

Education



**Interactive Learning 2.0:  
How Wi-Fi Enhances Learning and  
Improves Student/Teacher Interaction**

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## Table of Contents

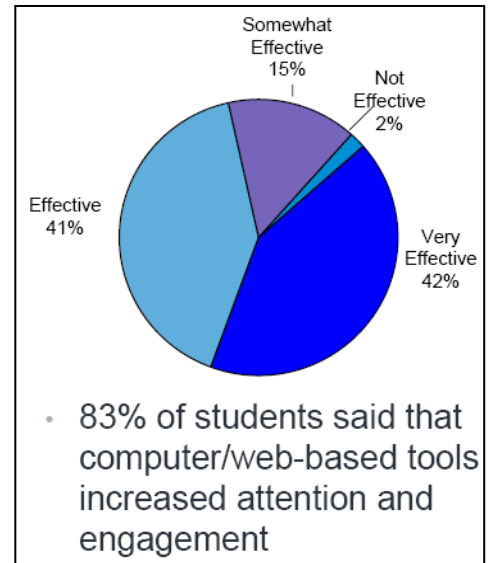
### **Interactive Learning 2.0: *How Wi-Fi Enhances Learning and Improves Student/Teacher Interaction***

Overview: The Case For Interactive Learning .....	2
Infrastructure Challenges .....	3
Applying Advanced Wireless Capabilities .....	5
Summary .....	6

## Overview: The Case For Interactive Learning

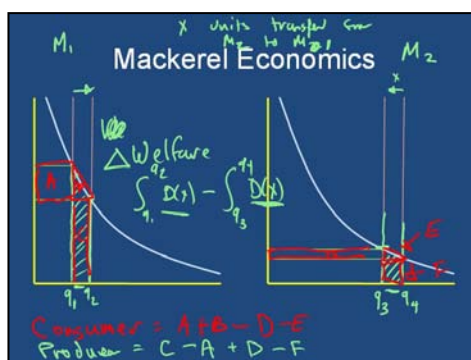
Over the years studies have shown that when students are actively, or more succinctly, "interactively," involved in a lecture, classroom discussion or self study, their learning and retention increases by as much as 20%. Since its inception, IT technology has been viewed as a tool that can foster student involvement. A recent study at the University of Pennsylvania showed that attention and engagement is dramatically affected when technology is used to enhance curriculum.

Multi-media is an effective teaching tool because it addresses both aural and visual learners. For this reason educators have added interactive multi-media tools to their armamentarium in hopes of better engaging students by seeking their feedback and thereby increasing their retention of the material presented. Interactive multi-media has been effected primarily through the use of a "smart classroom," a traditional lecture hall retrofitted with multi-media presentation tools (large screen TV's, theater style sound systems, multi-media computer systems, etc.) coupled with a hard-wired feedback system.

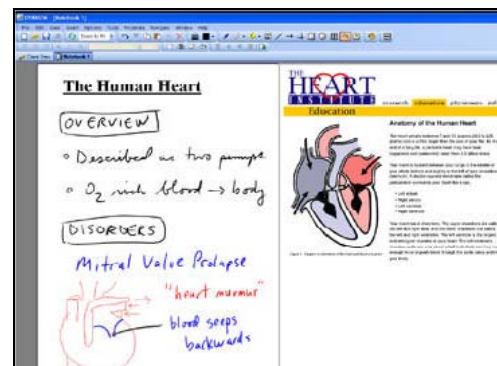


While quite effective, smart classrooms have had limited deployment due to their high cost and need for specialized physical spaces. However, as the adoption of Wi-Fi enabled laptops proliferates and schools rollout ubiquitous Wi-Fi coverage, the virtual smart classroom is fast becoming a reality. With suitable laptop and server software, smart classroom functions - including interactivity at almost any level of complexity – can be readily emulated anywhere without dedicated facilities or expensive, specialized systems.

The range of applications span from digital ink solutions from DyKnow and Classroom Presenter, to interactive whiteboards from LectureScribe and Microsoft OneNote, to Computer Based Testing (CBT) from companies such as Examssoft. These applications provide comprehensive authoring, collaboration and student/teacher communication tools encompassing both real-time classroom lecture/collaboration as well as anytime communications and interaction.



