

White paper

**70 Series Ultra Rugged Mobile  
Computers and IEEE 802.11n**

*Wireless Local Area  
Networking Overview*

## Summary

Wireless Local Area Network (WLAN) Communications has grown from its initial cable cutting wireless specification in IEEE 802.11 in 1997 to a ubiquitous broadband wireless access technology with the release of current specifications in 802.11n - 2009. Enterprise operations have come to depend on WLAN for everyday business operations whether in the warehouse, over carpeted space, or on the road at available hotspots. Wi-Fi is simply everywhere. Intermec has been involved with 802.11 since its inception and understands the demanding requirements of using Wi-Fi for business operations.

The Intermec 70 Series ultra-rugged mobile computing platform represents the state-of-the-art in technology and industrial standards for handheld mobile devices using Wireless Local Area Network (WLAN) Communications. No matter what WLAN compatible infrastructure deployment (IEEE802.11abgn), no matter what the frequency band of operation (2.4 GHz or 5 GHz), the 70 Series Wi-Fi integration is designed to comply with Wi-FiAlliance requirements and offer exceptional performance. A wide range of Wi-Fi legacy and current security standards operation are supported; WPA, WPA2 personal and enterprise. Most importantly, the 70 Series computers are the industry's first ruggedized handheld computers to contain the latest in Wi-Fi technology with IEEE802.11n operation.

To be effective both technically and financially WLAN needs to meet multiple requirements. The WLAN technology integrated into 70 Series computers is designed to meet the demanding requirements of enterprise operation. Intermec has heeded the following insights garnered from customers regarding 802.11 solution deployment:

**Performance** – enterprise operations have challenging RF environments. Parameters that impact the propagation of RF signals tend to be at their worst in warehouse environments; multipath, external noise sources, poor Signal-to-Noise Ratios [SNR], distances to Access Points. The performance, range, or general reliability of the WLAN always stands as the most important concern for enterprise operation.

**Dual Band Operation** – IT departments need the option to separate traffic into different bands. 2.4 GHz operation may be fine for most applications, but utilizing 5 GHz operation can separate traffic out of the congestion into a lower noise environment.

**Backwards Compatibility** – Let's face it, upgrading infrastructure and legacy devices takes time and money. During the period where older infrastructure equipment needs to be amortized IT departments do not want to penalize new Mobile Device purchases. Everything must be compatible.

**Throughput** – Whether it is due to new applications needing data bandwidth (such as Video or multimedia) or the sheer number of devices needed on a network at one time, throughput is a concern. As we progress into an all Internet Protocol world, throughput and quality of service is a growing concern.

The following paper now takes a deeper dive into the details of the 70 Series' 802.11n Wi-Fi CERTIFIED solution is addresses the challenges of enterprise operation.

## Performance

The Wi-Fi technology embedded in the 70 Series offers high radio output power levels.

- 802.11b 17.0 dBm +/-1
- 802.11g/n 13.0 dBm +/- 1
- 802.11a/n UNII 1 & 2 12.5 dBm +/- 1
- 802.11a/n UNII 2e & 3 11.5 dBm +/- 1

The 70 Series achieves optimal handheld to AP links via its antenna gains and ideal RF radiation patterns. This allows the 70 Series to achieve 100 mW radiated power.

Excellent sensitivity and high antenna gains also offer strong down-stream operation.

- 802.11b -96 dBm @ 1 Mbps
- 802.11g -87 dBm @ 11 Mbps
- 802.11a -71 dBm @ 54 Mbps
- 802.11a -68 dBm @ 54 Mbps

The 70 Series computers' Wi-Fi transceiver supports all the data rates of IEEE802.11bg from 1 Mbps, using Direct Sequence Spread Spectrum Modulation (DSSS) to 54 Mbps using orthogonal frequency division modulation (OFDM). Full IEEE802.11 protocol support makes the 70 Series backwards compatible with any legacy Wi-Fi infrastructure.

The 70 Series supports the **High Throughput (HT) Data Rates MCS0 through MCS7** through a **Single Stream** as required by IEEE 802.11n. The system supports **20 MHz BW operation**, and is able to **detect 40 MHz operation** of neighboring devices through its preamble support.

The 70 Series offers superior mobile Wi-Fi roaming performance through the **Intermec Dynamic Scan Threshold Algorithm**. Consider that a mobile device user must traverse through the enterprise operation while maintaining network connectivity to the available infrastructure. In the past this meant system engineers needed to fine tune static roaming thresholds. The **Dynamic Scan Threshold Algorithm** monitors the received signal strength indication (RSSI) and adjusts the scan threshold based on observed trends. The benefit of Dynamic Roaming Threshold is that roaming is adjusted for dense or sparse AP environment, *without having to manually adjust static parameters*. That means the 70 Series will adapt the roaming thresholds for optimal performance regardless of the network deployment.

