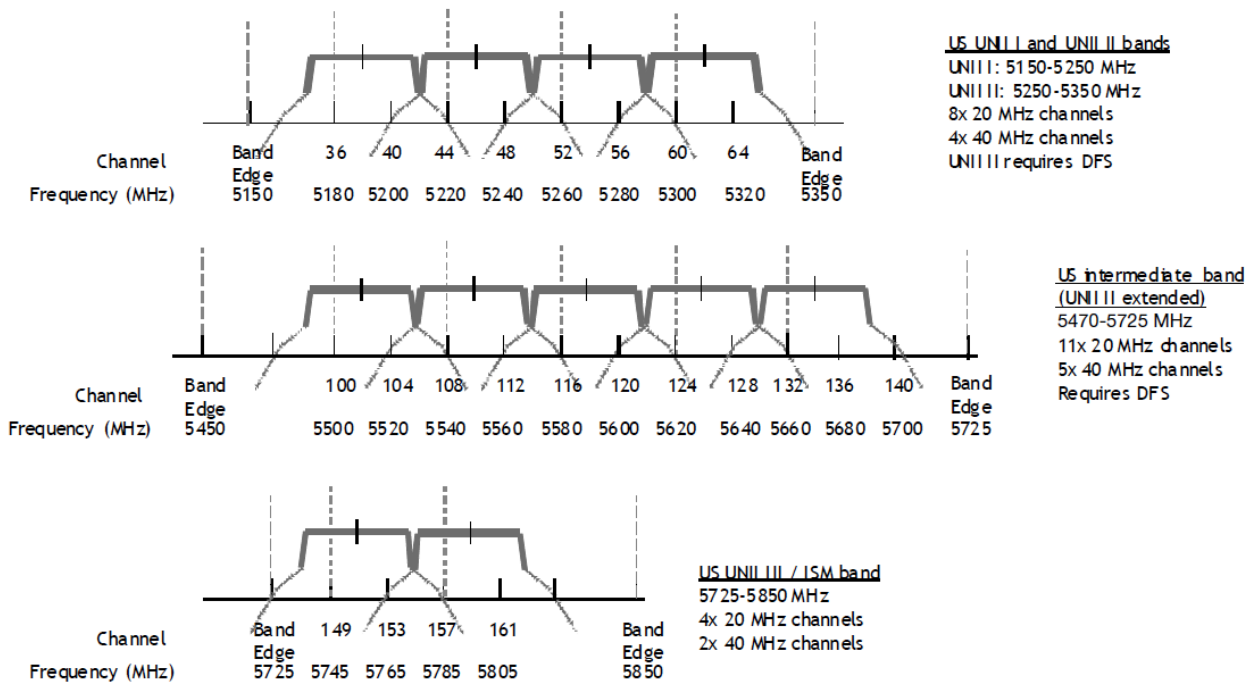
- Available RF spectrum (2.4GHz/5GHz)
- AP capacity
- AP placement and orthogonal frequency (channel) management
- AP & client power management
- AP load balancing & band steering
- Airtime fairness and load balancing
- Multicast and its optimization
- High Density environments

Each of these factors will be examined in turn.

Available RF spectrum: Until white space or other frequency allocations are available, there are currently two frequency bands available for Wi-Fi deployments; 2.4GHZ and 5GHz. Within the 2.4GHz segment, eleven 20MHz channels have been allocated. As these channels overlap RF spectrum, only three channels out of these 11 are available for use. In some cases where AP placement and signal propagation can be tightly controlled, a fourth channel can be deployed but this is not often the case. With only three orthogonal channels available, capacity is limited. Thus while possible, 2.4GHz is not the best choice for a Multimedia-Grade environment. At 5GHz, there are twenty 20MHz channels non-overlapping channels. The increase in spectrum over 2.4GHz results in much greater available capacity making 5GHz a better choice for propagating multimedia.