Classroom Presenter

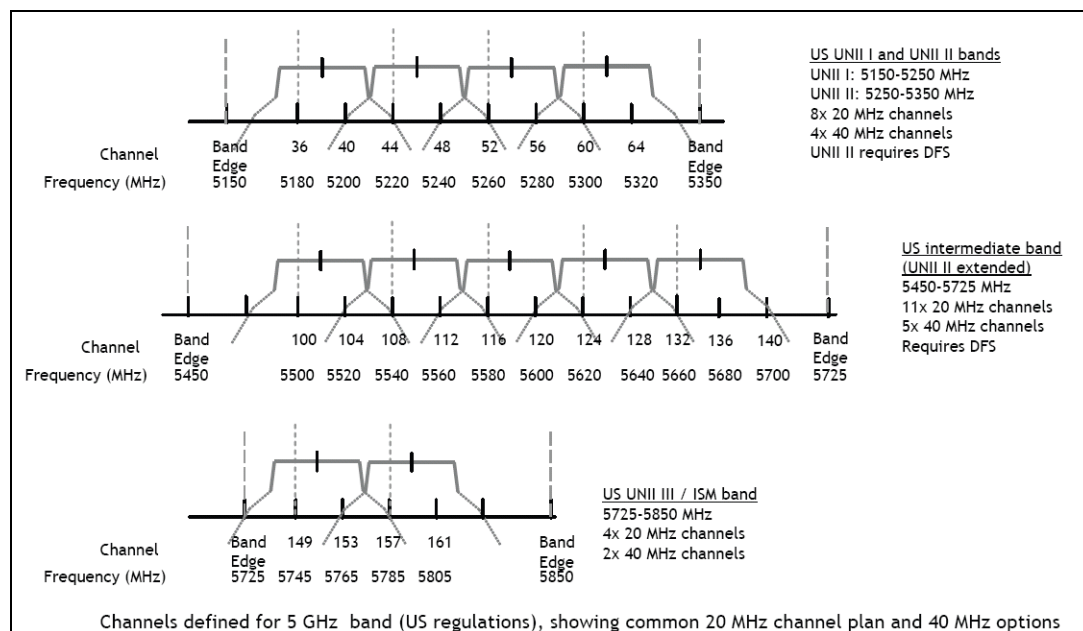


Dyknow Vision

## Infrastructure Challenges

Robust, high-performance wireless LAN infrastructure is needed to create an engaging interactive learning environment in a virtual smart classroom. This infrastructure needs to provide ubiquitous wireless coverage throughout the area in which a virtual smart classroom might be in session. This coverage needs to offer sufficient bandwidth to reliably deliver the intended data, voice, and video applications to all students, simultaneously, even in densely populated classrooms and lecture halls. Additionally, and with an eye towards privacy for students and teachers alike, the network needs to control network access and secure transmitted data.

Achieving these objectives requires both capable Wi-Fi infrastructure equipment and proper network design. Providing reliable Wi-Fi access in typical school environments is no mean feat. Radio is an open medium that must be shared and is susceptible to time and location varying interference. The 802.11b/g standard provides three or four useable 20MHz channels for signal transmission, whereas 802.11a and 802.11n offer twenty-three 20MHz channels - eleven if one uses higher capacity 40MHz 802.11n channels (channel availability varies by region). The chart below presents the available channels in the 5GHz band.



Sophisticated Wi-Fi infrastructure automatically adjusts Wi-Fi access point channels and transmit power levels to optimize performance dynamically in any given setting, for any given level and type of interference, and in the event of an AP failure. Automatic optimization reduces IT overhead and ensures that the network always performs at maximum capability.

Extending wireless coverage across a quadrangle or across campus may appear difficult due to the lack of LAN cabling. This situation is easily addressed with mesh technology, which conveys data by hopping wirelessly from access point to access point. The most economical mesh technology is one that can be downloaded into any access point, repurposing it without requiring a new stock keeping unit to inventory. Used in this manner mesh is a tool that can be used as and where needed without impacting network management or maintenance.

