
Nortel Networks Mobile Voice Client 2050

Engineering Notes and Guidelines for BCM

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2 Introduction

2.1 Background

Our customers are looking to add voice services to the generally available and popular WLAN 802.11b. Voice-over-WLAN using hand held PDA devices provides additional opportunities for our customers to meet their mobility requirements and enhance productivity. The Nortel Networks Mobile Voice Client 2050 is a UniStim based soft client that will compliment the Nortel Networks IP Softphone 2050 and Nortel Networks IP Phone 2001, 2002 and 2004.

This document is intended to raise awareness and emphasize subject areas that need to be considered in order to deliver effective audio quality while running the Mobile Voice Client (MVC) 2050 on a BCM.

2.2 Network Overview

Figure 1: Network Overview depicts the typical components needed to deploy an effective network to support the MVC 2050. A typical network will consist of the following main components:

- PDA running MVC 2050 – Pocket PC PDA supporting WLAN 802.11b
- WLAN Access Points – Nortel Networks WLAN Access Points 2220 and 2221 are standalone multi-mode access points supporting 802.11a/b and 802.11b, respectively. The WLAN Access Points provide the PDA with access to the LAN.
- BCM – Release 3.6 or later is required as the call server interface

Other beneficial network components:

- WLAN Security Switches 2250 – An additional layer for a centralized architecture that offers seamless roaming over multi-subnets and a highly secure WLAN. WSS 2250 allows mobile adaptive tunneling, centralized robust security, traffic filtering, bandwidth management, rogue access point detection, and multiple authentication options to an enterprise's existing WLAN.
- Contivity Secure IP Services Gateway - Provides IP routing, VPN, stateful firewall, policy management and QoS.
- BayStack 460 – All Nortel Networks WLAN access points can be powered via their Ethernet port. The BayStack 460-24T-PWR Power over Ethernet Switch is designed to provide Power over Ethernet capability while maintaining connectivity to standard 10/100 Mbps devices.

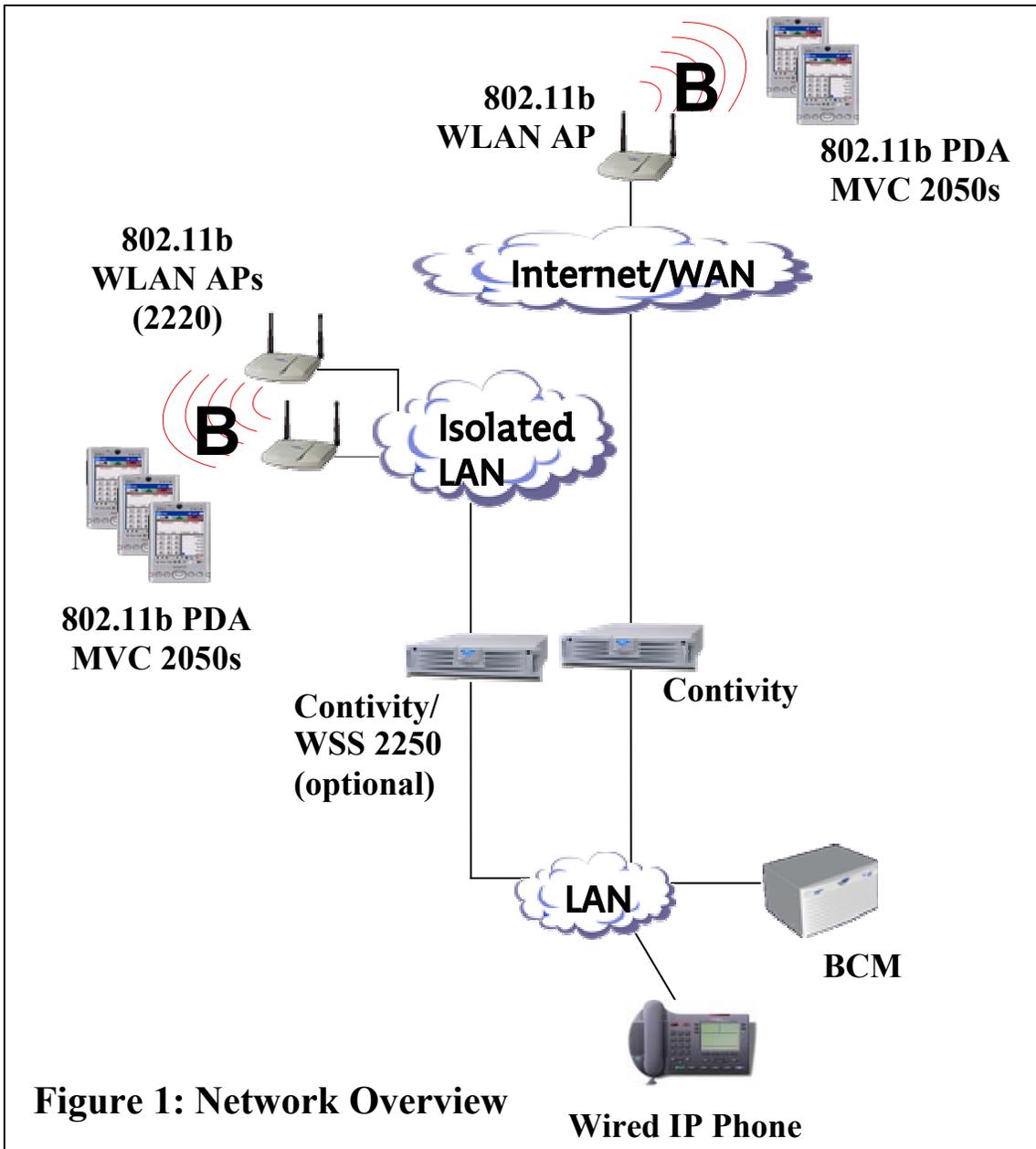


Figure 1: Network Overview

Wired IP Phone

3 Client Parameters

3.1 PDA General Description

A PDA device is a computer that fits in the palm of the user's hand. Its primary purpose is to carry the user's personal information like their address book, calendar, and notes. To keep the PDA small and light weight, constraints were made to the processor, amount of memory, and battery capacity. The PDA limitations need to be understood and managed to provide a positive MVC 2050 experience.

3.2 PDA Operation Parameters

At introduction, the MVC 2050 is supported by BCM when used on the following three Pocket PC PDA devices:

- HP iPAQ h5500 Series
- Dell Axim X3/x3i 400 MHz, X5 Advance
- Toshiba e800

The following Pocket PC PDA devices are not supported:

- HP iPAQ h5450/5455 Series
- Toshiba e750/e755

The PDA industry evolves at a rapid pace. In general, a new PDA model is released to the market every six months to a year. Contact Nortel Networks for the latest PDA models that Nortel Networks support, PDA models that have been tested and known issues. It is important that the user keeps their PDA up to date with the vendor's latest drivers.

When this document refers to a PDA, it will be referring to the supported Pocket PC PDA devices. The MVC 2050 is currently not supported on other PDA devices, such as Palm PDA devices.

Recommendation: Keep PDA up to date with the latest drivers.

3.2.1 Processor and Memory

Some Pocket PC PDA devices use Intel® XScale® PXA255 400MHz processor and have both SDRAM (RAM) and Flash memory (ROM). The newer PDA devices use the Intel® XScale® PXA263 400MHz processor. Refer to Table 1: PDA Processor and Memory, for the processor and memory specifications of the PDA devices that were evaluated.

The PDA requires at least an Intel® XScale® PXA250 400MHz and 32MB of RAM, though an Intel® XScale® PXA255 processor and 64MB of RAM is recommended. While the MVC 2050 could be installed on Pocket PC PDA devices that do not meet the above specifications, the MVC 2050 will not perform to the user's expectations.

Table 1: PDA Processor and Memory

PDA Device	CPU		Memory		Notes
	Type	Speed	ROM	RAM	
Dell Axim X5 Advance	PXA255	400MHz	48MB	64MB	1
Dell Axim X5 Basic	PXA255	300MHz	32MB	32MB	1
Dell Axim X3i 400MHz	PXA263	400MHz	64MB	64MB	2
Toshiba e800 / e805	PXA263	400MHz	64MB	128MB	3
HP iPAQ 5550/5555	PXA255	400MHz	48MB	128MB	4,

Note 1: Initially released using use Intel® XScale® PXA250, which is slower and uses more power than PXA255.

