03/29/2011

InscapeData THE LEADING OUTDOOR NETWORK APPLIANCE COMPANY

Total Turnkey Solutions for Outdoor PoE, Wired/Wireless, and IP Video Applications

Introduction to 802.11n Outdoor Wireless Networks

Features and Benefits

802.11n is the latest amendment to the 802.11 standard with promise to increase speed comparable to wire-line performance. The new level of performance puts 802.11n standard based outdoor long range radios in the spot light to outperform costly proprietary wireless and wired systems. In many installations wireless is the only option.

802.11n Standard & Compatibility

The IEEE (Institute of Electrical and Electronics Engineers, Inc) or also pronounced as (Eye-triple-E) is the world’s leading professional non-profit association for the advancement of technology. It serves the aerospace, biomedical, electric power, consumer electronics, and computers and telecommunications industry. IEEE standardization efforts are organized by projects, each of which is assigned a number. The most famous IEEE project is the IEEE 802 project to develop LAN standards. Within each project, individual working groups develop standards to address a particular facet of the problem. Working groups are also given a number, which is written after the decimal point for the corresponding projects. Ethernet, the most widely used IEEE LAN technology, was standardized by the third working group, 802.3. Wireless LANs were the eleventh working group formed, hence the name 802.11.

Within a working group, task groups form to revise particular aspects of the standard or add on to the general area of functionality. Task groups are assigned a letter beneath the working group. The case of the letter in a standards revision encodes information. Lowercase letters indicate dependent standards that cannot stand alone from their parent, while uppercase letters indicate full-fledged standalone specifications. For example, 802.11b adds new clause to 802.11, but cannot stand alone, so the “b” is written in lowercase. In contrasts, the 802.1X are self-contained and standalone specifications where as 802.11n is not standalone specification.

IEEE 802 family, which is a series of specifications for LAN technologies focuses on the physical (layer 1) and data link (layer 2) of the OSI model. *Physical layer* defines all the electrical and physical specifications for devices. It defines in particular the relationship between a device and the communication medium. In other words, it defines the protocol which interconnects devices together to form a network. *Data link layer* describes the functional means to transfer data between network entities. It provides access control, device identification, error checking, and the essentials for reliable data communication. IEEE 802.11 (WLAN standard) introduces physical layer communication methods using FHSS (Frequency Hopping Spread Spectrum) and DSSS (Direct Sequence Spread Spectrum). 802.11b specifies high-rate direct-sequence layer (HR/DSSS). 802.11a & 802.11g describes a physical layer based on orthogonal frequency division multiplexing (OFDM). 802.11n, the newest addition provides higher data speeds using MIMO-OFDM. Below is a table of data speed based on working group.

03/29/2011

WLAN Speeds based on 802.11 working group

Working Group	Maximum Data Rate/Speed
802.11	2 mbps
802.11b	11 mbps
802.11g	54 mbps
802.11a	54 mbps
802.11n	600 mbps

802.11n also known as MIMO was ratified in October of 2009 to bring the highest data rate to date for multi-media applications. IEEE 802.11 has been readily available since 1998 offering speeds at 2 mbps and 2010 at 600 mbps. IEEE 802.11 is one of the most successful industry standards in history. It has been experiencing exponential growth in multi-industry support and rapid advancement with newer extensions released periodically to enhance wireless performance.

MIMO High Speed Networks

The promise of 802.11n outdoor networks is to provide “wire like” speeds up to 600 Mb/s. The 10 fold increase in over the air data rate compared to prior generation wireless speed of 54 Mb/s is due to the use of Multiple-In Multiple-Out (MIMO) technology. MIMO utilizes multiple antennas and parallel transmission schemes to achieve higher performance. In addition, the 802.11n specification adds new encoding algorithms and wider channels which together increase over the air data transfer rate significantly.