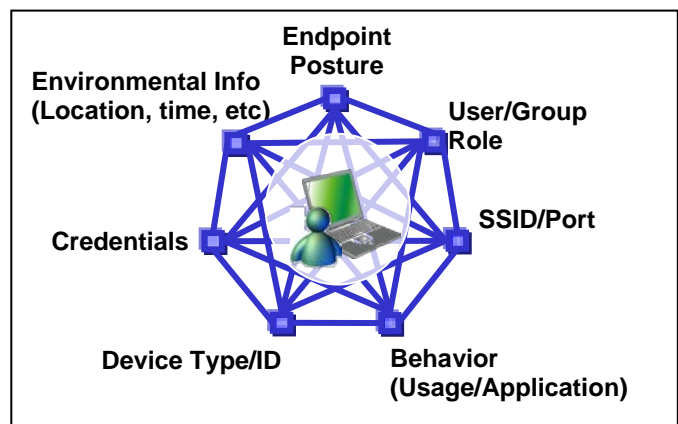
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If local power is an issue, access points can be powered over Ethernet using standard Power-over-Ethernet technology, or from a battery pack equipped with a solar charger. Used in conjunction with mesh technology, the latter solution offers a completely wire-free wireless network.

Another challenge is security, both in terms of access to the network and the privacy of the contents. Only authorized users should have access to the wireless network, to prevent unauthorized access to applications and servers, the disruption of legitimate users, and degradation of network performance. The applications used in smart classrooms and other interactive learning environments are typically licensed only to authorized users, and reasonable care must be taken to enforce this condition of use. Unauthorized traffic will consume bandwidth, sometime purposefully, degrading application performance and interfering with the work of legitimate network users.

A robust Network Access Control architecture should be considered to ensure that only legitimate users are granted access based on a multidimensional view of user identity. That is, access rights should take into consideration multiple parameters (as depicted in the diagram below) and be enforced by a stateful firewall.

Finally, personal information, grades, confidential faculty communications, and related sensitive information sent over the wireless LAN need to be protected from prying eyes. High security encryption using industry-standard algorithms offers the best defense of confidential information, and should be integral to any school network.



Multimedia content can be an important factor in smart classrooms and interactive learning, and the network needs to be designed to accommodate the high bandwidth, large files, and large number of simultaneous users typical of a multimedia environment. Intuitively, adding access points might seem the best way to increase bandwidth, however, the picture isn't quite so simple. There is no assurance that the network activity will be evenly spread across all of the access points, or make best use of available Wi-Fi channels, regardless of how many devices are installed. It is therefore important that the wireless LAN include a dynamic load-balancing capability to ensure even distribution of network activity without overloading any particular access point. Likewise, to enhance reliability against single channel interference – a common issue, especially when nearby home are within range of the school - and take best advantage of the spectrum made available by the FCC, channel management is an essential feature of a sophisticated wireless LAN.

High density lecture halls present a unique challenge with respect to interference. A smart classroom with 300 to 400 users in a single 50' X 100' lecture hall requires application awareness to condition the network to correctly allocate bandwidth, and airtime fairness and

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load-balancing to ensure a good user experience in the presence of both low speed 802.11b and high speed 802.11n clients.

Besides Wi-Fi considerations, any heavily populated smart classroom environment will need to take into consideration the capacity of the servers required to support large numbers of simultaneous users. Network address management can also be problematic. Most lectures run 60 to 90 minutes before a new cadre of students arrive. DHCP servers must be capable of delivering the required number of addresses and subnets to adequately serve each class, and then reclaim those addresses for use by the next group of students.

## Applying Advanced Wireless Capabilities

Thanks to the pioneering efforts of wireless LAN vendors, the challenges described above can be mitigated. Adaptive Radio Management (ARM) is one of the most important of these breakthroughs because it automatically optimizes the RF environment, simplifies network setup, ensures reliable coverage, and mitigates interference. ARM technology also dynamically determines the best channels and power levels at which to operate to insure adequate coverage and performance while minimizing interference.

ARM provides linear throughput increases as additional access points are added, and uses advanced load balancing techniques to ensure a good user experience in densely populated classrooms. To do this, ARM guides clients to the appropriate band, channel and access point, dynamically adapting the network to spread the load and avoiding over-subscribing any particular access point.