Note 2: Initially released using Intel® XScale® PXA255

Note 3: Difference between the e800 and e805 - ArcSoft Photobase is on the e805

Note 4: iPAQ 545x was replaced by iPAQ 555x.

One significant limitation of the PDA is the size of the CPU. It is not as powerful compared to a desktop computer and can be easily overburdened with tasks. It is important not to overload the PDA processor with constant, intensive tasks. For example, having multiple applications open when using MVC2050 can impede the PDA from processing the MVC 2050 voice packets to and from the access point, hence reducing the audio quality.

It is recommended to set the processor speed to the maximum setting which is 400MHz. It is not recommended to reduce the processor speed to conserve battery power because this will decrease performance. For the Dell Axim X5 and X3i, it is not recommended to set the processor to the Auto setting, which changes the speed according to system status.

Recommendation: Set the processor speed to the maximum - 400MHz.

Recommendation: Try to avoid exceeding an overall CPU consumption of 70%

3.2.2 Battery Life

Battery life will vary depending on the type of battery, usage patterns and the configuration of the PDA. Each PDA vendor offers two types of rechargeable, replaceable batteries: standard and high capacity. The high capacity battery will

provide more milli Amps per hour hence providing longer talk-time when compared to the standard battery.

The use of some applications or attachments significantly decreases the battery life of the PDA. Refer to the PDA user guide for recommended battery saving techniques. Lowering the setting of the screen brightness and reducing the time that elapses until the screen light automatically shuts off after the last operation will increase battery life.

The use of 802.11b wireless connection consumes battery life however it can not be avoided. For a Standard battery, it is possible for the battery life to last up to 12 hours (Idle mode, no user input or output). The battery life sharply decreases to almost 3 hours when transmitting and receiving WLAN 802.11b (Idle mode, power management on). Further, during a call, someone is usually talking and therefore the PDA is constantly transmitting or receiving and battery life falls to around an hour.

In general, the PDA WLAN Power Management (i.e. turning off the WLAN when inactive for a certain amount of time) has little bearing on performance since the BCM constantly sends Keep Alive messages to poll each MVC 2050. Since there are known PDA WLAN power Management issues, it is suggested to turn off the PDA's WLAN Power Management. WLAN Power Management is advantageous to use when using Pocket Internet Explorer to save battery life.

Table 2: PDA WLAN 802.11b Power Consumption

PDA / 802.11b Card	Transfer (mA)	Receive (mA)	Stand-by (mA)
HP iPAQ 5500 Series	<500	<260	<20
Dell TrueMobile 1180 CF Card	280	180	10
SanDisk Industrial 802.11b CF Card	<330	<260	<80

Recommendation: Use the high capacity battery.

Recommendation: Reduce the screen brightness and reduce the time that must elapse before the screen light is automatically shut off .

3.2.3 WLAN Interface

The MVC 2050 is supported on an 802.11b WLAN. The Dell Axim X3i, HP iPAQ h5000 Series and Toshiba e80x PDA devices have built-in 802.11b wireless Ethernet networking. For the Dell Axim X5, a CompactFlash 802.11b card is needed for wireless Ethernet networking. The 802.11b CompactFlash card can be purchased from Dell or from a third party, like SanDisk or Socket Communication. Table 3 shows the supported WiFi interfaces for each PDA device.

Table 3: Supported WiFi Interface Configuration

PDA Device	Built-in 802.11b	CompactFlash 802.11b	Secure Digital 802.11b	Bluetooth
HP iPAQ 5500	√	√ ⁽¹⁾	√	√
Dell Axim X5		√		√ ⁽²⁾
Dell Axim X3i	√			
Toshiba e80x	√			

Note 1: Requires an expansion pack.

Note 2: Not build-in, require CompactFlash Bluetooth card.

The stability of the connection and the data rate, which determine the throughput rate, will depend on the PDA WLAN hardware and its configuration. For example, if the power is reduced to the WLAN interface on the PDA to save battery life, the performance of the WLAN card and therefore the throughput could also be reduced which could reduce audio quality. Testing has shown that while roaming, the handover from one access point to another was faster when using an external CompactFlash WLAN card compared to the PDA built-in WLAN.

Table 4 reveals that the further the PDA device is from the access point, the lower the throughput/data rate is. The table also illustrates that closed-in areas (indoors) will reduce the throughput compared to open spaces since indoor spaces have more interference, like cordless phones, microwaves and walls that block the signal. Information on throughput is relative – it depends on the application. Also, coverage information for closed space is relative due to the complication of indoor infrastructure definition. Refer to Section 5 WLAN Network for more WLAN information.

Table 4: PDA WLAN Throughput/Data Rate vs. Distance

PDA / 802.11b WLAN Card	Throughput (Mbps)	Data Rate (Mbps)	Distance	
			Open Sight (ft)	Closed Space (ft)
HP iPAQ 5500 Series	>4.5	11	1000	100
	>2	5.5	1100	200
	>0.7	1	1200	300
Dell TrueMobile 1180 WLAN CF Card		11	525	115
		5.5	885	115
		1	1750	165
SanDisk Industrial 0MB WLAN CF Card		11	1150	
		5.5	1475	
		1	2300	

The HPiPAQ H5500 Series had a connection issue with their built-in 802.11b WLAN interface. It has been resolved by installing HP WLAN driver 3.2.34.133 and iPAQ h5000 I Preset for Roaming utility. Contact HP Support for the utility.

The Nortel Networks Access Point 2220 will also need to be running software release 1.3.

PDA devices can also have Bluetooth capabilities, either integrated or with an external card. Using a Bluetooth accessory while on a voice call is not recommended due to interference and contention. Bluetooth and 802.11b operate in the same frequency band. Essentially, 802.11 signals will cease when they are within the area of a Bluetooth device. Using Bluetooth will also increase CPU consumption. Interference and CPU saturation will lead to a decrease in audio quality. PDA vendors are working to minimize this issue.

Customers could deploy an 802.11g WLAN CompactFlash card to take advantage of higher data rates; however 802.11g has not been tested. At this time, 802.11a is not an option since 802.11a is not available as a WLAN CompactFlash card. Refer to Section 5 WLAN Network for more information on the different 802.11 characteristics.

Recommendation: Use PDA devices on an 802.11b WLAN.

Recommendation: Move closer to access point to increase throughput / data rate.

Recommendation: As much as possible, avoid areas with WiFi interference, like areas with microwave ovens and cordless phones.

Recommendation: Do not operate a Bluetooth accessory while on a voice call as it is not supported.

3.2.4 Headsets

PDA headsets/headphones are not supplied with MVC 2050. They must be purchased separately and are the customer's responsibility. Nortel Networks suggests customers contact their PDA vendor for more information. The HP website has a list of recommended headsets for their PDA devices. Headsets play an important part in the overall audio quality. In general, MVC 2050 works best with a headset since it reduces background noise and echo. However, using an inadequate headset can reduce audio quality by injecting noise, delay, and acoustic echo.

The headset and headphone tested by Nortel Networks are:

- Plantronics M130i Headset: has noise-canceling microphone feature that reduces background noise.
- Jensen JM-11 Behind-the-Neck Headphone: used with Dell Axim PDA devices.

Table 5 shows the audio port supported for each PDA. Dell Axim X5 Advance and Dell Axim X3i 400MHz only has a headphone jack and not a headset (a headphone/microphone) jack. The user will need to hold the PDA up to their mouth and use the built-in microphone on the PDA.

Table 5: PDA Headset – Audio Port Specifications

PDA Device	Headset		Size of Jack (mm)
	Headphone	Microphone	
HP iPAQ 55xx Series	√	√	3.5
Dell Axim X5/X3i	√		3.5
Toshiba e80x	√	√	3.5

When the PDA built-in speaker and microphone are used, the microphone will pick up sounds from the speaker creating an acoustic echo path. Automatic Gain Control (AGC) is used to reduce the echo. However for the Dell Axim X5, the echo is severe and a headphone is required.

As mentioned in Section 3.2.3 WLAN Interface, Bluetooth accessories are not recommended and this includes Bluetooth headsets.

Recommendation: Using a headset will improve audio quality compared to using the built-in speaker and microphone of PDA.

Requirement: Customers are required to use a headphone when using the Dell Axim X5.

Recommendation: When using the PDA built-in speaker and microphone, activate AGC to reduce feedback.

