Designing WLAN (802.11) to Support Tablet PC Mobility

Summary

Wireless Local Area Networks (WLAN) have been part of the enterprise landscape for several years, and have enabled workers to achieve notebook PC connectivity in multiple locations throughout a campus including offices, conference rooms, and temporary workstations. As such, corporate IT departments have had to become adept at providing wireless coverage in essential areas of the campus.

These areas are more easily described as "hotspots" and do not require any high degree of quality of service, (QOS), or roaming. As corporate networks evolve the need for high levels of QOS and a high degree of roaming connectivity are becoming necessary.

A Changing Environment – Mission Critical Wireless

New types of ultra-mobile devices, which have different usage characteristics than the notebook PC require different wireless design methods and practices. Devices such as tablet PCs, wireless VoIP phones and Wi-Fi enabled PDA's place greater demands on the design and performance of enterprise wireless networks.

This document discusses the issues that must be addressed to successfully support WLAN connectivity for these types of highly mobile devices.

Additional transitions are now also underway on the device side of these deployments. While notebook computers connected through a WLAN have changed the work patterns of many enterprise workers, the notebook PC is still largely a stationary device when it is in use. Emerging devices (like Tablet PCs) that are used while standing and walking will change these working patterns even further and will place stringent demands on the WLAN installations to which they must connect.

The factors which drive these demands are increased mobility, reduced weight and power consumption of the client device, different and more varied physical usage models and general increase in wireless bandwidth requirements.

These highly mobile devices by virtue of their size and proximity to the human body have different wireless characteristics that will also drive WLAN design.

The net impact of these factors is that IT organizations must design their WLAN installations at a higher level of sophistication than previously required.

New networks must have wider, more evenly distributed coverage, with smaller cell sizes to accommodate a higher density of users with increased mobility and bandwidth needs.

Table 1 illustrates some of the additional demands that ultra-mobile devices will place on a WLAN when compared to a Notebook PC.

Table 1 – The impact of ultra-mobile devices versus Notebook PC on WLAN networks

Factor	Notebook PC	Ultra-Mobile Device (Tablet PC, VoIP phone, PDA..)	WLAN Impact of Highly Mobile devices versus Notebook
Mobility	•Used in common work areas. •Used on flat surface or in lap when sitting.	•Used while standing and walking. Used every where on the campus.	•100% coverage required. •Must cover isolated locations: supply closets, elevators, stairwells, etc. •Multiple rapid AP hand-offs during data receive/transmit.
Weight & Power consumption	•Up to 6 lbs. •Large batteries typical.	•Less than 4 lbs. •Smaller batteries typical to achieve smaller size & weight. •Lower power consumption needed to provide adequate battery life.	•Transmit power of client device may be lower or dynamically managed.
Physical usage model	•Placed in front of user for keyboard data entry with display always vertical.	•Held close to users body in a wide variety of orientations. •Used while in motion. •Subject to stringent SAR regulations to protect users body from concentrated radiation.	•Transmit power of client device may be lower. •Human body may interfere with return path. •Client device antennae constantly re-orienting.
Bandwidth	•1 user – 1 device •Some users on wired network. •Resident apps with occasional data synch.	•Possibly multiple-ultra mobile devices per person. •More people on wireless network. •More server based apps with heavy data transfer.	•Individual access points will begin to see capacity issues if cell density is too low.

Motion Mobility Services highly recommends a design review of any existing or planned WLAN installations that are expected to support a population of ultra-mobile devices. Motion Mobility Services is available to help enterprises design effective WLAN deployments that will ensure delivery of the productivity gains desired from an ultra-mobile device deployment.

We next present a technology discussion to provide guidance on WLAN design issues.

Technology Discussion: WLAN Design Issues

Wireless network design is considerably more complex than wired network design. Wireless communications are affected by environmental variables much more than wired networking and are therefore subject to more variable performance. Wireless signals suffer loss and quality degradation as they move through space, especially inside buildings where walls, furniture, human bodies and other obstacles cause absorptions, reflections and refractions, they are also susceptible to interference from other wireless devices such as electrical equipment, microwave ovens and even other wireless devices on the same network that are competing for the same wireless frequency resources. High quality network design practices should be employed to reduce the variability of network performance.

