

The Value of Cisco Compatible Extensions (CCX) for Mobile Computers

A Summit Data Communications White Paper

October 2007



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The Importance of Standards

Once used primarily in vertical markets such as retail and transportation, wireless LAN or Wi-Fi[®] products now are everywhere: in homes, coffee shops, offices, hospitals, airports, and many other types of environments. Wi-Fi involves communication through radios that use a specific type of radio frequency (RF) technology. Many of today's popular portable and mobile computing devices, such as notebook computers and phones, include Wi-Fi radios as standard equipment.

The foundation of the Wi-Fi boom is interoperability, which ensures that the Wi-Fi radio in a client device will interoperate with the Wi-Fi radio in infrastructure products such as access points (APs) and routers, regardless of who makes the radios, the client device, or the infrastructure products. Interoperability results from all products supporting the same standards for communication and interoperation. Standards for wireless LAN products are defined and ratified by the 802.11 Committee of the Institute of Electrical and Electronics Engineers, or IEEE. As a result, wireless LAN products often are referred to as 802.11 products.

The IEEE defines standards but has no mechanism for enforcing them. As a result, interoperability of wireless LAN products is ensured not by the IEEE but by the Wi-Fi Alliance[®], a non-profit industry association of more than 300 member companies. The Wi-Fi Alliance determines how well products implement the IEEE 802.11 specification by developing rigorous interoperability tests and running those tests against products from different vendors. Since the introduction of the Alliance's certification program in March 2000, more than 3,500 products have passed all required tests and been designated as Wi-Fi CERTIFIED[™].

As an example, to achieve the Enterprise level of Wi-Fi certification, a product with an 802.11g radio must pass a broad range of tests that demonstrate support for:

- 802.11b and 802.11g, including acceptable throughput for both
- The security standards of Wi-Fi Protected Access[™] (WPA) and WPA2, the latter of which is equivalent to the ratified wireless LAN security standard of IEEE 802.11i
- At least one Extensible Authentication Protocol (EAP) method in conjunction with WPA and WPA2

Organizations that run business-critical applications on mobile devices demand that those devices be Wi-Fi CERTIFIED. For many of these organizations, however, Wi-Fi CERTIFIED is not enough.

CCX

About 65% of the wireless LAN infrastructure systems in today's businesses use products from Cisco Systems, Inc. As a result, most organizations with business-critical mobile devices want to ensure that their devices interoperate with a Cisco wireless LAN infrastructure and support Cisco wireless LAN innovations for enhanced security, mobility, quality of service, and network management.

Nearly all mobile device vendors claim that their devices work well with a Cisco wireless LAN infrastructure. Fortunately, you don't have to take a vendor's word for it. Since 2003, Cisco has managed a program by which Wi-Fi radios and mobile devices with those radios can earn the Cisco Compatible logo. The logo signifies that a radio or device interoperates with a Cisco wireless LAN infrastructure and supports Cisco innovations. The program is called the Cisco Compatible Extensions (CCX) program.

Within CCX, Cisco licenses a specification of IEEE standards and Cisco innovations. A licensee, typically a firm that offers wireless LAN radios for client devices, implements support for all required elements of the specification in the software for a Wi-Fi radio. The licensee then submits the radio, or a client device that uses the radio, to an independent lab for rigorous testing. Only by passing all tests does the radio or device earn the Cisco Compatible seal.

CCX and Standards

The CCX program has a structure that is similar to that of the Wi-Fi certification program. With both programs:

- One or more specifications define what features must be implemented in the hardware and software for a Wi-Fi radio or a device that uses a Wi-Fi radio.
- Compliance testing is conducted by an independent lab that is approved by the organization that manages the program
- A device must pass all tests to be approved

Perhaps the biggest difference between the programs is the types of devices that qualify for each program. The Wi-Fi certification program is for any type of product that uses Wi-Fi technology. The table below shows the types of devices that can be Wi-Fi CERTIFIED:

Device Type	Description	Examples	CCX?
Radios	Provide Wi-Fi capabilities to devices	<ul style="list-style-type: none"> • Reference design • Module embedded or used in device • Cards used in device's external slot 	✓
Client devices: General	Computers used for general applications	Laptop, notebook, and desktop computers	✓
Client devices: Voice ASDs	Application-specific devices (ASDs) for which the primary application is voice communications	<ul style="list-style-type: none"> • Dual-mode phones that support both Wi-Fi and cellular • Single-mode phones that support Wi-Fi only • Dual-mode and single-mode smartphones 	✓
Client devices: Data ASDs	ASDs that run primarily data applications	<ul style="list-style-type: none"> • Data terminals and other mobile computers • Personal digital assistants (PDAs) • Printers and print servers 	✓
Consumer electronics	Non-business devices that benefit from Wi-Fi	Cameras, audio devices, video devices, gaming devices, storage devices and servers	
Infrastructure devices	Link client devices to the network	<ul style="list-style-type: none"> • Routers for homes and small offices • Cable, DSL, and other broadband gateways • APs, switches and controllers, and routers for enterprises • Other types of infrastructure devices 	

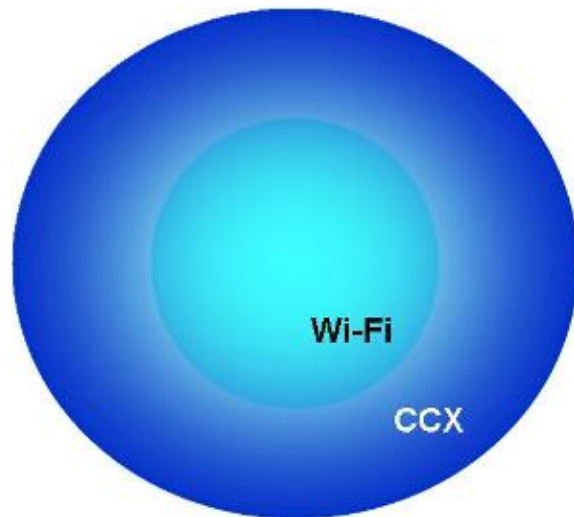
CCX is for client devices and the Wi-Fi radios that they use. Those radios and client devices are tested as they interact with Cisco wireless LAN infrastructure products, which are used by businesses and other organizations. As a result, CCX targets business devices, not consumer devices. In short, CCX is for all of the categories in the table above except for consumer electronics and infrastructure devices.

Another difference between CCX and the Wi-Fi certification program is what is in the specification. According to Dave Molta and James Blandford of *Networking Computing*¹, Cisco launched CCX to ensure that a broad range of client devices support the proprietary features of Cisco's wireless LAN infrastructure offerings. Because the CCX specification includes Cisco-defined technologies and features, Cisco has been accused of using CCX to bypass the standards process and force customers to use proprietary features.

The CCX specification, however, is for more than Cisco technology. In fact, the CCX specification is a superset of the specification used for Wi-Fi compliance. A device cannot be certified as Cisco Compatible unless that device or the wireless LAN radio that it uses is Wi-Fi CERTIFIED.

The CCX specification also includes some IEEE standards that are not ratified and have not been incorporated into Wi-Fi compliance testing. Cisco even uses CCX as a way of introducing and proving innovative solutions that Cisco then takes to the appropriate IEEE 802.11 task groups as proposed standards. CCX features have been proposed to the following task groups:

- 802.11h and 802.11k: Radio measurements
- 802.11r: Fast roaming
- 802.11u: Expedited bandwidth request
- 802.11v: Real-time reporting and client diagnostics
- 802.11w: Management frame protection



The CCX specification is a superset of the Wi-Fi specification

Molta and Blandford summarized their findings as follows:

We have reservations about vendors that abandon industry standards to pursue proprietary approaches, but we see no evidence of this practice in Cisco's CCX program. The company has diligently added support for all newly developed IEEE standards to new versions of CCX and has turned to proprietary extensions only when the features have significant value to customers and equivalent functionality is not available through standard protocols and services.

Because it requires program participants to implement support for both established and emerging IEEE and industry standards, CCX encourages support for standards in the market. As vendors vie for prominence in CCX by implementing support for new CCX versions faster than competitors do, support for standards is accelerated across a broad range of mobile devices.