The 70 Series also tracks a configurable number of AP candidates via the **Tracking Scan Algorithm**. Periodically probe requests are sent to candidates' channels to keep the list up-to-date. The algorithm also uses Cisco's CCX compliant AP neighbor list if it contains better candidates than are currently being tracked. The benefit of the Tracking Scan is that the 70 Series will have current network data and may be able to roam immediately without additional scanning.

### Efficiency

Enterprise operations also demand long runtimes for handheld products without sacrificing communications availability. Battery requirements of the 70 Series Wi-Fi are approximately 60% of legacy technologies while providing the outstanding RF performance just described. This allows for longer device operation without impacting communications requirements.

### Security

The 70 Series is capable of a rich suite of security configurations such as WPA™ – Enterprise, Personal and WPA2™ – Enterprise, Personal. In addition the system allows for a wide suite of authentication types;

- EAP-TLS
- EAP-TTLS/MSCHAPv2PEAPv0/EAP-MSCHAPv2
- PEAPv1/EAP-GTC
- EAP-FAST

### Interoperability with IEEE Standards

The industry anticipation of IEEE 802.11n comes to fruition in the 70 Series with operation on both 2.4 GHz and 5 GHz channels. But the question remains – just what exactly is 802.11n and how does it help with range and throughput? What is the impact on legacy support? For that we need to dive a little deeper into the specifications so as to relate the details back to the pragmatics of enterprise operation.

The 70 Series is able to interoperate in a mixed wireless environment with other devices using any of the now released IEEE 802.11abgn standards. If the deployment needs 802.11n Greenfield operation the 70 Series is able to comply with the appropriate preambles and High-Through (HT) data rates.

The 70 Series is certificated with both the Wi-Fi Alliance (Wi-Fi) and Cisco Compatible Extensions (CCXv4). These industry association compliances ensure the 70 Series is interoperable with a wide range of infrastructure products and is able to take advantage of the features they offer. It is the customer's assurance that Intermec has met all the rigors of Wi-Fi implementation for the enterprise operation.



### Enhancements for 802.11n

The 70 Series achieves its interoperability with legacy modes and 802.11n enhancements by supporting all the necessary HT Physical (PHY) Layer preambles; **non-HT format (Legacy)**, **HT-mixed format**, and **HT-greenfield format**.

In **non-HT format** the 70 Series sends and receives PHY layer packets with the legacy format used for 802.11abg. This allows full interoperability with both infrastructure and other devices that only support legacy modes. Performance is as shown earlier for legacy operation

In **HT-mixed format** the 70 Series is able to take advantage of high throughput rates offered by supporting Access Point Infrastructure while still maintaining interoperability with other devices that only support legacy mode.

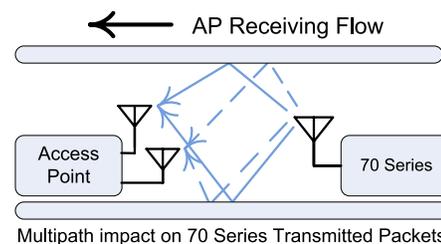
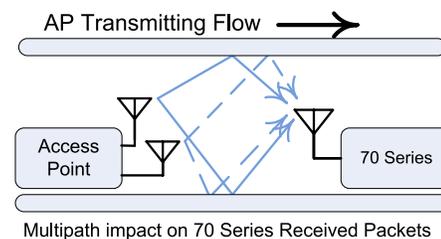
The 70 Series supports the optional **HT Greenfield preambles** so as to interoperate with infrastructure and devices that only support HT capabilities. This feature allows the 70 Series to acknowledge 20 or 40 MHz operation by other devices in the network.

IEEE 802.11n achieves key enhancements in WLAN operation via WLAN Antenna systems used in the infrastructure, the radio Physical Layer, and Media Access Layer. These key enhancements translate into better range, reliability, throughput, and efficiency for the enterprise operation. It is important to understand the enhancements require coordination with a compatible 802.11n infrastructure.

### Multiple Input Multiple Output (MIMO)

Methods of combating RF multipath propagation issues are addressed in 802.11n. In fact the normally detrimental effects of multipath propagation are exploited for 802.11n. As a result, the AP and STA working together can use the available antennas (at either the AP or STA) to add resilience to fading, or marginal coverage areas. The Intermec 70 Series Computer follows the Wi-Fi Alliance classification of a Handheld (HH) Device.

The Series 70 Computer supports a **Single Spatial Stream**. During transmit from 70 Series computers, the supporting AP will use Maximum Ratio Combining for best reception of a Multipath impaired signal. For reception by the 70 Series Computer the AP can use beam-forming (to point the RF energy at the STA) or Space Time Block Coding. Future Software release of 70 Series computers will add support for MIMO through processing of **Space Time Block Coded (STBC)** signal sent by a compatible Access Point. STBC allows devices with one spatial stream to realize improvements in performance despite RF propagation impairments.