High speed 802.11n is a clear choice for densely populated smart classrooms because it offers 6x the throughput of 802.11g access points. In conjunction with load-balancing and channel re-use, 802.11n allows even the largest lecture halls and auditoriums to be well served.

Application performance in a wireless network relies heavily on a robust bandwidth control mechanism, enforced by the access point. Airtime fairness algorithms should be applied at every access point to ensure that users obtain fair and consistent access to the network. It's also important that network resources are allocated based on channel-time and not throughput to ensure that slow clients don't consume a disproportionate amount of airtime resources. This is especially important for computer based training applications in which the timeliness of test downloads and uploads can affect students' grades.

While user-based bandwidth management is necessary for role based quality of service, SSID-based wireless bandwidth management can be used to allow fine-grained control over the wireless resources any SSID might consume. With this feature, it is possible to guarantee a minimum available bandwidth per SSID so that in a multi-service environment, users of one SSID are prevented from starving another SSID for resources. Minimum bandwidth can be thereby be reserved for specific applications to allow more network services run on the same shared physical equipment.

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To scale broadcast video and interactive learning applications, transport via multicast over a diverse channel plan can add efficiency and save significant Wi-Fi bandwidth. Unicast traffic is exponentially more bandwidth intensive than multicast. Older single-channel architectures are not designed to support multicast traffic and can actually reduce the overall throughput of the single cell, causing duplicate frames to be sent to clients.

It's recommended that either 802.11a technology or high performance 802.11n technology be deployed to support large venues of 300+ people. These technologies offer more channels and are therefore less susceptible to co-channel interference and throughput reductions. The number of users per access point is primarily determined based on bandwidth required for the area of a campus being served. At roughly 25 Mbps of available throughput, each 802.11a access point and associated switch can effectively support between 20 to 30 users at 500Kbps sustained to 1Mbps peak throughput. 802.11n supports roughly 6x the performance at 150Mbps, for around 100 users per access point. This should result in more than adequate performance for today's emerging interactive classroom applications, even video. By taking advantage of its orthogonal channels, an 802.11a or 802.11n deployment can theoretically support thousands of users before channel re-use is required. If multiple access points have to operate on the same channel, which occur if 2.4GHz is used due to the smaller number of available channels, then coordinated access to the channel can be invoked across all access points sharing that channel.

It should be noted that the 802.11 data rate adaptation mechanism can slow clients on the network to reduce the rate of otherwise higher speed clients. As campuses see more and more non-laptop clients, which are primarily slower 802.11b/g capable, it becomes increasingly important to actively move higher speed clients that support 802.11a and 802.11n over to the 5GHz band. 802.11b/g is fast becoming a "junk band" that adversely affects how interactive learning applications and real time applications such as voice and video are delivered. Intelligent client steering helps solve this issue by associating 802.11n clients with the best band, channel, and access point.

As for the system concerns, deploying subnets and associated DHCP infrastructure with twice the planned supported capacity will help eliminate the most common address management issue - address exhaustion. DHCP lease times must be kept short to ensure address timely reclamation, allocate twice the number of addresses needed for the venue, and time out leases no more than 15 minutes past the maximum lecture period to ensure that address will always be available. Obviously this can be tuned for each environment, but dynamically allocated, NAT'd addresses should be in good supply for this type of application. Server capacity will be highly application dependent. Many of the smart classroom applications are great candidates for server load balancing. The point here is to engineer the solution, not just the network.

## Summary

The virtualization of smart classrooms, coupled with the propagation of interactive learning throughout and outside the classroom, is just the start of a movement to extend and improve the quality of learning. Ubiquitous Wi-Fi deployments are enabling these exciting new paradigms and wireless technology is now available to easily deploy and manage high quality, interactive learning environments.

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## About Aruba Networks

Aruba is the global leader in distributed enterprise networks. Its award-winning portfolio of campus, branch/teleworker, and mobile solutions simplify operations and secure access to all corporate applications and services - regardless of the user's device, location, or network. This dramatically improves productivity and lowers capital and operational costs.

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