CCX for ASDs: Features

The CCX specification defines the features that a Wi-Fi radio, or a client device that uses a Wi-Fi radio, must support to be deemed “compatible” with a Cisco wireless LAN infrastructure. Cisco has published five versions of its CCX specification, with each version building on the last. Today, a product can be certified only at one of the two most recent versions: Version 4 (V4) or V5.

In each version of CCX, some features that are classified as optional for application-specific devices, or ASDs. Examples of ASDs are mobile computers, smartphones, and printers. The CCX specification for ASDs is a subset of the CCX specification for laptops. Some CCX features are not required for ASDs because many ASDs lack the computing power or operating system foundation required to support the features.

Here are the primary features of CCX V4 for ASDs:

- Wi-Fi certification for the device or the radio in the device
- WPA and WPA2 with at least one of the following EAP types: LEAP, EAP-FAST, and EAP-TLS
- Wi-Fi Multimedia (WMM), a standard for quality of service (QoS)

- Cisco roaming enhancements, such as AP-assisted roaming and fast 802.1X re-authentication via the Cisco Centralized Key Management (CCKM) protocol
- Improved client and network management through support for multiple SSIDs and VLANs on an AP, AP-specified client transmit power, and client-based RF scanning and reporting
- Voice features, introduced in V4:
 - Call Admission Control (CAC): The ability to reserve and control bandwidth for voice, improving the quality of voice calls
 - Unscheduled Automatic Power Save Delivery (U-APSD), also called reverse polling: Allows synchronization of send/receive in one atomic operation to improve battery life, increase capacity per AP, and reduce congestion
 - Voice metrics: Provides information to predict and tune networks for optimum voice over wireless LAN performance

CCX V4 and Mobile Computers

CCX V4 for ASDs is essentially CCX V3 for ASDs plus the voice features listed above. Support for voice features bring few benefits to mobile computers, which can be considered business-class ASDs that are used for data applications. Without certification at CCX V4, however, mobile computers cannot use any CCX features when interacting with Cisco's flagship wireless LAN infrastructure solution, which is known as the Cisco Unified Wireless Network.

Most Cisco APs can operate in one of two configurations: autonomous or controller-based. APs that run without Cisco controllers are said to run in autonomous mode and an autonomous configuration. APs that rely on controllers are said to run in lightweight mode as a part of a controller-based configuration. Cisco's controller-based solution is the Cisco Unified Wireless Network, and Cisco is delivering most of its wireless LAN enhancements for that solution and not for autonomous APs.

The software that runs on controllers supports CCX versions 1 through 4. For each client device radio that associates to a controller-based AP, the controller interrogates the client radio for the highest CCX version that it supports. If the radio is not certified to support V4 or higher, then the controller does not support any CCX features for the client. As a result, **CCX V4 certification is essential for all devices that want to use CCX features with the Cisco Unified Wireless Network.**

The Value of CCX for Mobile Computers

For network administrators, CCX reduces costs, complexity, and risks. By using CCX devices, an administrator has the assurance that the devices will interoperate with a Cisco wireless LAN infrastructure. In fact, because the CCX specification incorporates all key requirements for Wi-Fi certification, the Cisco Compatible seal provides the assurance of interoperability even with non-Cisco wireless LAN infrastructures. And because many of today's Cisco innovations are likely to become tomorrow's IEEE and industry standards, an administrator may be able to change the infrastructure in the future without having to abandon the CCX features exploited by today's infrastructure and clients.

When only CCX-certified devices can connect to the wireless LAN, the infrastructure can have a single configuration that supports a rich set of capabilities in key areas such as security and mobility. On the security front, the network can require the use of WPA or WPA2 with the organization's preferred choice of an EAP type. To ensure application persistence on mobile devices, the network can require the use CCKM for fast EAP re-authentication. In contrast, when the wireless LAN must accommodate devices that lack support for some CCX features, network administrators have to do one or more of the following:

- Introduce security risks by using weaker security schemes supported by devices not certified for CCX
- Increase network complexity and costs by creating additional wireless LANs for non-CCX devices and tying those wireless LANs to network VLANs to protect sensitive data on the network

- Purchase and deploy additional software to maintain network connections on devices with inferior mobility

Because CCX brings key benefits to network administrators, those administrators increasingly are demanding the Cisco Compatible seal on a broad range of devices, including mobile computers. Given that Cisco has a 65% share of the market for enterprise wireless LAN infrastructure and an even greater mindshare among customers, mobile computer vendors that fail to earn the Cisco Compatible seal may find themselves losing deals to competitors that do.