Recommendation: Review PDA vendor's website for approved headsets.

Recommendation: Do not operate a Bluetooth accessory such as a Bluetooth headset while on a voice call as it is not supported.

3.2.5 Microphone and Audio Settings

All supported PDA devices provide individual settings for the microphone, speaker and/or headset gain and volume control that work in conjunction with the PDA device or headset type. The microphone and audio settings should be adjusted depending on the users' environment (i.e. ranging from quiet to a noisy environment). It is recommended that options are exercised to adjust for peak performance. Refer to the PDA Help menu to adjust the specific PDA devices' settings. See Section 7.1.2 Settings for suggested settings.

3.3 Applications

The configuration of the PDA device will have an affect on audio quality. Audio quality could be affected by the type of operating system or applications running in the background.

3.3.1 Operating System

A Pocket PC PDA is a PDA device that runs on Microsoft Windows CE operating system. The operating system has an affect on how flexible the support of the MVC 2050 is. If operating system prioritizes the CPU ineffectively with other tasks, audio quality can be negatively affected.

The MVC 2050 runs on Windows Mobile 2003 operating systems. Using Pocket PC 2002 increases the CPU consumption and is therefore not supported.

Requirement: Use Windows Mobile 2003 and not Pocket PC 2002.

3.3.2 Client VPN

Security is an important aspect of the WLAN. A client VPN establishes the necessary IPsec tunnel to a Contivity or WLAN Security Switch. The MVC 2050 can coexist with Certicom® movianVPN® client. Improperly implementing security can potentially allow unauthorized parties with 802.11b interfaces to obtain access to the rest of the Intranet. However, like any other application running on a PDA, it does consume CPU resources. While on a call, the movianVPN consumes on average 20% of the CPU resources.

Recommendation: Use a client VPN only if enhanced security is required.

3.3.3 Other Applications

Degradation in audio quality could occur when simultaneously executing other applications while on a call. The PDA processor will be running other tasks instead of processing the voice packets. While running some of these applications, audio quality could be temporarily affected when a spike in CPU consumption occurs. While in most cases, a spike will have a temporary effect, if there has been a number of consecutive spikes (for example opening the Inbox and then launching Excel), then the sharply increased CPU consumption could cause the call to drop or freeze the PDA device. It is important to keep the consumption from exceeding 70% for a stable call.

It is recommended to minimize the use of the Pocket Internet Explorer while on a call. Both applications consume a significant amount of CPU and will be vying access to the 802.11b WLAN.

If the user is experiencing poor audio, check to see if other applications are running in the background. Tapping on the “X” at the top right corner of the application window does not stop an application; it only sets it to run in the background. Applications running in the background will also use program memory.

Besides consuming CPU resources and program memory, running applications while on a call will also consume battery life.

Recommendation: Users should strive to minimize using other applications while using the MVC 2050 for optimal audio quality.

Requirement: Minimize use of Pocket Internet Explorer and other applications that access the WLAN, while on a call.

3.3.4 System Inputs and Outputs

User interactions with the PDA, such as tapping the PDA screen or pressing a button, will use scarce CPU resources. The CPU consumption can be characterized as a spike. It commonly occurs when tapping the screen to turn up the volume, scrolling down a page, or when a sound notification occurs. Since the CPU is now tasked with an operation, the voice call could be interrupted. If the interruption is continuous, the voice call could drop. Using expansion packs will also consume CPU and battery resources.

To reduce impact, it is recommended if the user has many actions to execute, proceed in gradual stages. For example, if a user requires viewing an Excel file, it is recommended to tap on 'Start', pause, then tap on the Excel icon. That way, instead of a 100% spike, the user would have two smaller CPU consumption spikes. This gradual process becomes more significant if the user's overall CPU consumption is already above 60%.

For notifications, the CPU consumption will spike since the message is displayed on the screen and a sound is produced. Turning off the sound notification is not encouraged to reduce CPU consumption since the call will be interrupted anyway.

Recommendation: For tasks that required executing many actions, proceed in gradual stages.

3.3.5 Super Task

A major factor for poor audio quality is for the overall CPU consumption to exceed 70%. SuperTask is a tool that monitors CPU consumption. SuperTask, or any other CPU monitoring tool, is recommended to be installed on the PDA. Additional information regarding SuperTask can be found at their website which is provided in Section 9.1 Websites.

Recommendation: Install a CPU monitoring tool like SuperTask.

3.4 MVC 2050 Parameters

The MVC 2050 has two audio tabs to control the audio quality. The QoS tab, meaning support of 802.1p/Q, is currently not supported. The MVC 2050 also does not have an echo canceller. The dominant issues causing poor audio quality are CPU consumption greater than 70% and a poor WLAN connection. Before adjusting the Audio Quality tabs,

- Check to see if CPU consumption is below 70%.
- Check if WLAN connection
 - is stable
 - is data rate high - 11Mbps vs. 1Mbps
 - is VPN client is connected (if used)

Recommendation: Review CPU Consumption and WLAN connection before adjusting audio tabs.

3.4.1 Audio Tab

There is an audio quality slider to adjust the number of buffers between the MVC 2050 application and the PDA audio hardware. Decreasing the number of buffers will reduce overall speech path delay however it does increase the chances of reduced audio clarity, and receiving broken or absent audio.. Increasing the number of buffers will improve clarity but will increase overall speech path delay.

Recommendation: Adjust audio quality slider to trouble shoot audio quality problems when there is too much delay or broken / absent audio.

3.4.2 Advanced Audio Tab

The Advanced Audio tab provides the option of using Global IP Sound® NetEQ, using the communication server settings or overriding the communication server values. At introduction, GIPS NetEQ is the only option available and is enabled by default. GIPS NetEQ software has been bundled with MVC 2050 to provide loss concealment and compensation for up to 30% loss packet.

3.4.3 Volume Control

The volume up and volume down icons on the MVC 2050 Operation Toolbar are controlled by tapping the screen. As mentioned in section 3.3.4 System Inputs and Outputs, CPU consumption will increase when tapping on the screen. Therefore, tapping volume icons could cause broken speech and if the volume icons are tapped too many times, the call could be dropped.

Requirement: Try to avoid rapidly tapping volume controls.

4 Communication Server

At introduction, the following Business Communications Manager servers are supported.

Table 6: Applicable Systems

System	Applicability
BCM200	Y
BCM400	Y

Requirement: The communication server must be Release 3.6 or above.

4.1 Configuration

The MVC 2050 is configured the same as the IP Softphone 2050. Refer to BCM i2050 Install Guide for configuration details.

Recommendation: Configure the MVC 2050 the same way as an IP Softphone 2050.

4.2 Audio Quality

The perceived quality of a voice transmission is dependent on many factors, such as codec characteristics, echo canceller, jitter buffer size and the perception of the individual listener.

Refer to BCM IP Telephony Configuration Guide to configure the codec and jitter buffer parameters.

4.2.1 Codec

The MVC 2050 supports G.711 A-law and μ -law. G.711 provides higher audio quality compared to other codecs since there is minimal compression. The disadvantage is that G.711 does require more bandwidth so the network must be able to handle the higher throughput or else audio quality will suffer.

G.729 and G.723 are codecs that use compression therefore would use less bandwidth, however the PDA would have higher CPU consumption since it would be required to compress and decompress the voice packets. In consequence, G.729 and G.723 are not supported at introduction.

4.2.2 Payload

The MVC 2050 supports G.711 with 10ms, 20ms and 30ms payloads. The MVC 2050 at 10ms payload has 100% CPU consumption and thus, setting the payload to 10ms is not recommended. In general, a user using 802.11b WLAN would experience the best quality at 20ms. However for the MVC 2050, the PDA CPU consumption at 30ms payload is on average 16% less than the CPU consumption at 20ms payload. If the user has other applications running, like VPN or using an expansion pack, it is recommended to use a 30ms payload.

Recommendation: Set payload of G.711 to 30ms.

5 Wireless LAN

In general, the MVC 2050 is supported on an 802.11b WLAN. This is due to the PDA built-in WLAN interface is 802.11b. Testing was therefore done on this standard. This is not to say that 802.11g, or 802.11a, could not be used however, 802.11b is currently the more popular standard. Future PDA devices and access points will undoubtedly be supporting new standards, and when they do, testing will occur on those standards.