<table>
<tr><th>IEEE Standard</th><th>802.11g</th><th>802.11a</th><th colspan="3">802.11n</th></tr>
<tr><td>Technology</td><td>SISO-OFDM</td><td>SISO-OFDM</td><td colspan="3">MIMO-OFDM</td></tr>
<tr><td>Frequency</td><td>2.4 GHz</td><td>5 GHz</td><td colspan="3">2.4 GHZ or 5 GHz</td></tr>
<tr><td rowspan="2">Data Rates</td><td rowspan="2">1, 2, 6, 9, 12, 18, 24, 36, 48, 54</td><td rowspan="2">6, 9, 12, 18, 24, 36, 48, 54</td><td colspan="2">20 MHz</td><td>40 MHz</td></tr>
<tr><td colspan="2">7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2</td><td>15, 30, 45, 60, 90, 120, 135, 150</td></tr>
<tr><td>Bandwidth</td><td>20 MHz</td><td>20 MHz</td><td colspan="3">20 MHz
40 MHz</td></tr>
<tr><td>Spatial Streams</td><td>1</td><td>1</td><td colspan="3">1 to 4</td></tr>
<tr><td rowspan="5">Data rate</td><td rowspan="5">54mbps</td><td rowspan="5">54mbps</td><td>Spatial Streams</td><td>20 MHz</td><td>40 MHz</td></tr>
<tr><td>1</td><td>72.2mpbs</td><td>150mbps</td></tr>
<tr><td>2</td><td>144mpbs</td><td>300mbps</td></tr>
<tr><td>3</td><td>216.7mpbs</td><td>450mbps</td></tr>
<tr><td>4</td><td>288.9mbps</td><td>600mbps</td></tr>
<tr><td>New Wireless Technology</td><td>N/A</td><td>N/A</td><td colspan="3">Beam Forming, Multiple Antenna, and many others are currently in development</td></tr>
<tr><td>Wireless Range Comparison</td><td>N/A</td><td>N/A</td><td colspan="3">At least 4.3x Better than SISO</td></tr>
<tr><td>Multipath Issues</td><td>Yes</td><td>Yes</td><td colspan="3">No</td></tr>
<tr><td>Spotty Coverage Issues</td><td>Yes</td><td>Yes</td><td colspan="3">No</td></tr>
</table>

IEEE 802.11a, g, n wireless technology comparison

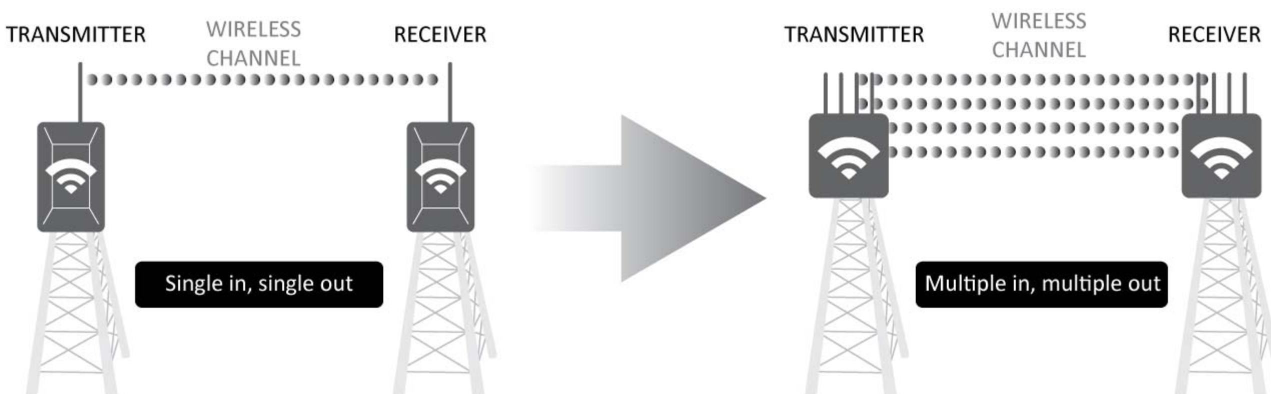
03/29/2011

Understanding MIMO

Multiple-input, multiple-output (MIMO) antenna systems are used in the most current wireless standards, including 3GPP LTE, and mobile WiMAX systems. The technique supports enhanced data throughput even under conditions of interference, signal fading, and multipath. The demand for higher data rates over longer distances has been one of the primary motivations behind the development of MIMO-OFDM communications systems.