Channels defined for 5 GHz band (US regulations), showing common 20 MHz channel plan and 40 MHz options



AP Capacity: Today's enterprise-grade APs and controllers are capable of delivering non-blocking performance at maximum channel rates even with full encryption and user/network policy management active. The main concern is having control over, or at least being aware of, how that bandwidth is being allocated. For example, multicast rates, traffic identification/priority policy and QoS policy all have an impact on how bandwidth is consumed. Make sure to select a system that gives you maximum flexibility when managing available Wi-Fi bandwidth. Some APs have multi-radio capability extending their capacity across other spectrum from the same physical footprint. This allows legacy 2.4GHz traffic to be accommodated concurrently with 5GHZ traffic allowing greater flexibility in steering clients to the appropriate bandwidth or services without adding additional APs.

AP placement and orthogonal frequency management: As noted earlier, the primary way to increase capacity in a Wi-Fi infrastructure is to add or upgrade APs. AP frequencies and power levels must be set such that interference to and from adjacent APs is minimized. This is achieved through maximum use of orthogonal channels as well as strategic placement of APs with respect to one another. At some point, all available channels will be utilized and must be re-used. This places more stringent requirements on AP placement and power management so that co-channel interference is minimized. It has been observed that the RF environment into which the infrastructure is deployed can be dynamic, with one set of channels being clear today but riddled with noise or competing services tomorrow.

Achieving the required capacity to become Multimedia-Grade means scaling of the number of APs. Empirically determining the optimal AP placement coupled with manual, dynamic management of AP channels and power levels is impossible. These capabilities must be an automated part of the planning and operation features of the Wi-Fi infrastructure.

AP & client power management: AP power management was briefly discussed above, with regard to its ability to help manage adjacent channel and co-channel interference. Whenever noise or even valid, but unwanted Wi-Fi frames are detected in a channel (such as a client associated with another AP whose frames are being heard on an adjacent AP), this forces detection mechanisms within the protocol to determine what's happening. These mechanisms delay the channel's availability for valid traffic, thus reducing its capacity. Therefore, in multimedia environments, it's especially important to insure that reception of noise or adjacent AP/client transmissions are minimized or eliminated. RF power management can add significantly to AP placement and orthogonal channel selection strategies in reducing adjacent channel or co-channel interference. In developing a Multimedia-Grade network, it is key to select a system that includes AP power management.

Unfortunately, the state of the art in client power management is woefully lacking. Client power is manually set, often to maximum. In cases where the client is close enough, its high power can cause either adjacent channel or co-channel interference. At the moment there is little that can be done to automatically correct this problem. It requires the ability to monitor the spectrum for offending clients, track them down and manually adjust their power. There are emerging mechanisms currently being defined in 802.11k and 802.11v that allow cooperative control between the AP and the client. This direct, positive control will allow the AP to send the client an appropriate power level for it to set, much like what happens for cell phones today.

AP load-balancing & band-steering: Once multiple APs have been deployed to increase capacity in a given area, a mechanism is needed for clients to effectively and fairly access that capacity. As discussed in the previous section on client power management, emerging 802.11 standards for cooperative control will eventually solve this problem. Ideally, it would be advantageous to steer between available bands and their channels on a per-session basis. Beyond simple load balancing, this would allow policies to be established based on client roles or application requirements guiding clients to APs with not only the required bandwidth but also the desired services.

In the mean-time we must rely on the Wi-Fi infrastructure to leverage mechanisms in the protocol to "nudge" clients from AP to AP in order to load balance traffic within the coverage area. Nudge is the operative word as the client ultimately makes the final decision on where to associate. While nudging is quite effective, it is not 100% and may result in sub-optimal load balancing in some cases.

Airtime Fairness: As organizations increasingly support a "bring your own device" environment, it becomes more important to have the infrastructure manage access to airtime, so that older devices don't jeopardize the wireless resource and starve newer high throughput clients. Airtime fairness techniques dynamically manage the per-client airtime allocation looking at traffic type, client activity, and traffic volume before allocating airtime. This ensures that all clients have acceptable performance for multimedia applications. This is especially true in high density environments.