The WLAN was built for data access and could provide inconsistent audio quality, which could lead to poor performance and dissatisfied MVC 2050 user. A successful deployment of the MVC 2050 in a WAN begins with an understanding of the underlying network and the traffic that it transmits.

5.1 WLAN Introduction

The wireless medium is not a wire. It is a highly changing environment in which transmission errors are unavoidable and quite common. Some factors can be controlled while others are fundamental limitations of the wireless medium that must be recognized and taken into account when using the MVC 2050.

The three IEEE 802.11 standards, 802.11a, 802.11b and 802.11g, were the first radio layers to be ratified. The focus was on enhancing security and network-based management. The 802.11 basic MAC mechanism, CSMA/CA, is similar to Ethernet CSMA/CD protocol except that CSMA/CA uses Collision Avoidance instead of Collision Detection. Table 7 summarizes the essential characteristics of the 802.11 physical layers. It is important to note that 802.11b standard operates within three non-overlapping channels in the 2.4MHz band and can support up to 11Mb/s data rate. Devices using 802.11g are backward compatible with 802.11b but they will have the same data rate as 802.11b devices when deployed within a 802.11b network – losing their advantage. In addition, 802.11b devices communicating on an 802.11g network will force all 802.11g devices into ‘compatibility mode’ whereby they have to transmit additional overhead in order to warn 802.11b devices they are transmitting. This extra overhead incurs a performance penalty on the 802.11 network for 802.11g devices.

Table 7: 802.11 Physical Layers

	802.11b	802.11g	802.11a
Adopted by IEEE	1999	2003	1999
Technology	DSSS	OFDM & DSSS	OFDM
Frequency band	2.4 GHz ISM	2.4 GHz ISM	5 GHz ISM
Channels (US)	3 non-overlapping	3 non-overlapping	13 (increasing to 24 in US)
Physical rates	11, 5.5, 2, and 1 Mb/s	All 11a and 11b rates	54, 48, 36, 24, 18, 12, 9, and 6 Mb/s

5.1.1 Coverage and Capacity

The audio quality for the MVC 2050 user is highly dependent on the coverage and capacity of their WLAN. The wireless medium is a dynamic, shared medium affected by several interacting factors. The following are known WLAN factors that degrade the coverage and capacity.

One fundamental factor of the wireless medium is that the data rate will decrease in direct relation to the distance from the access point. The farther a MVC 2050 user is from its access point, the weaker the signal it receives and the lower the physical rates that it can reliably achieve. Of course other physical characteristics, such as obstacles (walls, cubicles, water, etc.) and sources of interference (microwave ovens, cordless phones) will cause the signal to be absorbed or reflected, changing the coverage and capacity as well.

In addition to the standard MAC, IP, TCP,UDP and RTP headers, there is a radio preamble signal used to enable the dynamic coding inherent in 802.11 systems. This fixed overhead will consume bandwidth and has to be factored into the WLAN capacity. Section 5.3 VoWLAN looks at bandwidth calculations for voice.

For multiple MVC 2050 users that are simultaneously active on the same access point, there are further reductions in the overall media coverage and capacity. The rate a MVC 2050 user connects to the access point not only affects them but also the MVC 2050 users around them. A MVC 2050 user connected at a lower data rate will use proportionately more transmit time and will have a disproportionately large impact on the total system throughput. Since each device will still get access to the same percentage of capacity, but total capacity is now smaller, the result is that each user will have less throughput available to them. This effect is sometimes called the 'edge user' effect since the outer edge of the access point's coverage area is where the lowest data rate occurs. A 'sticky client' can cause this effect since the roaming user will 'stick' with their access point at a lower data rate instead of moving to the closer, higher data rate access point.

The layout of access points will have an effect on coverage and capacity. If the access points are placed closer together the PDA distance to the access point would be shorter, and the user would then use less of the medium, resulting in a higher system throughput. Unfortunately, simply adding more access points to increase capacity may in fact have the opposite effect, as seen in the next section.

While a little contention improves the utilization of the medium, too much contention reduces the efficiency and wastes scarce bandwidth. When there is one too many users on an access point, the performance is dramatically degraded to the point that all users have poor audio quality and their call is dropped.

5.1.2 Large WLAN

Wireless capacity is a finite, scarce resource and can not be engineered by over-provisioning, which is customary for wired LANs. Due to the shared nature of the wireless medium, deploying more access points might contribute to polluting the air waves without increasing the capacity. Interference resulting from two or more simultaneous transmissions on the same channel is called co-channel interference. For 802.11b, there are only three non-overlapping frequencies so reusing frequencies will occur. The more densely the access points are placed, the worse the interference from users on the same frequency will be, potentially reducing coverage and capacity. The noise level is also dependant on WLAN traffic. As the traffic changes, so will the capacity of the WLAN. The noise level will increase as the traffic increases, reducing capacity and coverage. Frequency planning, assigning frequencies to access points in a way that maximizes the distance between access points using the same frequency, can lower the interference, increasing both coverage and capacity. In a multi-story building, these effects make the deployment of WLANs more complex since it is now needs to be examined in three-dimensions. A large WLAN is more complex than a single access point.

A well characterized WLAN plan is essential to deploy an effective WLAN. A site survey will take into account the physical environment (coverage area shape and obstructions) and radio conditions (signal strengths and interferences). While a simple site survey may guarantee coverage, it will not guarantee capacity or performance targets. WLAN traffic and co-channel interference are other factors that must be characterized for large WLANs. Further analysis, using automatic planning tools, is then required. The WLAN user population, usage pattern and WLAN applications will also change over time, so constant monitoring is required by intelligent management systems.

5.2 Wired LAN

While the focus is usually placed on the wireless part of the network, the wired network must not be ignored. To obtain the best possible audio quality, QoS needs to be implemented and enforced from end-to-end; both on the wired and wireless LANs and they need to properly align with each other. Refer to BCM Data Networking Guide for recommended optional configurations.

5.3 Voice over WLAN

To meet the user's expectations of a satisfying quality of experience, the user will need to be able to initiate a call at will, obtain the audio quality it is expecting during a call, and maintain the call as the user roams.

5.3.1 Bandwidth

While data traffic tends to generate bursts of rather large packets, voice traffic is made up of short packets that are fairly evenly distributed in time. Data and voice can coexist on the same WLAN however; if no precautions are taken, even a single bursty data stream can temporarily saturate the medium and negatively impact audio quality. A mix of voice and data deployed on the 802.11b standard could result in an unsatisfactory experience. QoS mechanisms are the most effective way to insure that voice traffic gets higher priority access to the wireless medium. The draw back is if the QoS is too stringent, the data applications will suffer. Separating voice and data traffic users by frequency would be another way to ensure priority is given to voice packets. This could be done by placing data users on the 802.11a radio while MVC 2050 users would use 802.11b. 802.11b has scarce resources with only 3 non-overlapping channels while 802.11a is not as scarce since it has more non-overlapping channels. By moving the hungry data applications from a scarce resource to a more plentiful resource, it will leave the MVC 2050 users alone on the scarce resource which is a more efficient use of the resources that are available. Table 8: Overhead for G.711 Codec at 20ms Payload reveals the makeup of a WLAN MSDU carrying a G.711 20ms payload. This table shows that for 20ms of voice, which corresponds to a 160-byte voice payload, about 252 bytes are actually sent. In other words, over 33% of the bytes sent are overhead and not the voice payload. Table 9 shows the calculated time it would take to transmit a G.711 20ms payload at various data rates and preambles. Table 9 also provides an estimate to the maximum number of MVC 2050 users that can be on one access point. A number of observations can be made from these tables.

- Connecting at a higher data rate will use less time on the medium; less time on the medium means other users will have the opportunity to use the medium, increasing the number of users on an access point
- Shorter preamble reduces the amount of overhead transmitted before each frame thus increasing the voice capacity
- A lower connected data rate user will consume more of the medium's available time, leaving little time for the higher data rate connected users – dragging all users, or capacity, down to the data rate of the 'edge' user

Table 8: Overhead for G.711 codec at 20ms payload

Description	Size
MAC Header	24 bytes
CCMP Header	8 bytes
LLC/SNAP Header	8 bytes
IPv4	20 bytes
UDP	8 bytes
RTP	12 bytes
Voice Payload	160 bytes

CCMP MIC Trailer	8 bytes
MAC Trailer (CRC)	4 bytes
Complete MAC Frame ¹	252 bytes

Note 1: For every voice packet sent, a 14-byte acknowledgement is also transmitted at the highest mandatory rate not greater than client data rate.