For years the traditional way to achieve higher data rates is by increasing the signal bandwidth. Unfortunately, increasing the signal bandwidth of a communications channel by increasing the symbol rate of a modulated carrier increases its susceptibility to multipath fading. For wide-bandwidth channels, one partial solution to solving the multipath challenge is to use a series of narrowband overlapping subcarriers. Not only does the use of overlapping OFDM subcarriers improve spectral efficiency, but the lower symbol rates used by narrowband subcarriers reduces the impact of multipath signal products.

MIMO communications channels provide an interesting solution to the multipath challenge by requiring multiple signal paths. In effect, MIMO systems use a combination of multiple antennas and multiple signal paths to gain knowledge of the communications channel. By using the spatial dimension of a communications link, MIMO systems can achieve significantly higher data rates than traditional single-input, single-output (SISO) channels. A receiver can recover independent streams from each of the transmitter's antennas. A 2 x 2 MIMO system produces two spatial streams to effectively double the maximum data rate of what might be achieved in a traditional 1 x 1 SISO communications channel. There are several degenerative modes of a MIMO system outline in the table below to accommodate backward compatibility of prior generation 802.11 wireless technology and the dynamic environmental factors where true MIMO is not achievable.



SISO vs MIMO Wireless Bridge

While research has produced multiple methods to approximate the maximum channel capacity of a MIMO system, the channel capacity can be estimated as a function of N spatial streams. A basic approximation of MIMO channel capacity is a function of spatial streams, bandwidth, and signal-to-noise ratio (SNR). It is possible to investigate the relationship between the number of spatial streams and the throughput of various implementations of SISO and MIMO configurations. IEEE 802.11n is designed to support MIMO configurations with as many as four spatial streams with up to 300 Mb/s.

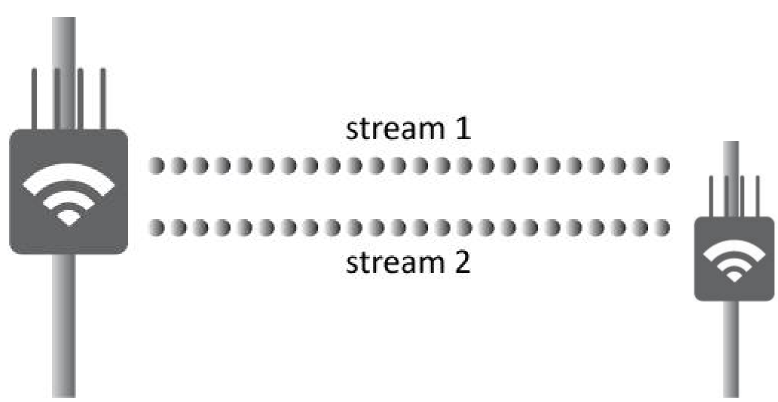
Multiple-input and single-output (MISO)	Degenerate case when the receiver has a single antenna.
Single-input and multiple-output (SIMO)	Degenerate case when the transmitter has a single antenna.
Single-input single-output (SISO)	Radio system where neither the transmitter nor receiver have multiple antenna.

Degenerate modes of MIMO

While MIMO systems provide users with clear benefits at the application level, the design and test of MIMO devices is not without significant challenges. MIMO systems require antenna designers to deal with the challenge of placing multiple antennas. Also, transceiver designers must solve the challenge of combining multi-channels. Finally, digital-signal processing (DSP) engineers are required to implement more sophisticated baseband processing algorithms to better interpret the channel model to produce error free transmission. The MIMO system benefits such as improvements in data rate and resilience to multipath are likely to motivate continued development of MIMO-OFDM communications systems.