Mobile Radio Considerations

To achieve a successful two way radio communication both of the radios involved in the communication must be able to talk to and hear each other. If one radio is able to receive a signal from another but is not able to transmit a signal back to the original sender then two-way communication cannot effectively exist. The same example would be true of a really powerful radio that is talking to a less powerful radio. <u>Two way communications will be limited to the ability of the radios to accommodate the limits of the less powerful radio.</u>

This is one of the main reasons why networks with wider access point spacing and high powered antennas are at a real disadvantage when using small form factor low power ultra-mobile devices. The devices simply cannot effectively communicate with the network access points.

This phenomenon is known as reverse link radio attenuation, it is the primary reason why most incorrectly engineered wireless networks will fail when used for high throughput and quality of service data communications.

Even if the network works with one type of equipment that may have a more powerful radio or a higher gain antenna, the network will not work correctly with other types of equipment. <u>The need for a well designed network that can accommodate low power wireless devices is one of the most important issues facing designers and users of wireless networks today.</u>

Figurer 1 shows how lower power devices cannot always communicate with access points that do not have the correct spacing, channel separation and power settings. This transmission by the client device back to the Access Point is known as the Return Path.

Figure 1 – Illustration of Return Path communications link

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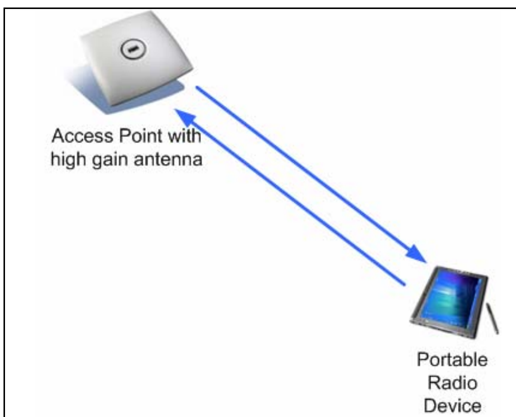
<td>
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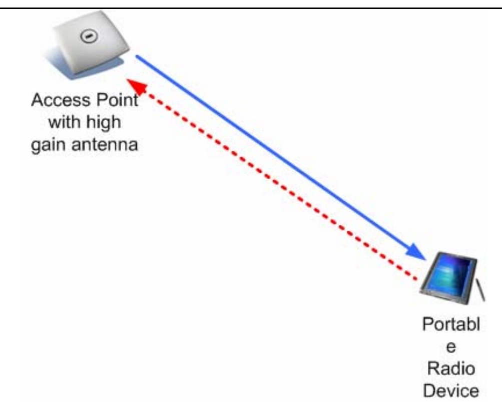
<td>
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<td>In this example the Access Point can send a signal with good quality to the portable device.</td>
<td>The further away the portable device is from the Access Point the less able it is to communicate with the network.</td>
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Rate vs. Distance

The further a device is from its access point, the weaker the signal it can send and receive and the lower the physical rate that it can reliably achieve. The radio link throughput is a function of a number of factors including the physical data rate and the frame error rate. (The frame error rate increases as the distance increases). A high frame error rate will negate any speed advantages of a high data rate by causing too many retransmissions, 802.11 devices constantly monitor the quality of the signals received from devices with which they communicate. When there turn comes to transmit they use this information to select the data rate that is expected to provide the best compromise between speed and reliability. Usually the data rate will vary in direct proportion to the distance from the access point. Table 2 shows the bandwidth and other key specifications for the 802.11 standards.

Table 2 – 802.11 specifications

	802.11b	802.11g	802.11a
Technology	DSSS	OFDM	OFDM
Frequency Band	2.4 Ghz	2.4 Ghz	5 Ghz
Channels (US)	3 Non-overlapping Channels 1,6,11	3 Non-overlapping Channels 1,6,11	13 increasing to 24
Physical Data Rates	1, 2, 5.5, 11 Mbps	All 11a and 11b data rates	6, 9, 12, 18, 24, 36, 48, 54 Mbps

Table 3 – 802.11b/g 2.4 GHz data rate versus distance

Distance From Access Point In Feet	54	48	36	24	18	12	9	6	1
100							X	X	X
80						X	X	X	X
60			X	X	X	X	X	X	X
40	X	X	X	X	X	X			
20	X	X							

Data Rate Over Distance In Mbps

Table 3 shows how distance can affect the transmit rate that can be achieved between two radios, in this case an access point and a Motion tablet using 802.11 b/g.