Table 9: Calculated Packet Time and Estimate Maximum Capacity

Data Rate (Mbps)	Packet Time (µs)	Number of Users ⁽¹⁾
1	2572	~3
2	1564	~5
5.5	923	~8
11	740	~10
2	1316	~6
5.5	675	~11
11	492	~14

Note 1: The results shown may not be what a user will experience. Many factors will vary these results. The results shown are provided to set users' expectations.

Table 10: Calculated Throughput for 802.11b WLAN provides a reference for throughput of an 802.11b WLAN for the packet sizes of G.711 20ms and 30ms payloads. Table 10 shows that the throughput rate a user will get is not equal to the data rate, but significantly lower - especially for smaller packet sizes inherent to VoIP. A call using G.711 at 20ms and 30ms payloads require 160kbps and 149kbps, respectfully. For 10 calls on an access point, the 20ms payload calls would consume 75% of the throughput. For 10 calls using 30ms payload, the calls would consume 54% of the throughput. This does not leave much room for error and it implies all MVC 2050 users are operating at 11 Mbps, short preamble, and perfect radio conditions. Actual deployments need to allow for fewer MVC 2050 users due to real world radio conditions and for rate scaling as MVC 2050 users move away from the access point. If data users were mixed in with MVC 2050 users over the same radio channel (even with proper QoS mechanisms), even fewer MVC 2050 users could be supported.

Table 10: Calculated Throughput for 802.11b WLAN

802.11b Preamble	Data Rate (Mbps)	Throughput ⁽¹⁾	
		200 (G.711 20ms payload)	280 (G.711 30ms payload)
Short	1	581	660
	2	912	1080
	5.5	1432	1815
	11	1710	2254
Long	2	1024	1190
	5.5	1729	2150
	11	2151	2772

Note 1: The results shown may not be what a user will experience. Many factors will vary these results. The results shown are provided to set users' expectations.

Therefore, the maximum number of simultaneous calls per access point depends upon the user's particular network. For example, an 802.11b WLAN capacity could range from 10 users to 2 when non-overlapping channels are used. Realistically, the number of users per access point is more likely closer to 5 users than the theoretical 10 users.

5.3.2 Delay

Delay is the time it takes from when the MVC 2050 voice packet is sent to when it is received at the far end. While data applications experiencing excessive delay will simply time-out, delay for the MVC 2050 will cause some degradation in audio quality or even a dropped call.

Delay can be fixed or variable. Examples of fixed delay include PDA processing IP packets, queuing delay (data transmission wait-time) at each network hop of the physical network, and propagation delay – the delay caused by the finite speed at which electronic signals can travel through a transmission medium. Examples of variable delay include queuing delay for traffic entering a network node, contention (vying for access) with other traffic at each network node, and queuing delay for traffic exiting a network node. Variable delays are affected by the amount of network traffic.

It is important to reduce the amount of delay throughout the wireless and wired networks. Reducing delay can be achieved by implementing a simplified end-to-end QoS, adding capacity to the wired LAN, minimizing the number of hops, segregating constant bit-rate voice traffic from sporadic data traffic, and lowering jitter buffer size (without increasing packet loss to the point where broken speech becomes noticeable).

- There is also a delay when a MVC 2050 user roams from one access point to another. This handover delay was measured and is shown in Table 11. It was observed that Handover delay varied with changes to the medium, traffic, etc.
- The user would experience about a half a second with no voice, or
- The user would experience between 2 to 10 seconds of 10ms to 100ms no voice periods.

It was also observed that the PDA device may not handover to the next access point even if it was directly under the other access point. PDA vendors are aware of these WLAN issues and are constantly updating their drivers to improve their characteristics. It is important to keep the WLAN drivers of the PDA up to date.

Table 11: Measured Handover Delay

PDA or CF WLAN Card	Time with no Voice	Voice Degraded Time
	Worst Case/Best Case	Worst Case/Best Case
Dell Axim X5 and TrueMobile CF WLAN card	0.710/0.268	0.710/0.263
Dell Axim X3i	No handover/0.172	No Handover/0.432
Toshiba e805	0.563/0.154	10.311/2.087

5.4 Optimal Access Point Configuration

The following are recommended access point configuration to enhance the MVC 2050 experience.

For WLANs with only access points:

- Create unique SSID for b-radio
- Enable MAC security using RADIUS or local database on 2220
 - Optional, recommended for enhanced security
- Enable Static WEP with longest key available that PDA will support
 - Optional, but recommended for enhanced security
 - If WLAN Handsets 2210 and 2211 are in use on this WLAN, this may be too cumbersome to be worthwhile. It is easier to type WEP keys on a PDA.
- If the only voice devices are MVC 2050 users then use 802.1x in place of the two steps above
 - Optional
- Enable p-bit device prioritization for QoS. Map the p-bit assigned to voice to the highest queue on the Access Points 2220.
 - Tagging on the switch port is required.
 - MAC based QoS up to 8 PDA devices is an option as well however it does not scale.
- Use RADIUS to designate, by MAC address or 802.1x, a unique tagged VLAN for each MVC 2050 user.
 - Specify a default VLAN for all other devices or
 - Map all devices to various appropriate VLANs
 - This has not been validated
- Do not use Close System

6 Summary of Limitations and Recommendations

The MVC 2050 is the latest in technology – converging IP Telephony, 802.11 WLAN and a PDA device which offers a great deal of efficiency and productivity benefits. It is very important; however, that customer expectations be well understood and managed, such that the MVC 2050 results in a positive customer experience and customer satisfaction. PDA performance is constantly improving with Moore's Law and this will directly benefit MVC 2050 performance specifications going forward. The WLAN performance will also change as the PDA moves from 802.11b to an 802.11 standard that includes QoS. Here is a summary of the known limitations and recommendations.

6.1 CPU Consumption

One significant limitation is the CPU inside the PDA. The processor is not as powerful compared to one in a desktop computer and can be easily overburdened with tasks. In total, CPU consumption should not exceed 70% while on a call. Once the CPU consumption is over 70%, audio quality of the call will suffer.

Testing has shown that decreasing the payload size of the G.711 codec will cause an increase in CPU consumption. Increasing the payload from 20ms to 30ms will on average decrease CPU consumption by 16% and the MVC 2050 will be more stable. At 10ms payload, the CPU consumption is 100% - dropping the call. Here is a list of requirements and recommendations to reduce CPU consumption and thus help improve audio quality:

- Set CPU to 400MHz (Maximum).
- Use Windows Mobile 2003.
- Set the Payload of the G.711 codec to 30ms.
- When possible, avoid using a VPN Client, like movianVPN.
- Minimize repeatedly tapping screen or repeatedly pushing input buttons on PDA.
- Minimize running applications that consume significant amount of the CPU.
- Minimize running multiple small applications that add to a significant amount of the CPU.
- Minimize operating extension packs that consume significant amount of the CPU.

6.2 Battery Consumption

To be mobile, the PDA runs on a battery that is small and light-weight. The battery has limited storage capacity. . The number of calls and the duration of the calls have a direct relationship to the capacity of the battery. The WLAN interface and MVC 2050 application will consume battery life. For the standard battery,

call duration can be about an hour to two hours, depending on the PDA. For the high capacity battery, a call can be sustained for about two hours to over six hours, depending on PDA..

Here is a list of recommendations to reduce battery consumption:

- Use high capacity battery
- Use battery saving techniques described in PDA user manual, such as
 - Reduce the screen's brightness.
 - Shut off screen light when idle.
- Avoid saving battery techniques that reduce CPU speed.

6.3 PDA Speaker and Headset

The PDA device does not have the same acoustic properties compared to the headset of a desktop phone. There will be acoustic echo at the other end of the phone call. Dell Axim X5 Advance and Dell Axim X3i 400MHz only have a headphone jacket and not a headphone/microphone jack. The user will need to hold the PDA up to their mouth and use the built-in microphone on the PDA.

Recommendations:

- Use a headset when on a call.
- Adjust the PDA microphone and speaker settings for peak performance according to whether the user is using the built-in microphone and speaker or a headset and if the user is in a noisy or quiet environment.
- Activate AGC when using built-in PDA speaker and microphone
- Do not use a Bluetooth headset

6.4 Roaming

There are two known roaming issues. The first is related to the HP iPAQ h5550 PDA. The HP iPAQ h5550 attempts to bounce from one AP to another even if the PDA is motionless directly under one access point. The second is with Nortel Networks Access Point 2220 using pre-1.3 software. If the AP is pre-1.3 software, the network connection will drop. In consequence, the connections to the VPN and the BCM as well as any call in progress will also drop.