High Density environments: Enterprise and campus environments commonly serve high density client environments areas such as auditoriums and lecture halls. There is increasing interest in outdoor environments such as stadiums as well. Given their minimum population densities of 300+ in areas as little 5,000 square feet, these venues demand special consideration. With such great numbers of clients in such a small area, the maximum number of orthogonal channels available must be deployed within the geography and channel reuse is highly likely. This dictates the 5GHz band to be the only viable option for high density. In addition, it demands close attention be paid to AP and client power levels and may require manual intervention to tune them for optimum levels. With channel reuse likely, power control is key even with client devices wherever possible. Special antennas will most likely be required as well to control signal propagation using directivity and polarization so APs deployed in these areas must support external antenna connections.

With all channels in use, and assuming the venue's close proximity to other APs in the enterprise or campus, client contention for limited Wi-Fi resources is unavoidable. This will likely degrade capacity and performance to some degree no matter what is done to prevent it. If multimedia content is common amongst users, multicast may provide an advantage even at slower rates. Due to frequent turnover within these venues, special consideration must be given to managing client address space. Managing short lease times coupled with an adequate pool of addresses is necessary to avoid address exhaustion.

Enabling Mobility

First and foremost, enabling mobility means deploying a ubiquitous Wi-Fi infrastructure; in many cases, even outdoors. With converged clients such as the iPhone, Blackberry and Android derivatives, an acceptable user experience is achieved only if the client is allowed to roam. This requires network ubiquity.

While not supported by some clients, standards based techniques such as Opportunistic Key Caching and PMK-Caching should be used wherever possible in the infrastructure to promote faster roaming among APs. Active initiatives in the Wi-Fi Alliance such as IEEE 802.11k and 802.11r seek to standardize these capabilities.

Mobile address management is key as well, requiring mechanisms to preserve or re-establish connectivity while maintaining sessions. Emerging “fast roaming” technology should be explored for voice environments to preserve call quality and continuity.

Application Assurance

The Multimedia-Grade Network is all about the user experience. To effectively manage and preserve network resources, the Wi-Fi infrastructure must establish certain service level agreements to propagate that experience as it was intended. The following are important agreements to be established in any Multimedia-Grade infrastructure.

Quality of service: A Multimedia-Grade Wi-Fi infrastructure must support QoS from end to end. On the Wi-Fi side, adherence to 802.11e is required. QoS should then be mapped appropriately and seamlessly from Wi-Fi to the edge and through the core. In situations where devices cannot conform to 802.11e, the Wi-Fi system should provide additional mechanisms for identifying then mapping traffic to other mechanisms in the system that will deliver or assist in providing the required level of service. For example, segregating video traffic by mapping it to a specific set of SSIDs, which are then mapped to appropriate VLANs in the edge and the core, allow devices that associate with that SSID to use those services at the required level of QoS. Preferably, the Wi-Fi system would support traffic segregation on a per-session basis. This is a better option for converged multimedia communications and a more granular approach to managing bandwidth and policy. The ability to identify and manage multiple streams from one device or even one application without the need for separate VLANs is even better.

SSIDs and application performance: Another negative effect that comes from adding an SSID for every device type or application is reduced air quality. Every new SSID adds management traffic to the air and negatively impacts application performance. It is critical to reduce SSIDs and use other means to prioritize traffic and segment users.

Access provisioning: To preserve security policy and effectively manage bandwidth, all multimedia devices must be authenticated at the Wi-Fi edge using Wi-Fi system authentication mechanisms and/or integrating with global network authentication services (Radius/ACS/ using 802.1x, etc.). However, some multimedia devices encountered are simple appliances, unlike the more intelligent iPad and iPhone class of devices. Examples include voice intercoms (Vocera), surveillance cameras (Axis), Wi-Fi-enabled set top boxes

(Roku) and Net TV's (Apple TV/Samsung). Wi-Fi systems must provide flexible authentication mechanisms ranging from simple MAC address recognition to matching with device type, traffic type, SSID and location data all the way up full 802.1x compliance.

High availability: Users expectations for Wi-Fi have changed over the course of time - from its acceptance as a best-effort overlay service to its current status as a business-critical necessity. A Multimedia-Grade Wi-Fi infrastructure must provide extremely high availability, with mechanisms for redundancy at both the AP and controller levels. Infrastructure power must be fully redundant as well.

