

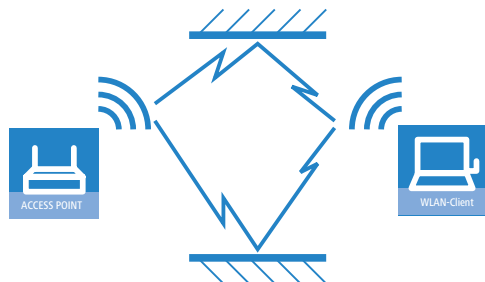
# LANCOM™ Techpaper

## 802.11n for Outdoor Applications

The current 802.11n draft 2.0 offers major advantages for wireless LAN operation with regard to data throughput, range and network coverage. Many of these aspects are also of great benefit when using outdoor wireless networks. This Techpaper introduces the technical background details to 802.11n that are relevant for point-to-point connections. To put these details into perspective, we will first introduce the topics of polarization diversity and MIMO.

### Polarization diversity in wireless LANs based on IEEE 802.11a/g

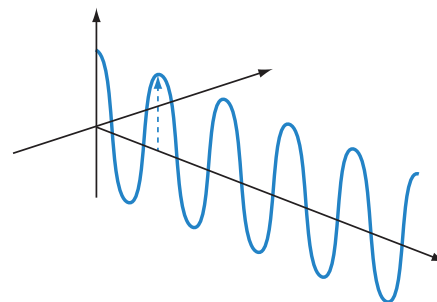
Among other things, the transmission of radio signals can suffer from significant signal losses due to reflection and scatter. Depending on antenna type, an Access Point's antennas transmit data in several directions at once. These electromagnetic waves are reflected by the surrounding surfaces causing a broadcast signal to reach the WLAN client's antenna over many different paths; this is also referred to as "multipath propagation". Each of these paths has a different length meaning that individual signals reach the client with a different time delay.



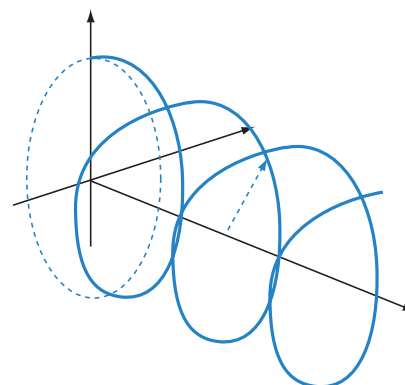
These time-delayed signals interfere with each other to the detriment of the original signal; in extreme cases the signals can cancel each other out completely. The polarization diversity method is used to improve the quality of signals for wireless LAN connections based on IEEE 802.11a/g. Polarization diversity takes advantage of the fact that electromagnetic waves have a certain polarization.

Polarization is an important parameter used to describe radio waves with an electrical field that can be characterized by the length and direction of a vector (amplitude vector). There are two different basic types of polarization:

- **Linear polarization:** The amplitude vector always points in the same direction relative to the direction of wave propagation; only its length changes. When represented on a plane the amplitude vector describes a line, thus the name "linear polarization".



- **Circular polarization:** in the case of circular polarization the amplitude vector retains its length. However, it turns evenly around the axis along the direction of propagation. When represented on a plane the amplitude vector describes a circle, thus the name "circular polarization".

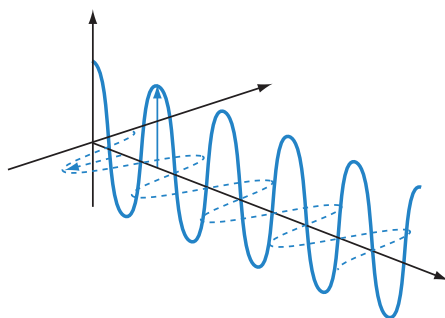


- **Elliptical polarization:** A special form of polarization involves the superimposition of the two variants mentioned above. In this case the amplitude vector revolves and changes its length at the same time. This is referred to as elliptical polarization due to its representation on a plane.

- **Orthogonal signals:** If two linearly polarized waves are offset to each other in such a way that one wave lies on the horizontal plane while the other is on the vertical plane, we talk of "orthogonal signals". This means that these signals can be superimposed on the same frequency without interference and can be clearly separated again at the receiving end. By exploiting these wave characteristics by using appropriate antennas, the transmission performance of a wireless link can be doubled.

# LANCOM™ Techpaper

## 802.11n for Outdoor Applications

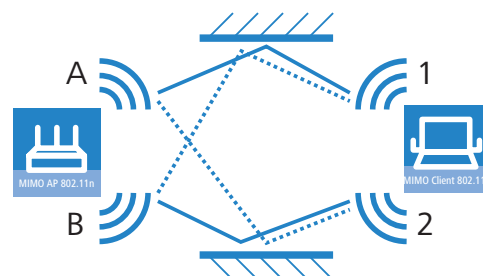


Diversity methods work by receiving the signal not just once but several times; the reception can be improved either by selecting one signal or combining both. The differing polarization of the waves is used to differentiate one signal from the other. The receiver uses two linearly polarized signals at 90° to one another and selects the receiving antenna offering the best level of reception (Rx diversity), which generally results in a diversity gain of approx. 3 dB. This requires special polarization antennas that use filtering to select the signals with the desired direction of polarization.