Recommendations:

- Install HP WLAN driver 3.2.4.133 and iPAQ h5000 IP Reset For Roaming utility
- Use software release 1.3 or later for Nortel Networks Access Points 2220

6.5 Communication Server

The MVC 2050 only supports G.711 codec. The BCM only supports 10, 20 and 30ms payload for G.711 codec. As the payload decreases from 30ms to 10ms, the

CPU consumption of the PDA increases to the point where the PDA freezes.
Configure the MVC 2050 the same as a IP Softphone 2050

- Set the payload to 30ms to improve CPU consumption on the PDA.

6.6 WLAN

Fundamental factors of the WLAN are:

- The farther away a WLAN device is from the access point, the weaker the signals received and lower the data rate.
- Obstacles will cause the signal to be reflected or absorbed potentially affecting data rate and user throughput.
- There is a fixed overhead.
- Lower data rate users will drag other users closer to their throughput.
- Contention, frequency interference from re-use and increased traffic will reduce throughput rate.

The following access point configurations can improve throughput:

- Separate data and voice SSID
- Configure MAC address per access point
- P-bit priority QoS
- Short preamble
 - Eliminate 1 Mbps connection.

For MVC 2050 users,

- Try to avoid areas that have interferences, such as
 - Microwave ovens
 - Cordless phones
- Minimize using other applications that use the WLAN
- Try to avoid Bluetooth devices

7 Tips and Tricks

Here are some of the tips and tricks discovered while this product was developed.

7.1 PDA

7.1.1 Known Issues

It is important not to drain the battery beyond the low battery warning. If the battery is too low, the PDA devices will hard reset possibly removing important applications. It will also damage the battery if it occurs too many times – the battery won't hold the charge. In general, do not drain the battery below 40%.

For the Dell Axim PDA devices, if the user enables the option to 'turn off device if not used for (menu: 15 seconds to 15 minutes)', the PDA will shut off even if the user is on a call. The problem is, 'not used' refers to input like a tap on the screen. The work around is to not enable this feature.

The Dell TrueMobile 1180 Wireless CF card, v.7.82 build 799, A01 (date: 6/25/2003) has a WiFi Power Management issue - it turns on even if the user selected it off and the WLAN connection can unexpectedly drop. The Dell TrueMobile 1180 Wireless CF card uses an Agere chipset and Agere has a newer driver that resolves this issue. It is recommended to use Agere's latest driver.

The Dell Axim X5 can not recognize SanDisk WiFi cards that also have Flash memory within the CompactFlash card and only SanDisk 0MB WiFi CompactFlash card work with those PDA devices.

7.1.2 Settings

To set the processor speed:

- Dell Axim X5, X3i: Start -> Setting -> System-> Power-> Processor
- HP iPAQ 5550: Not Applicable since it constantly operates at 400MHz

To determine the PDA's Pocket PC version:

- Start->Setting->About
 - Window Mobile 2003 will start with Version 4.x.x.
 - PPC2002 will start with Version 3.x.x.

To determine which applications are running or to stop an application:

- Start-> Setting->Memory->Running Programs

The controls for the volume of the PDA built-in speaker and headset are slightly different for each PDA.

- Dell Axim: Volume control icon at top of screen.
- HP iPAQ h5550: Volume control icon at top of screen and volume buttons on the side of PDA.
- Toshiba: Start->Setting->Systems->Advance Audio

The AGC control can be found:

- Dell Axim X5: Start -> Setting -> System-> Microphone
- HP iPAQ h5550: Start -> Setting -> System-> iPAQ Audio

While testing the MVC 2050 the following microphone settings were used:

Toshiba e805, either using built-in microphone and speaker or with Plantronics M130i headset:

- Change settings from Interview to Custom
- Enable AGC, and
- Disable boost

HPiPAQ h5550 with Plantronics M130i headset:

- In quiet environment, use default setting (i.e. disable AGC)
- In noisy environment, enable AGC and customize to acceptable level

Dell Axim X5/X3i

- Follow PDA Help instructions

7.2 Applications

7.2.1 Different Operating Systems

Most programs have a different version of their program to work on the different operating systems, movianVPN to mention one. While some versions may work on the other operating systems, the program's performance may be poor or even freezes the PDA. Be careful when installing programs and make sure that the right version is used.

It is recommended to periodically backup the data on the PDA device and backup data before installing a new application. That way, if the PDA gets into a state where only a hard-reset will resolve the issue, the user can then easily restore its data to the state before the problem occurred.

7.2.2 WLAN Interface

In general, when the PDA device is placed in its cradle, the wireless network connection will be turned off, dropping the connection to the BCM and any active calls. The reason for this is that ActiveSync, which uses PPP to connect to the host PC, causes the device's wireless connection to be dropped. By turning off ActiveSync, it is possible to use the MVC 2050 while the PDA is in its cradle.

When upgrading HP iPAQ driver and utility, if the error message 'cannot copy xxxxxx.dll' occurs while attempting to overwrite the original 'vnetusba.dll' or 'leap.dll' files, rename the existing files in the '\Windows' folder and try again. What is happening is that files copied into RAM (as opposed to ROM) are locked while in use and cannot be deleted or overwritten. The driver revision listed in Asset Viewer will not change immediately after the drivers are copied. To update the WLAN driver revision in Asset Viewer, disable and re-enable the WLAN radio, then perform the soft-reset. If the WLAN driver revision is still not updated, remove the battery for a few seconds and replace it back again.

7.3 MVC 2050

Here are a few tips that can help make the MVC 2050 experience more pleasant. Refer to the MVC 2050 User Guide for all the features of the MVC 2050.

7.3.1 ClearType

The MVC 2050 uses a special font that requires ClearType to be enabled on the PDA device. ClearType smoothes the edges of screen fonts for many programs. To enable ClearType, go to Start-> Setting-> Screen and check the Enable ClearType box.

7.3.2 Sound Tab

This feature provides an audible indication when the MVC 2050 has connected to the server, the server is unreachable or when the server is unresponsive. This is helpful to the user when they are roaming with the MVC 2050 running in the background since they will know if the MVC 2050 is not connected without having to look at the PDA screen. Users must provide their own .wav files.

7.3.3 Program Buttons

The PDA has four program buttons located on the front of the device. By default, the buttons launch the programs that are identified by the icons on the buttons. It is possible to reprogram a button to speed up the launch of the MVC 2050 application. This can be done by going to Start-> Setting-> Buttons, highlight the button from the list to assign the MVC 2050 to that hardware button, then choose MVC 2050 from the list of possible button assignments, click 'ok' at top right of screen to enable the change.

8 WLAN Handsets 2210 and 2211

MVC 2050 users may also be on a WLAN that deploys Nortel Networks WLAN Handsets 2210 and 2211. This section will briefly look at this network.