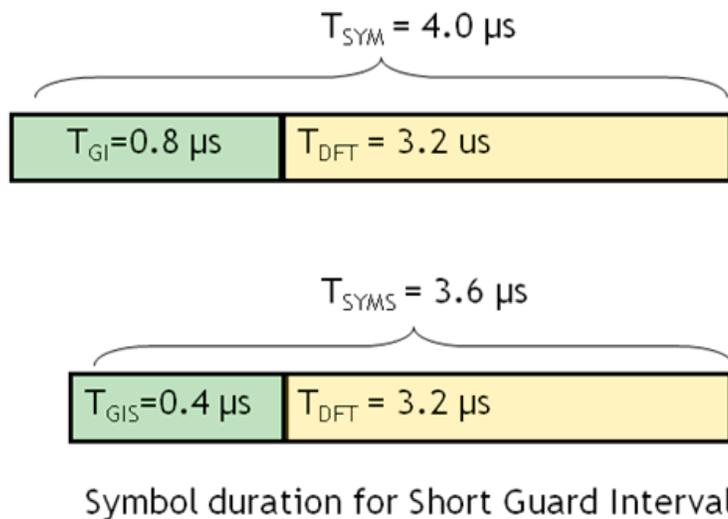


### Improved Modulations

For 802.11n IEEE uses Modulation Coding Schemes (MCS) indexes as updated terminology for indicating configurations in use. The table below shows the additional data rates the 70 Series is able to achieve via MCS0 through MCS7. IEEE 802.11n uses OFDM with additional subcarriers to achieve the increase data rate. The 70 Series supports these additional rates in a 20 MHz Bandwidth (BW) as required by specification and ultimate compliance with legacy channel BW's. As stated earlier the 70 Series is able via Greenfield Preamble support to detect networks that allow for 40 MHz operation. As is the case with legacy data rates, the AP and 70 Series computers will determine rates available for mutual use during the association process.

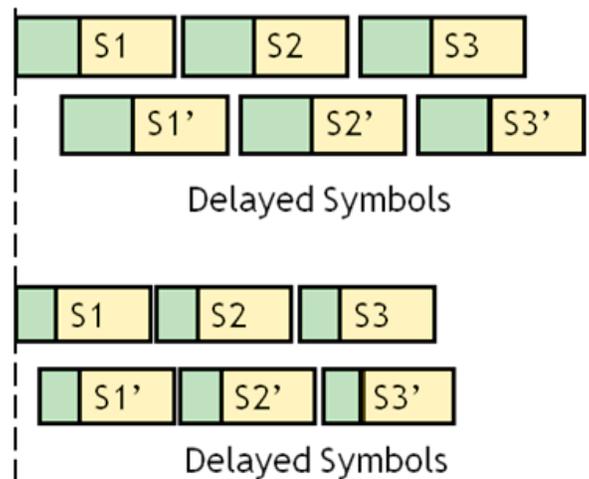
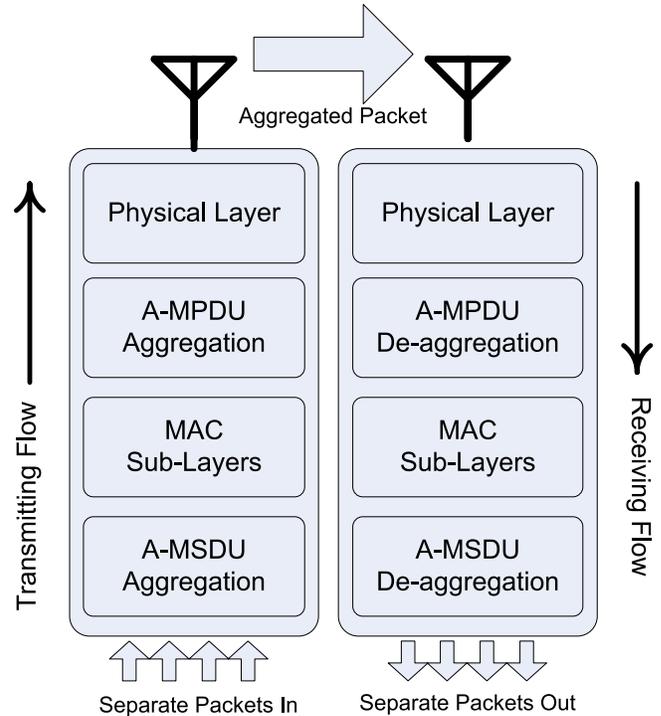
MCS Index	Modulation	Data Rates (Mbps)	
		800ns GI	400ns GI
0	BPSK	6.5	7.2
1	QPSK	13	14.4
2	QPSK	19.5	21.7
3	16-QAM	26	28.9
4	16-QAM	39	43.3
5	64-QAM	52	57.8
6	64-QAM	58.5	65
7	64-QAM	65	72.2