Understanding MIMO Spatial Stream

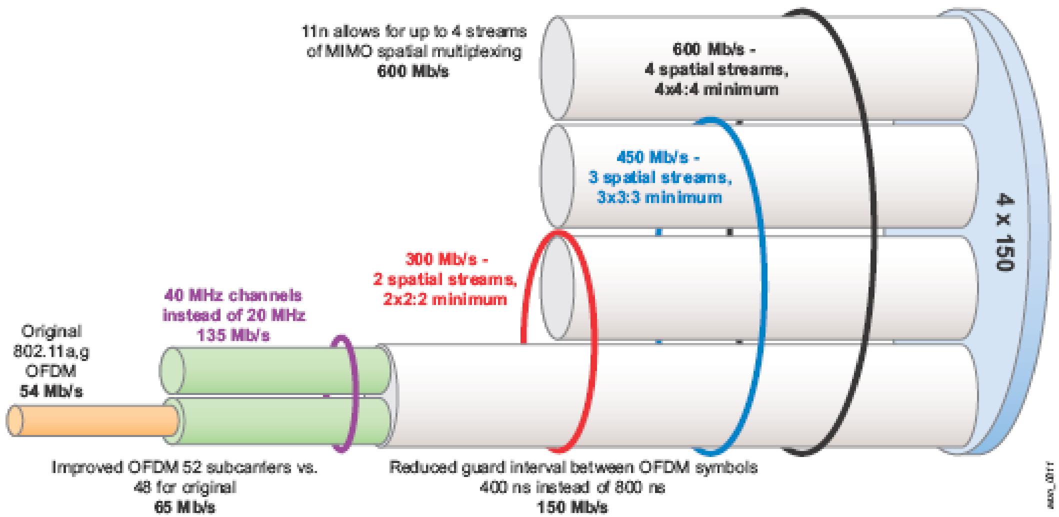
The concept of spatial streams of data is related to the ability to perform parallel transmission of wireless data through the use of multiple radios. For outdoor 802.11n systems like the Inscape 802.11n outdoor rugged access point and bridge products, multiple internal and external antennas make up the transmission and reception antenna array to achieve high speed 802.11n transmission. More spatial streams allow the wireless bridges or access point to transmit more data simultaneously. Spatial streams split data into multiple parts and forward them over different radios, and the data takes different paths through the air to reach the receiver and vice versa.



Outdoor MIMO radios with 2 spatial stream

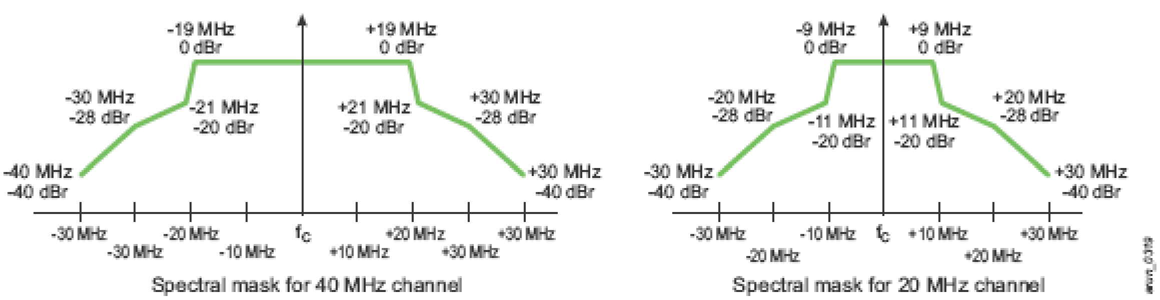
The technical advantage of a MIMO and spatial stream is that outdoor access point and bridge use multipath transmission as the multipath may add to the signal interference where as MIMO take advantage of multipath to increase speed. Multiple antennas are needed to transmit and receive multiple spatial streams. Depending on hardware, an AP or client can transmit or receive spatial streams equal to the number of antennas it has. However, the AP may have more antennas than spatial streams.

More streams equals more speed. The following figure illustrates how 802.11n increased transmission speed compared to 802.11a/g networks.