8.1.1 Network Overview

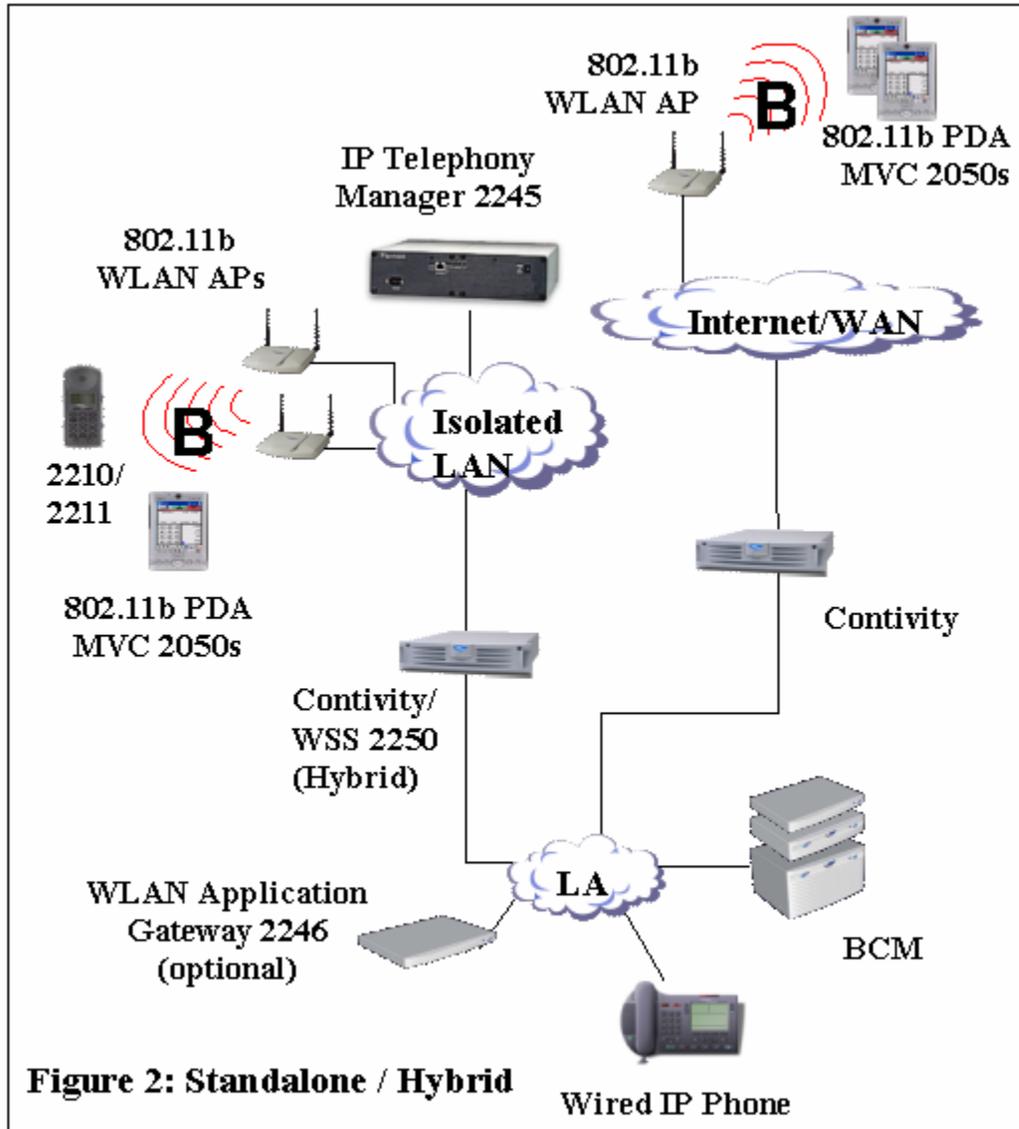
Figure 2: Standalone and Hybrid represents two networks. Standalone network is the simplest wireless configuration and is very similar to Figure 1: Network Overview. It is generally for a small WLAN with a few users. The standalone network consists of the following main components.

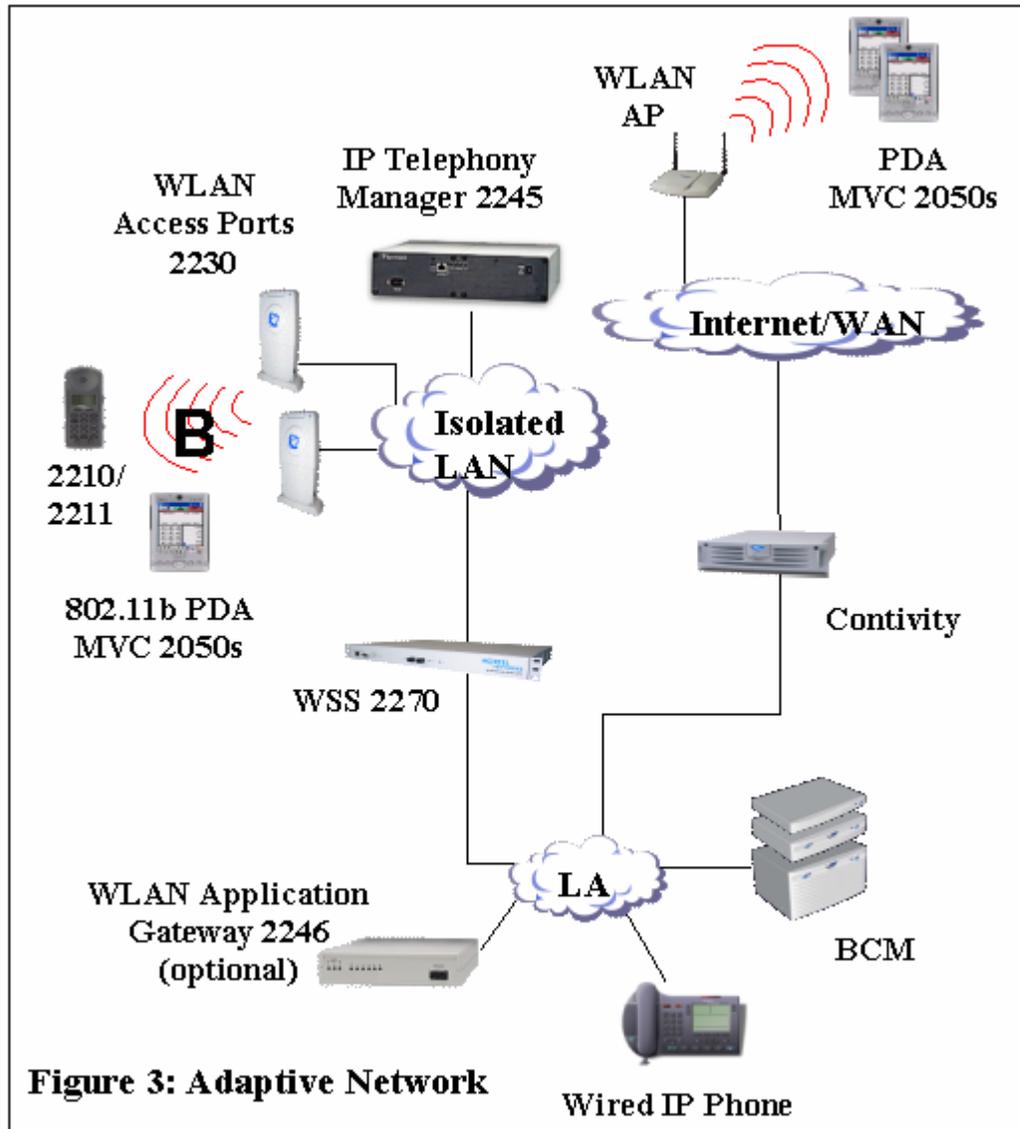
- WLAN Telephony Manager 2245 – An Ethernet LAN application that works with the access point to provide QoS (SVP protocol) for WLAN Handsets 2210 and 2211 on the wireless LAN. This component is only required when WLAN Handsets 2210 and 2211 are deployed. It is not required for the MVC 2050.
- WLAN Application Gateway 2246 – An OAI that enables third party software applications to communicate with the WLAN Handsets 2210 and 2211. The WAG 2246 is optional.
- WLAN Access Points supporting 802.11b – WLAN Access Point 2225 is a standalone multi-mode access point supporting 802.11a/b/g.

The Hybrid Network uses the same components as the Standalone network however it is for larger installations which require centralized security and therefore has a WSS 2250.

Figure 3: Adaptive Network is for customers in a greenfield environment. Like the Standalone or Hybrid Networks, an Adaptive Network uses the WTM 2245 and WAG 2246. However, the WSS 2250 and access points are replaced by:

- WLAN Security Switches 2270 – Security Switch 2270 provides centralized security and management plus total control of their RF domain.
- WLAN Access Ports 2230 and 2231 – Multi-mode access ports with air monitoring capability and complemented by the WLAN Security Switch 2270.





8.1.2 MVC 2050

The SVP protocol is a proprietary QoS extension that provides the WLAN Handsets' traffic with priority over data traffic. While providing QoS to targeted WLAN handsets, voice traffic from MVC 2050 users will be invisible to the WTM 2245, potentially resulting in decreased audio quality for MVC 2050 users on the same access points as 2210 and 2211 WLAN handsets. If the access point is prioritizing PDA devices at the same level as the WLAN handsets 2210 and 2211, then both types of devices will receive the same level of QoS. If the MVC 2050 users are treated at a lower priority, then quality may be less on the MVC 2050 than the WLAN Handsets 2210 and 2211.