### MIMO and multipath propagation

The MIMO (multiple input, multiple output) technology described in 802.11n draft 2.0 transforms the disadvantages of multipath propagation in WLAN transmissions into an advantage that enables an enormous increase in data throughput. In all previous WLAN standards it was considered impossible to transmit different signals on the same channel simultaneously as the receiver could not distinguish between them. MIMO uses the reflection of electromagnetic waves and the associated spatial aspect to obtain a third criterion for identifying the signals.

A signal sent by transmitter A and received by receiver 1 follows a different path than a signal from transmitter B to receiver 2. Due to the different reflections and changes in polarization that both signals experience along their paths, each of these paths takes on its own characteristics. The receiver therefore "sees" two different data streams, which in the 802.11n parlance are referred to as "spatial streams".



By using multiple data streams in parallel, data throughput can be increased many times in an 802.11n WLAN. At this time (early 2008) the available devices are capable of realizing two spatial streams, which corresponds to a doubling of data throughput.

MIMO employs several antennas both for the transmitter and for the receiver in order to enable a spatial differentiation of the data streams. For two data streams, two antennas are sufficient at either end of the connection; this is referred to as 2x2 MIMO. More antennas can be used than are actually necessary for the data streams in order to further safeguard data transmission, e.g. with 3x3 MIMO for two spatial streams. Additional spatial information is transmitted with a third signal. If the data from the first two signals cannot be identified unequivocally, their computation can still be performed with the aid of the third signal. The data streams are split between multiple antennas by using cyclic shift diversity (CSD), whereby the signal is transmitted with different "cyclic phases". The signal with the best SNR (signal to noise ratio) is selected at the receiving end with the help of MRC (maximum ratio combining), resulting in a significantly better signal from 3x3 MIMO than with the 2x2 variant.

### 802.11n for outdoor applications

Using 802.11n outdoors requires special consideration. MIMO makes use of the spatial characteristics that are primarily generated by reflections to differentiate between the data streams. However, with outdoor point-to-point connections there is a direct line of sight (LOS) between transmitter and receiver; the Fresnel zone must also be free of obstructions. Consequently, for this application there are no reflections that can be used to differentiate between spatial streams.

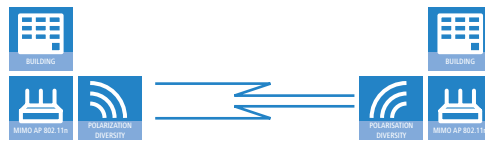
For this reason, outdoor applications with 802.11n use a combination of the established polarization diversity method and MIMO technology: MIMO provides the possibility of generating several parallel data streams and uses polarization as the defining characteristic of each data stream. This combination is implemented with what

# LANCOM™ Techpaper

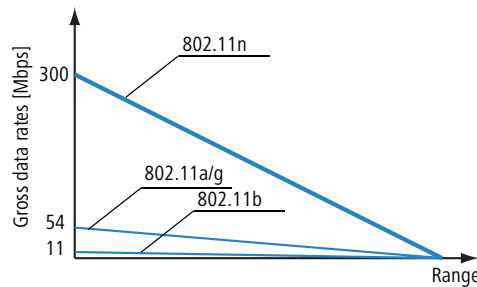
## 802.11n for Outdoor Applications

are known as dual-slant antennas. These are antennas with two separate ports combining two polarization antennas turned through 90° to each other in a single housing:

- The two ports allow separate data streams to be received from the Access Point.
- The different polarizations allow the data streams to be transmitted in parallel through the medium of "air".



This approach opens up completely new dimensions of data throughput and range for outdoor P2P links as well. Even after taking all available performance functions (such as turbo-mode, bursting, compression) into consideration, previous methods achieved a net data throughput of approx. 40 to 50 Mbps. P2P connections with 802.11n achieve up to 90 Mbps net using ordinary antennas and **one** data stream. Dual-slant antennas transmit **two** separate data streams and therefore theoretically up to 180 Mbps net. The net data throughput observed in practice when using these polarization diversity antennas is up to 130 Mbps.



Comparison of data rate and range for 802.11n and IEEE 802.11a/b/g with outdoor applications

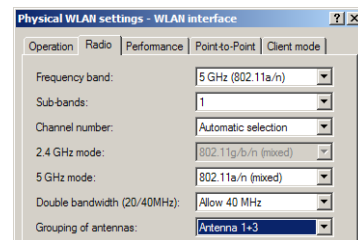
### Installation and configuration

The LANCOM L-310agn Wireless currently supports the operation of outdoor connections with 802.11n and the following dual-slant antennas:

- AirLancer Extender O-D9a
- AirLancer Extender O-D60a
- AirLancer Extender O-D80g



The dual-slant antenna ports are connected to "Ant 1" and "Ant 3". Accordingly, antenna grouping must be set to "1 + 3" in order for the Access Point to be able to assign data to the correct ports. This prevents transmission over the third antenna interface as only two ports are used for dual-slant operation.



**i** As an alternative to a dual-slant antenna, it is possible to connect two separate antennas with linear polarization mounted at 90° to one another on a mast and connected to ports "Ant 1" and "Ant 3". With this variant, however, more effort is involved in aligning the antennas to achieve optimal signals.