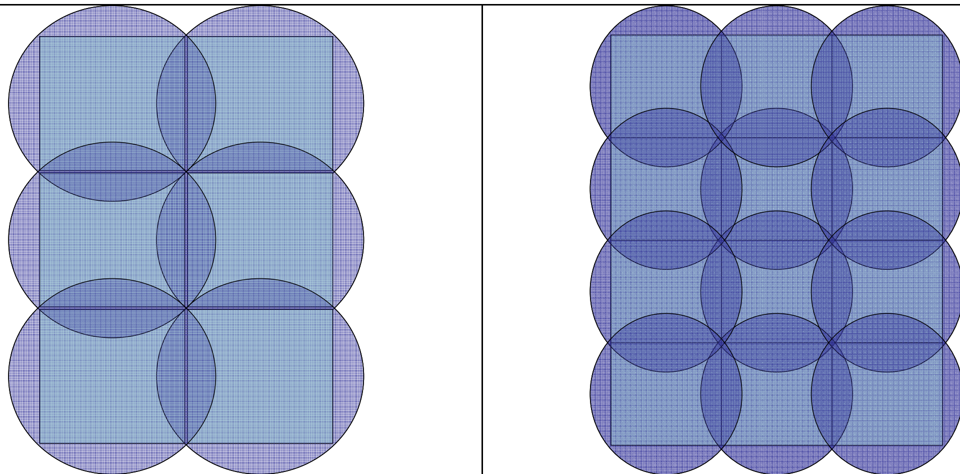
Capacity, coverage and access point spacing

The two most important measurements of network quality when describing WLAN performance are capacity and coverage, both of these are directly related to AP spacing and density.

Capacity is the amount of throughput that a WLAN system is able to provide users. When the Access Point spacing is decreased the required service area for each Access Point decreases, because of this the average distance from a user to the closest Access Point decreases. This has two immediate and noticeable effects:

1. <u>It increases the per Access Point capacity</u> by allowing for the mobile units on the same AP to connect at a higher speed.
2. <u>It increases the coverage reliability</u> by increasing the margin of safety in the range to achieve the minimum required connect speed. Coverage reliability is further enhanced by the fact that the cells will provide a good degree of overlap in the case that one of the cells is not working properly.

Figure 2 describes how reliability and throughput can be achieved by adding additional access points with lower power and increased connection speeds. ***It is important to understand that every device that is connected to the Access Point affects all devices attached to the Access Point.***



6 cells at 12 Mbps average rate Total Capacity = 72 Mbps	**12 cells at 24 Mbps average rate Total Capacity = 288 Mbps**

Figure 2 – Examples of different wireless cell densities

Assume a car travels 108 miles with the first half of the trip at 54mph and the second half at 6mph it will result in the average speed for the entire trip being 10.8 mph rather than the 30 mph that may have been expected.

This is often referred as the "edge user effect" and can explain why larger cells can result in poor throughput even though some devices can be very close to the access point.

Contention and Collisions
Collision detection is different in 802.11 wireless LAN's than in regular Ethernet networking. Wireless LAN's use a collision avoidance mechanism to arbitrate between devices trying to access a shared wireless frequency space, if many devices try to access the medium at the same time it is very likely that two or more transmissions will collide.

When this happens the entire duration of the transmissions is wasted and the devices involved in the collision are forced to wait for the next transmission period. The bandwidth of a wireless LAN cannot be divided up between an arbitrarily large number of devices.

Motion Specific Design Requirements:

Because of the types of antennas and the portable nature of the Motion Computing devices, specific design requirements are considered best practice for the Motion LE1600 and the LS800 models for optimal performance in a wireless network. (See Table 3)

Table 3 – Selected gain factors used in wireless network design

802.11g	
Portable receive antenna:	-3 dBi
Body loss (dB)	-3 dBi
Portable Receiver noise figure	10 dBi
Design height above floor	4.5 ft

Due to the effects that the device chassis has on the antenna propagation the network design should include 3dBi of loss for the antennas inside the LE1600 and the LS800 this means that the design distance needs to be adjusted to accommodate this affect. Similarly, because the human body can interfere with the signal leaving the device a 3dBi of loss should also be assumed in the design.

Minimum and maximum signal level

It is assumed that the minimum usable signal for sustained throughput would be around -75 dB and that the average throughput would be -65dB for the majority of the working areas. Signal loss due to building materials are assumed to be within industry standards for material types listed in Table 4.

Table 4 – Signal loss due to various building materials

Material Type	Attenuation 2400/5000 MHz		Reflectivity 2400/5000 MHz	
Brick Concrete	13 dB	15 dB	40%	40%
Drywall & Metal Stud	3 dB	3 dB	20%	20%

Guidelines to verifying adequate wireless coverage

A site survey is the most important part of a wireless network design; however it is critical to consider the requirements of the devices being used if a successful deployment is to be achieved.

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