The medium to long term solution is the 802.11e standard which will replace proprietary QoS. The short term solution is:

- Under SVP, the WTM 2245 can be configured to specify how many simultaneous conversations can be supported on each access point, typically 8 on 802.11b WLAN. The number could be decreased to 5 or 6, if there is a mix of WLAN Handsets 2210 and 2211 and MVC 2050 users.
- Provide a mix of QoS mechanisms that support SVP and MAC based filtering and/or 802.11p/Q on a single access point.
- Support Multiple SSID. For example, all of the voice. i.e. SVP devices and MVC 2050 users could be on the 802.11b and the data devices could be on the 802.11a.

8.1.3 Optimal Configuration

The following are recommended to enhance the MVC 2050 experience.

Global settings:

- Disable Aggressive Load Balancing
- Enable Ethernet Broadcast support
 - Only required if using PTT for WLAN Handset 2211
- Enable L3 LWAPP mode
 - Optional, but required if using PTT for WLAN Handset 2211
- Disable 802.11g support
- Set Gold queue length to 20
 - This can only be done by CLI
- Create a unique interface, VLAN, on WSS 2270 to map voice clients to
- Do not use Closed System

Per SSID settings:

- Create dedicated WLAN/SSID for voice devices only
- Map SSID/VLAN to the dedicated voice VLAN/interface.
- Enable MAC security using RADIUS or local database on 2270
 - Optional but recommended for enhanced security
- Enable Static WEP with longest key available that PDA devices will support
 - Optional but recommended for enhanced security
 - If WLAN Handsets 2210 and 2211 are in use on this WLAN, this may be too cumbersome to be worthwhile
- If the only voice devices are PDAs then possibly you might do 802.1x in place of the two steps above (optional)
- Set Gold QoS for WLAN/SSID

Per radio settings:

- Use WLAN override to disable all other WLANs and SSIDs than the voice SSID on 802.11b.
- Use WLAN override on the 802.11a radios to disable the voice WLAN/SSID.

9 Resources

Here is a list of useful websites and documents.

9.1 Websites

- PDA Sites:
 - HP – Download latest drivers and discussion group
<http://h10010.www1.hp.com/wwpc/us/en/sm/WF02d/215348-64929-215381.html>
 - Dell – Login required to download drivers (under Service & Support)
<http://www1.us.dell.com/content/products/category.aspx/pda?c=us&cs=19&l=en&s=dhs>
 - Toshiba – Download latest drivers and specifications
<http://www.toshiba.com/tai-new/>
 - Axim user groups - Helpful for solving Axim issues
<http://www.aximsite.com/boards/> and
<http://www.aximusers.com/>
 - Dave's iPAQ – An iPAQ discussion group
<http://www.davesipaq.com/index.shtml>
 - Pocket PC PDA Buyer's Guide – Reviews of various PDA devices
<http://www.pdabuyersguide.com/ppc.htm>

- PDA Programs:
 - Microsoft – Windows Mobile / Pocket PC
<http://www.microsoft.com/windowsmobile/default.msp>
 - SuperTask – CPU consumption monitoring tool
<http://www.softwareandson.com/SuperTasks/>
 - Certicom's Movian VPN Client
<http://www.certicom.com/index.php?action=product,mvpn>
 - Apani Networks Netlock VPN client
http://www.apani.com/datasheets/netlock_vpn_nortel.html
 - XCPUScale – Clocks CPU to different speeds
<http://immiersoft.com/>
 - Handango – Various Pocket PC Software
<http://www.handango.com/PlatformSoftware.jsp?siteId=1&jid=E7881E57CEAC488A51537D6AF1BEFC79&platformId=2>

- WiFi Sites:
 - WiFi Planet – Tutorials, discussion groups, etc.
<http://www.wi-fiplanet.com/>
 - MobileInfo.com - Mobile computing and wireless information
<http://www.mobileinfo.com/Default.asp>
 - SanDisk – CompactFlash WLAN cards
<http://www.sandisk.com/>
 - Socket – CompactFlash and SD WLAN cards
<http://www.socketcom.com>
 - pocketWiNc – WLAN sniffer for PDA
<http://www.cirond.com/site/products/wifispotter.htm>

- Headsets
 - Plantronics – Approved headsets for HP iPAQ PDA devices
http://www.plantronics.com/ipaq/en_US/catalog/display_category_type.jhtml;jsessionid=D1M15GRQABIU0CQBGNTCFEYKAEZWKIV0?id=cat4820075&rootId=cat4820068&productTypeId=cat4820075&requestid=195673

- Other
 - Google – For finding PDA programs and resolving issues
<http://www.google.com/>

9.2 Documents

BCM MVC 2050 Documents:

MVC 2050 User Guide

Reference: i2050 Install Guide

10 References

- [1] WLAN Security Switch white paper
 - [2] Nortel Networks Mobile Unit 2201 Install guide
 - [3] Nortel Networks WLAN Access Point 2220 User Guide
 - [4] Application Guide of the WLAN Security Switch 2200
 - [5] Using the Nortel Networks Wireless LAN Access Point 2220
 - [6] Dell Axim X5 User Guide
 - [7] Dell Axim X3 User Guide
 - [8] Toshiba Pocket PC e750/e755 User's Manual
 - [9] Toshiba Pocket PC e750/e755 Detailed Specifications
 - [10] Toshiba Pocket PC e800/e805 User's Manual
 - [11] Toshiba Pocket PC e800/e805 Detailed Specifications
 - [12] HP iPAQ Pocket PC h5100 and h5500 series User's Guide
 - [13] HP iPAQ Pocket PC h5400 series User's Guide
 - [14] Switches Improve WLAN Range and Performance
By Jim Geier July 2nd 2003 From WiFi Planet
 - [15] Moving Towards Converged Mobility: Straight Talk on Voice over Wireless LANs
- 1)

11 Definitions & Abbreviations

AGC	Automatic Gain Control
AP	Access Point
Bluetooth	A wireless technology standard for short-range (30 ft) networking devices that allows for enabled devices to automatically recognize each other.
BST	Battery Saving Techniques
CF card	CompactFlash card – A removable card that is used to expand the capabilities of the PDA. Common types of CF cards include wireless and memory cards.
CLI	Command Line Interface
Codec	COder / DECoder
CPU	Central Processing Unit
CR	Change Request
DCF	Distributed Coordination Function
DSSS	Direct Sequence Spreading Spectrum
EDCA	Enhanced Distributed Channel Access
G.711	64k bps voice digitization
G.729	8kbps compressed voice digitization
HCCA	HCF Controlled Channel Access
HCF	Hybrid Coordination Function
IP/UDP	Internet Protocol / User Datagram Protocol
ISM	Industrial, Scientific and Medical. This refers to the unlicensed radio bands which are typically unused due to interference from medical, industrial and scientific equipment. WLANs use these bands since no governmental approval is needed for transmission, making it a great deal cheaper.
ITG	Internet Telephony Gateway
Kbps	Kilobits per Second
LWAPP	Light-Weight Access Point Protocol
MAC	Medium Access Control
MB	Mega Bytes
MSDU	MAC Service Data Unit
OAI	Open Applications Interface

OFDM	Orthogonal Frequency Division Multiplexing
PCF	Point Coordination Function
PDA	Personal Digital Assistant
PLCP	Physical Layer Convergence Procedure
PPC or Pocket PC	A device which runs Microsoft Windows CE operating system
PPP	Point to Point Protocol
PTT	Push-To-Talk
QoE	Quality of Experience
RAM	Read Access Memory – The primary temporary storage area for instructions and data. Any information stored in RAM is lost when PDA is reset.
ROM	Read Only Memory – Memory that stores data and programs that can not be deleted or written to by the PDA. All information is retained after the PDA is rested.
SD card	Secure Digital card – Functions the same as CF but is a smaller form factor.
SDRAM	Synchronous dynamic RAM.
SSID	Service Ser IDentifier
SVP	SpectraLink Voice Priority
TCP/RTP	Transmission Control Protocol / Real-Time Transport Protocol
VLAN	Virtual LAN
VoWLAN	Voice over WLAN
VPN	Virtual Private Network
WEP	Wired Equivalent Privacy
WiFi	Wireless Fidelity – generally referring to any type of 802.11 network
WLAN	Wireless LAN
WME	Wireless Multimedia Enhancement™
WMS	Wireless Multimedia Scheduling
WPA	WiFi Protected Access™

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