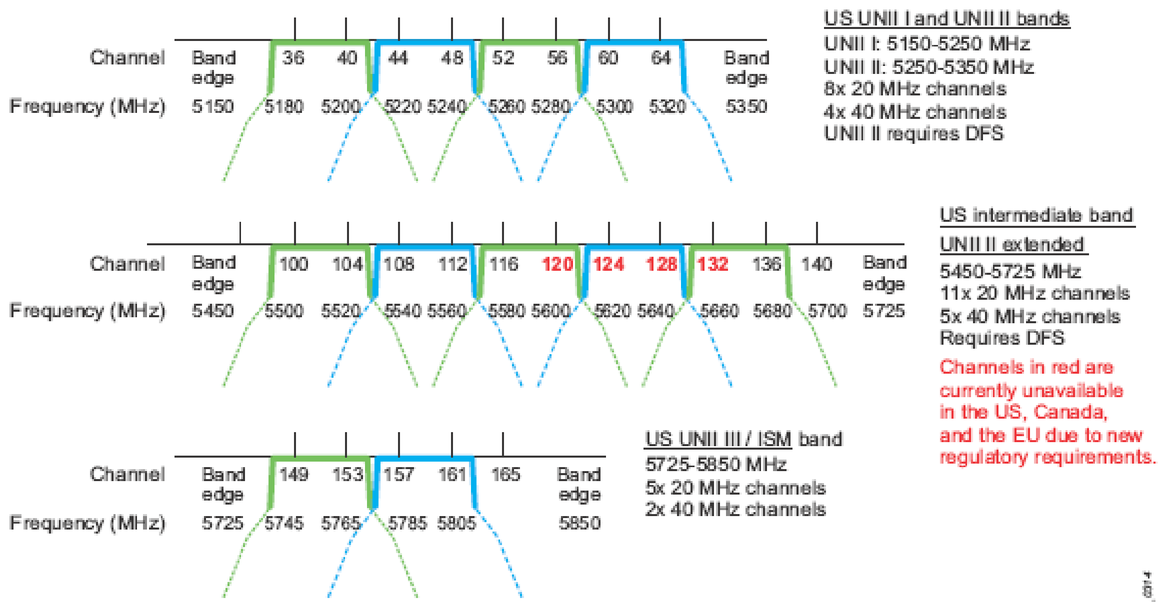
Channel Bandwidth

Previously, 802.11 transmissions were transmitted using 20 MHz data channels. Anyone who has deployed an IEEE 802.11 standards based outdoor access point or bridge has worked with 20 MHz channels, with each AP set to a single, nonoverlapping channel. With 802.11n, two channels can be bonded, which actually more than doubles the bandwidth because the guard channels in between also are used. Figure 3 shows the difference in width for a 40 MHz spectral mask as opposed to the 20 MHz mask originally specified for 802.11 Transmissions.



20 MHz channel vs 40 MHz channel

In the 5 GHz band, multiple 40 MHz channels are available, and depending on the regulatory domain, additional channels are available with dynamic frequency selection (DFS) enabled. Figure 4 outlines the availability of 40 MHz channels in the 5 GHz band.



40 MHz Channels in the 5 Gigahertz Band

Due to the limited number of channels in the 2.4 Gigahertz band, it is not suitable to use 40 MHz in this band. Doing so will degrade network performance and disrupt neighboring 2.4 GHz networks. Inscape Data does not recommend the use of 2.4GHz spectrum for outdoor real-time video and voice applications.

High Throughput (HT) OFDM

Orthogonal Frequency Division Multiplexing is the wireless encoding scheme used in current 802.11 system. The new HT OFDM in 802.11n offers increased speeds compared to legacy OFDM schemes used in 802.11a/g wireless products. The table below reflects the optimization of the OFDM subcarrier translate to increase throughput.