To achieve high availability in a Wi-Fi network, it has become critical that organizations implement infrastructure based spectrum analysis so that the network will automatically steer around sources of electromagnetic interference, be that Wi-Fi based interference or non-Wi-Fi based interference. Tracking down noise and other RF sources is key to maximizing available channel bandwidth in a Multimedia-Grade infrastructure. Having these tools deployed within the infrastructure is preferable as they allow constant monitoring and mitigation as the RF environment changes from day to day or even minute to minute

Optimizing multicast for application performance: In the quest to preserve precious wireless bandwidth, multicast can be quite effective, given the right content paradigm. Anytime video content is broadcast live, as opposed to on-demand, multicast can potentially save bandwidth. For example, if I were to stream CNN live, I could deliver standard (not HD) If one channel of standard broadcast quality video (not HD) were streamed using MPEG-2, it would consume 2Mbps of bandwidth. If 50 people associated with an AP and 20 of them chose to watch CNN, a unicast delivery scenario would mean each user would receive their own copy of the broadcast. That's 20 users requiring 2Mbps each or 40Mbps of wireless bandwidth being steadily consumed. If running 802.11n, the load could be accommodated but at the expense of available bandwidth for other users. Running 802.11b/g/a means the AP is dead in the water without off-loading that traffic to other APs. In a multicast scenario, the content is streamed only once and every user accesses that same stream. Thus only 2Mbps is consumed leaving plenty of bandwidth remaining for other uses.

However, multicast suffers from one key disadvantage. Its traffic is not acknowledged. Clients cannot indicate to the transmitter that they missed a packet and because there is no retransmission mechanism, any errors due to lost packets cannot be corrected. Multicast over Wi-Fi compounds this difficulty. Wireless frames are subject to loss and corruption over the air. These factors are addressed in a unicast connection using 802.11 protocol features such as acknowledgements, retransmission and rate adaptation. But with 802.11 multicast, there is no acknowledgement or adaptation, and therefore some level of frame loss is inevitable. The error rate can be reduced by adjusting the modulation rate, given a constant over-the-air signal to noise ratio (SNR). For instance, if the rate is reduced from 48 Mbps to 24 Mbps, the error rate will be improved, provided that the noise level does not change. Because of the lack of acknowledgements, 802.11 multicast traffic is usually transmitted at a much lower rate than would be used for unicast traffic. This takes more time on the air, consuming more of the network's data capacity, but provides a margin of safety in case RF conditions deteriorate.

An additional challenge with multicast over Wi-Fi is that the modulation rate is set for the worst-case among the client population; normally the client most distant from the access point. For example, if four clients on an access point subscribe to a multicast group, and they would connect with unicast traffic at 36, 36, 24, and 18 Mbps, then the multicast stream must be transmitted at a maximum of 18 Mbps. As noted above, a safer figure would be 12 or 9 Mbps giving a better SNR to improve error rates and thus throughput.

Experience has shown that while multicast can conserve bandwidth, the reality of Wi-Fi is it may take some away due to increased errors rates. To effectively propagate the content, the modulation rate must be lowered at the expense of network capacity. A Multimedia-Grade Wi-Fi infrastructure must be flexible and accommodating, allowing selection of the best methodology for multimedia propagation in a given environment. The following are the key multicast optimization techniques for supporting multimedia in an Enterprise or campus environment:

- The infrastructure should automatically adapt by keeping track of the transmit rates sustainable for each associated client and using the highest possible common rate for multicast transmissions.
- Wireless needs to support IGMP snooping and IGMP proxy, ideally at the central controller, so that it can identify which APs and clients need particular transmissions, blocking all others. This adds significant efficiency to the overall network.
- The network should automatically select the best transmission mechanism based on real-time network and video usage information. When multicast is transmitted as unicast over the air, it can be transmitted at much higher speeds and has an acknowledgement mechanism to ensure reliability. The network should make this conversion when appropriate and then automatically switch back to multicast when the client count increases high enough that the efficiency of unicast is lost.

Integration: Transitioning to Multimedia-Grade

Edge

Edge enhancements required for upgrading to Multimedia-Grade Networks include increased AP termination bandwidth and network ubiquity. Multimedia-Grade APs will require a Gigabit Ethernet connection at the edge to accommodate 802.11n and even higher bandwidth APs in the future.