The 70 Series supports the optional **Short Guard Interval** for networks wanting the highest throughput possible. Normally the OFDM symbols are sent with an 800 nanosecond guard interval or cyclical prefix. In legacy operation this allows the OFDM symbols a good measure of multipath resilience as the guard interval is a repeat of the symbol just sent. In environments with multipath is not a significant concern the Guard interval can be reduced to 400 nanoseconds. This in essences speeds up the rate at which the symbols can be sent and this improves throughput. The graphics below depict how the Short GI of 400 ns (0.4 us) allows for a lower over-all symbol duration and hence faster data throughput. IT folks should be aware thought that the reduced guard interval has reduced multipath resilience.



### Improved MAC Layer Efficiencies

802.11n addresses improvements in MAC layer efficiency by allowing frames to be aggregated before transmission. Consider that the aggregation and creation of a super frame alleviates the overhead of channel access and acknowledgment of independent frames. The aggregation can occur before the MAC Layer (A-MSDU) or before the Physical Layer (A-MPDU). Mandatory for Wi-Fi CERTIFICATION is that HH Devices be able to support reception of both A-MPDU and A-MSDU data frames. The Intermec 70 Series complies with the mandatory requirements (RX A-MPDU, and RX A-MSDU) and allows for the transmission of A-MPDU. Aggregation provides more efficient use of the RF Channel resources when continuously transferring large amounts of data.



### Dual Band Operation

The 70 Series provides legacy operation with IEEE 802.11bg on 2.4 GHz. All channels are assured with the industry leading technology Intermec has integrated into the 70 Series computers. The 70 Series computers are dual-band capable with 5 GHz operation using IEEE 802.11a. Below is the rich list of channels that the system can operate under. The channels in use are dependent upon the regulatory domain of operation.

Band	Channel	Center FREQ (MHz)
2.4 GHZ ISM	1	2412
	2	2417
	3	2422
	4	2427
	5	2432
	6	2437
	7	2442
	8	2447
	9	2452
	10	2457
	11	2462
	12	2467
	13	2472
	14	2484
11a usa low U-NII lower band (UNII1) U-NII middle band (UNII2)	36	5180
	40	5200
	44	5220
	48	5240
	52	5260
	56	5280
	60	5300
	64	5320
11a Europe U-NII Extended band (UNII2 Ext)	100	5500
	104	5520
	108	5540
	112	5560
	116	5580
	120	5600
	124	5620
	128	5640
	132	5660
	136	5680
11a usa high U-NII upper band (UNII3)	140	5700
	149	5745
	153	5765
	157	5785
	161	5805

### Regulatory Domain Operation

Industry adopted standards 802.11d and 802.11h (now part of IEEE802.11-2007) are implemented to give the 70 Series Wi-Fi proper regulatory domain operation wherever the system operates on the globe. Working with appropriate configured Access Points, the 70 Series Computer Wi-Fi will configure its power level and channel sets as required for the country of operation. Thus a single deployed device configuration is capable of operating in any Wi-Fi infrastructure around the globe.

### Quality of Service

There is no doubt that media rich applications are gaining popularity in enterprise operation. The 70 Series takes this seriously with the implementation and validation of Wi-Fi Multimedia Alliance WMM® requirements to provide Quality of Service (QoS) based on IEEE802.11e. Wi-Fi Multimedia (WMM®) and WMM-PowerSave support is included to allow for proper Quality of Service (QoS) support for voice and/or video applications with the best possible power saving operation.

The 70 Series allows for WMM specified QoS for the delivery of data, voice and streaming media. This allows time sensitive applications like Voice over IP (voIP) to work alongside application like Web Browsers that have lower requirements for data latency. The 70 Series Computer Wi-Fi provides prioritization of data queuing with the following four Access Categories (AC)

Priority	Access Category	Description
<i>Highest</i>	AC-VO	Voice
	AC-VI	Video
<i>Lowest</i>	AC-BE	Best Effort
	AC-BK	Background

In legacy 802.11 power save operation the radio and driver make decisions on when to transfer data based on indications in beacon interval timing. WMM™ Power Save compliance means that the 70 Series Computer is capable of Unscheduled Automatic Power Save Delivery (U-APSD). In WMM the application itself (VoIP, Multimedia, etc) has more control on data transfer times and the device is able to 'doze' more effectively between frames. To the user this is all automatic as the 70 Series and the serving infrastructure will determine mutual abilities for using WMM Power Save or Legacy Power save.

Combined WMM® and WMM-PowerSave means the 70 Series ultra-rugged mobile computers delivers Wi-Fi QoS for voice or video while offering the industry interoperability of network power management.

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