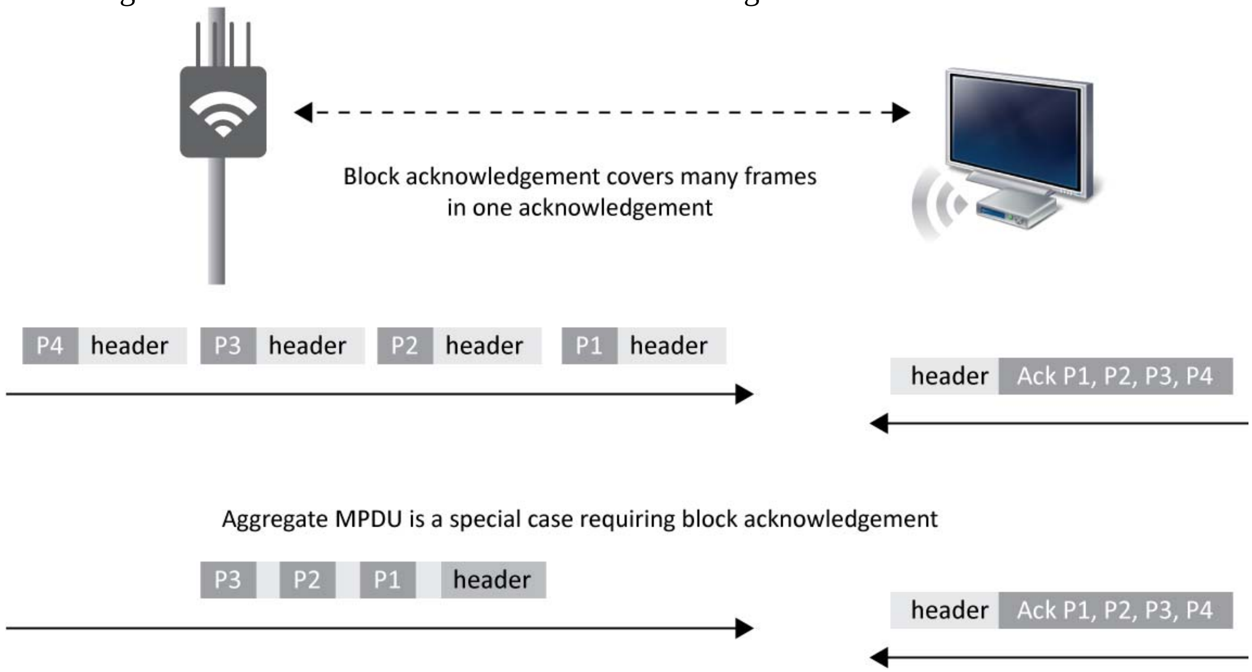
802.11a/g		802.11n (1 SS)
6	→	6.5
12	→	13.0
18	→	19.5
24	→	26.0
36	→	39.0
48	→	52.0
54	→	58.5
N/A	→	65.0

802.11n High Throughput Transmission OFDM vs. 802.11a/g OFDM

03/29/2011

Short Guard Interval
The guard interval is the spacing between OFDM transmissions from a client. This interval prevents frames that are taking a longer path from colliding with subsequent transmissions that are taking a shorter path. A shorter OFDM guard interval between frames, from 800 ns to 400 ns, means that transmissions can begin sooner in environments where the delay between frames is low. Ultimately, lower delay means faster speed.

Block Acknowledgement
Block acknowledgements confirm that a set of transmissions has been received, such as from an AMPDU. Only the single acknowledgement must be transmitted to the sender. Block acknowledgements also can be used to acknowledge a number of frames from the same client that are not aggregated. One acknowledgement for a set of frames consumes less airtime. The window size for the block acknowledgement is negotiated between AP and client. Figure 11 shows the two cases of block acknowledgement in action.



Block acknowledgement of 802.11n outdoor system

802.11 Nomenclature
In 802.11a/b/g wireless system, only a single antenna and single stream of data are involved. 802.11n adds multiple antennas and multiple streams of data to increase the transmission capabilities of wireless bridges and access points. It is important to understand 802.11 nomenclature and the new ‘n’ specific designations.

802.11 networks consist of four major physical components. Access points, Stations, Wireless Medium, and Distribution System.

03/29/2011

Access Points
Access points function as media converters from one type to another. It performs the wireless-to-wired bridging function as its core functionality.