Achieving network ubiquity means deploying Wi-Fi in every location into which a user may roam. To that end, wired switch ports should support power over Ethernet (POE) to provide AP power as AP location and density in a Multimedia-Grade deployment don't often match available sources of power. In certain circumstances, obtaining a wired connection for AP termination is problematic. The Wi-Fi system should provide a mesh option serving remote areas while maintaining all Multimedia-Grade capabilities of a wire terminated AP. Last, the Wi-Fi system should include outdoor hardened components allowing outdoor areas to be covered to complete a ubiquitous deployment.

Core

The main transition issue for Multimedia-Grade infrastructure is successfully propagating its traffic to and from the network core. Edge and core routers must insure they contain sufficient capacity for the offered load. VLANs must be pooled and mapped correctly to match those within the core. The seamless end-to-end propagation of QoS from the Wi-Fi client through the edge to the core then on to its destination and back is critical.

Enterprise/Campus infrastructure

Much of the required Multimedia-Grade support is similar to that required of most Wi-Fi infrastructure today; DHCP services to match the venues served (noting special considerations for high density environments as previously discussed) plus integration with authentication services (Radius/ACS/ using 802.1x, etc.).

Management & Monitoring

To date, the working group has not had the chance to fully consider or characterize available tools and methodologies for management and monitoring as it relates specifically to multimedia. However, the following experience is offered summarized from various informal conversations.

Spectrum analysis

Tracking down noise and other RF sources is key to maximizing available channel bandwidth in a Multimedia-Grade infrastructure. Spectrum analysis tools specific to Wi-Fi are needed to identify both RF sources as well as Wi-Fi sources so offending radiators can be identified, tracked and automatically mitigated.

Packet Capture

Packet capture is an absolute must for operating any Wi-Fi infrastructure. The Wi-Fi system should include a remote packet capture function as part of the AP or its associated controller in order to quickly and more comprehensively evaluate multimedia communications.

Session Visibility

Session visibility is extremely important to managing and delivering the required quality of service and record detail for session billing and statistics reporting. The prevalent tools for session visibility are focused on VoIP today. However, providing session visibility is desired for all multimedia communications for similar reasons. Preferably, this functionality should be provided as part of the Wi-Fi system.

Reporting

Being able to identify, track, summarize then report on mobile multimedia devices and their associated applications using Wi-Fi will greatly assist with understanding and managing multimedia trends within your Wi-Fi infrastructure. Much of today's reporting is captured via browser-based authentication but tools should preferably be able to track and identify all Wi-Fi traffic consuming bandwidth. Device types should be tracked and time stamped along with their traffic types, bandwidth consumption and optionally (per privacy policy) locations of consumption.

Next Steps

It is clear that devices like the iPad, iPhone, Blackberry and Android derivatives are re-defining mobile communications, making access to multimedia content highly available. Due to their rapid acceptance, it is also becoming clear that mobile communications will dominate with many users demanding it be their primary mode of access. This means mobile communications infrastructure must be ubiquitous, highly available and scale to the demands required of multimedia propagation.

This document represents a first step by this working group towards defining the challenges of becoming Multimedia-Grade and providing initial recommendations for scaling existing Wi-Fi infrastructure to provide effective multimedia propagation. The following activities have been identified as other possible next steps for furthering the goals of the working group.:

- Develop a detailed Multimedia-Grade reference design
- Develop Multimedia-Grade requirements and recommendations for client and infrastructure vendors to improve and insure multimedia communications by their products
- Develop a living knowledgebase for Wi-Fi issues and recommendations specific to propagating multimedia
- Develop and support a public forum for Multimedia-Grade questions/comments
- Develop a test suite specifically to certify Multimedia-Grade Wi-Fi infrastructure
- Develop a test suite specifically to certify Multimedia-Grade Wi-Fi clients
- Establish a Multimedia-Grade test laboratory for certification, interoperability testing and problem resolution

The Multimedia-Grade Working Group remains committed to improving the availability and quality of information specific to the effective propagation of multimedia content over Wi-Fi as well as exploring and documenting the state of the art in Multimedia-Grade infrastructure design.