Challenge: Achieving CCX on Mobile Computers

CCX has been an overwhelming success in the laptop world. According to Cisco, the top five vendors of laptop and notebook computers participate in the CCX program. Acer, Dell, Gateway, HP, Lenovo, and Sony offer laptop and notebook computers that are certified for CCX at Version 3 or above. When a new version of CCX is introduced, the first devices to support it are laptop and notebook computers, even though the required feature set for those devices is broader than that for ASDs.

While scores of firms manufacture mobile computers, only a handful offer mobile computers that are certified at any level of CCX. As of October 2007, no mobile computer had achieved CCX V4 certification, and only five vendors offered mobile computers certified at V3:

- Datalogic: Falcon 4400, Pegaso
- Intermec: CK31, CK61, CN3, CN30, CV30, CV60
- LXE: HX2, MX5, MX6, MX7, MX3X, VX6, VX7
- Psion Teklogix: 7530, 7535, 8525, 8530, Workabout Pro
- Unitech: PA962, PA966, PA982, HT660, RH767

Why are relatively few mobile computers certified for CCX? It's not because CCX features offer more value on laptops than on mobile computers. Security features are important on all types of devices, and features that enhance mobility, such as CCKM for fast 802.1X re-authentication, offer more value on mobile computers than on laptops because mobile computers run applications that can fail without a constant network connection.

With both laptops and mobile computers, support for CCX features is implemented primarily in the Wi-Fi radio software that runs on the device. The primary software components are a device driver, a security supplicant, and an administrative utility. Supporting CCX requires the following software development tasks:

- Modify the radio device driver to add support for driver-based CCX features
- Integrate a security supplicant that offers support for CCX security features
- Create an administrative utility for configuring settings required for various CCX features

In the laptop world, the required software development is done not by laptop vendors but by silicon providers. These firms provide not just silicon, or chips for Wi-Fi radios, but reference designs for radios in specific form factors that fit into laptops, such as mini-PCI or PCI Express. A reference design is not just the radio hardware but also the software that makes the radio work on the laptop operating system, which in the past was Windows XP but today is Vista. XP and Vista provide a security supplicant and administrative facilities within Windows Zero Config (WZC), but WZC does not support all CCX security features. As a result, the silicon provider must include an integrated security supplicant and an administrative utility in the reference design.

The high volumes of laptop sales worldwide attract many silicon providers, but the leaders are Intel, Atheros, and Broadcom. Intel, Cisco's lead CCX collaborator, is motivated to implement CCX support; Atheros,

Broadcom, and others are motivated to do the same so that they can compete with Intel. Once a silicon provider implements CCX support in a mini-PCI or PCI Express reference design and has that reference design certified for CCX, a laptop vendor can achieve the same level of CCX compliance by simply including the reference design in the laptop. The laptop vendor makes no hardware modifications or software modifications.

The mobile computer market is a challenging one for silicon providers, for reasons that include:

- Device volumes are one or two orders of magnitude lower than for laptops
- The percentage of the market addressed by a single reference design is reduced by the fact that different mobile computers use different radio form factors and run different operating systems
- Implementing CCX features requires software modifications for every reference design that a silicon provider offers
- Because mobile computers are specialized devices, radio software that works properly on one mobile computer often must be modified to run on another mobile computer, even when the two mobile computers have the same processor, memory, and other core hardware components

The table below lists these and other challenges and the results:

Issue	Laptops	ASDs	Result
Use of Cisco radios	Not a factor since 2003	Still prevalent in 2006	Demand for mobile computer CCX reference designs began only recently
Potential volume	Tens of millions	Hundreds of thousands	Fewer silicon providers produce mobile computer CCX reference designs
Wi-Fi radio form factors	Mini-PCI or PCI Express	PCMCIA, compact flash, SDIO, others	No single form factor offers a huge opportunity
Operating systems	Windows XP, Vista	CE 4.2, 5.0; Mobile 2003, 5, 6; Linux; others	Must produce different reference designs for different OSs
CPU	x86	x86, StrongARM, XScale, Freescale, others	Software modifications for different CPUs raise costs

The bottom line is that no silicon provider provides a CCX reference design for mobile computers. The challenge for mobile computer vendors is to take Wi-Fi radio reference-design software intended for laptops and do the following:

- Port the device driver to the operating system that runs on the mobile computer
- Modify the radio device driver to add support for CCX features not supported in the reference-design driver
- Integrate a security supplicant with support for security features not supported in the operating system
- Create an administrative utility for configuring settings required for various CCX features
- Test the resulting software set on the mobile computers and make modifications as necessary

The challenge is too great for most mobile computer vendors.

Fortunately, a viable alternative exists for mobile computers: radios from Summit Data Communications. Only Summit offers CCX-certified radios for mobile computers. Simply by using a Summit radio, a mobile computer that runs Windows CE, Windows Mobile, or Windows XP can be tested and certified for CCX. That is why the majority of Cisco Compatible mobile computers use Summit radios.

Why does Summit deliver CCX-certified radios for mobile computers when no other vendor does? Summit is dedicated to providing high-performance radio modules and cards that meet the challenging requirements of mobile computers. From its start, Summit has recognized that mobile computer users place a high value on CCX, and so Summit has engineered CCX support into every one of its products.

Summary

Organizations of all types and sizes worldwide rely on mobile computers, which run business-critical applications and must operate reliably. For most mobile computers, a critical piece of reliable operation is a reliable connection to a wireless network. That connection is provided by a Wi-Fi radio in the mobile computer. If the radio doesn't work, the device doesn't work.

IEEE and industry standards define how a Wi-Fi radio interoperates with a wireless LAN infrastructure, and the Wi-Fi CERTIFIED seal ensures interoperability. For many organizations that rely on mobile computers, however, Wi-Fi CERTIFIED is not enough. These organizations need assurance that their mobile computers will interoperate with a Cisco wireless LAN infrastructure and support Cisco wireless LAN innovations for enhanced security, mobility, quality of service, and network management. The Cisco Compatible seal gives organizations the assurance that they seek.

A mobile computer earns the Cisco Compatible seal through a program called Cisco Compatible Extensions, or CCX. Like the Wi-Fi certification program, CCX:

- Includes a specification that defines a set of features that must be implemented in the hardware and software for a Wi-Fi radio or a device that uses a Wi-Fi radio
- Requires compliance testing that is conducted by an independent lab that is approved by the organization that manages the program
- Requires that a submitted radio or device pass all tests to be approved

The CCX specification is a superset of that used for Wi-Fi certification. Cisco has published five versions of its CCX specification, with each version building on the last. Today, a product can be certified only at one of the two most recent versions: V4 or V5. Each version includes a specification for mobile computers and other application-specific devices, or ASDs. The specification for ASDs is a subset of the specification for laptops.

CCX has been an overwhelming success in the laptop world, where a few silicon providers do all of the work in their reference designs for radios. Because the mobile computer market is a challenging one for silicon providers, there are no CCX radio reference designs for mobile computers. The task of modifying reference-design software to support all required CCX features is a daunting one for most mobile computer vendors. An alternative is to use high-performance radios from Summit Data Communications, because those radios already are certified for CCX.

Summit Data Communications provides high-performance Wi-Fi radio modules and cards for mobile computers and other business-critical mobile devices. Summit radios are optimized for the challenging radio environments in which business-critical mobile devices operate, such as factories, warehouses, ports, hospitals, and retail stores. Summit solutions combine hardware, software, and services, with services including CCX pre-testing and procedural assistance.

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ⁱ “Cisco CCX plays by the rules,” *Network Computing*, 24 February 2006