Stations/Clients
Networks are essentially built to transfer data between stations. Stations are computing devices with wireless network interfaces. Since 802.11 is fast in becoming the defacto standard for linking together consumer electronics, device with 802.11 wireless interfaces is rapidly increasing from portable handheld scanners to mobile computing.

Wireless Medium
To move data from station to station, the standard uses a wireless medium. Radio Frequency has been the most popular although Infrared (IR) is also available. The top two popular frequency usages are 2.4 GHz and 5 GHz spectrum. Although 2.4 GHz is internationally accepted spectrum for use with WLAN, 5GHz and other frequencies are also becoming popular.

Distribution System
When several access points are used to provide large network coverage area, they also need to talk to each other and track stations moving from one coverage area to another. Distribution system essentially functions as a backbone to pass data to their destination. Ethernet has been the most successful backbone network and is available in almost all IEEE 802.11 access points.

Inscape Data fixed broadband wireless products are built upon the IEEE 802.11 standard platform and through proprietary algorithms extends the network communication connectivity range beyond 50km. Users can easily access the Inscape Data AirEther outdoor wireless system's user interface to adjust for distance and performance speed of the network link. The rugged outdoor design boasts IP67 and IP68 product certification and ensures reliable operation during the worst weather conditions. The table below references the Inscape Data outdoor fixed wireless broadband system and core relationship to the 802.11 Nomenclature.

IEEE 802.11 Nomenclature	Inscape Data AirEther Outdoor System	Inscape Data Model # Reference
Access Point (AP)	Access Point (AP)	Inscape Data SB300 Product set as Access Point Mode
Not Supported	Bridge / Backhaul (Proprietary)	BR300 Series product set as Bridge Mode or AP & AP Client mode.
Station	Client Bridge / Customer Premises Equipment (CPE)	SB300 or BR300 Series Product set as client mode
Medium	2.4 GHz 5.1 ~ 5.8 GHz	All Inscape Data Products Support Dual Band Capability
Distribution System	Ethernet port (RJ45)	All Product Support Ethernet
WDS (Wireless Distribution System)	Repeater	SB300/BR300

Inscape Data Wireless System and 802.11 Nomenclature

WDS is used widely in Mesh networking and repeater system allowing access point to communicate with access point wirelessly without medium conversion from wireless to Ethernet and Ethernet back to wireless (*Industry term: back to back*). It is a great means to deploy very quickly a wireless access point network with built in distribution system for wireless internet connectivity. WDS capability is available on Inscape Data AirEther SB54 and BR54 series access point. WDS is no recommended for voice and video application where low latency is required since half duplex systems need a time slot to receive then another time slot to transmit between access point, therefore potentially doubling the latency required.

New 802.11n Nomenclature
The new 802.11n designation include transmit, receive, and spatial stream nomenclature like the following:

T x R : S

- **Transmit:** The number of antennas that are dedicated to transmitting data.
- **Receive:** The number of antennas that are dedicated to receiving data.
- **Spatial Streams:** The number of individual data streams that the radio is capable of transmitting. An 802.11 a/b/g AP (1x1: 1) is capable of one stream of data or one transmission, to a client at a time. The number of spatial streams must be less than or equal to the number of transmit or receive antennas, depending on which way traffic is flowing.

Going Forward
With manufacturers and developers moving full speed forward with 802.11n hardware, 802.11a/b/g will soon be obsolete. It is very important to understand that backward compatibility to legacy wireless systems is built into the 802.11n standard. With an Inscape Data SB300 outdoor high power access point deployed, the users can rest assured their legacy wireless laptop is still compatible. However, the backward compatibility does come at the cost of performance where every wireless device on the 802.11n will have to operate on the degraded compatibility mode. Faster 802.11n wireless clients are unable to operate at optimal speeds.

The 802.11n technology standard continues to show momentum and further enhancements are already on the way. 802.11n outdoor wireless devices scales, is future proof, and provide the most cost effective wireless solution to the commercial industry. For more information on MIMO & 802.11n based wireless long range products from Inscape Data, please contact our sales or product team by e-mail, sales@inscapedata.com, or visit our website at http://www.inscapedata.com.