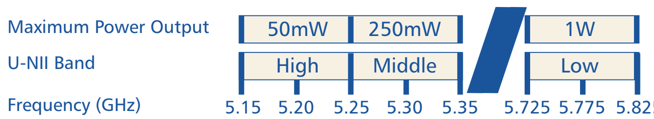
White Paper

802.11a: A Very High-Speed, Highly Scalable Wireless LAN Standard

The Institute of Electrical and Electronics Engineers [IEEE] has developed 802.11a, a new specification that represents the next generation of enterprise-class wireless LANs. Among the advantages it has over current technologies are greater scalability, better interference immunity, and significantly higher speed, up to 54 Mbps and beyond, which simultaneously allows for higher bandwidth applications and more users. This paper provides an overview, in basic terms, of how the 802.11a specification works, and its corresponding benefits.

Physical Layer

5 GHZ Frequency Band



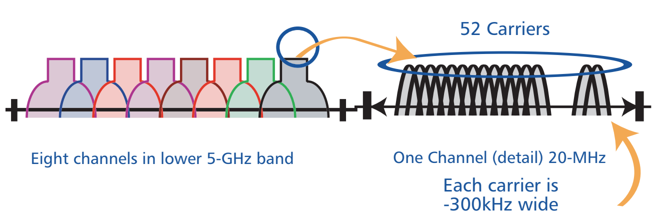
802.11a utilizes 300 MHz of bandwidth in the 5 GHz Unlicensed National Information Infrastructure (U-NII) band. Though the lower 200 MHz is physically contiguous, the FCC has divided the total 300 MHz into three distinct 100 MHz domains, each with a different legal maximum power output. The “low” band operates from 5.15 – 5.25 GHz, and has a maximum of 50 mW. The “middle” band is located from 5.25 – 5.35 GHz, with a maximum of 250 mW. The “high” band utilizes 5.725 – 5.825 GHz, with a maximum of 1 W. Because of the high power output, devices transmitting in the high band will tend to be building-to-building products. The low and medium bands are more suited to in-building wireless products. One requirement specific to the low band is that all devices must use integrated antennas.

Different regions of the world have allocated different amounts of spectrum, so geographic location will determine how much of the 5 GHz band is available. In the United States, the FCC has allocated all 3 bands for unlicensed transmissions. In Europe, however, only the low and middle bands are free. Though 802.11a is not yet certifiable in Europe, efforts are currently underway between IEEE and the European Telecommunications Standards Institute (ETSI) to rectify this. In Japan, only the low band may be used. This will result in more contention for signal, but will still allow for very high performance.

The frequency range used currently for most enterprise-class unlicensed transmissions, including 802.11b, is the 2.4 GHz Industrial, Scientific & Medical (ISM) band. This highly populated band offers only 83 MHz of spectrum for all wireless traffic, including cordless phones, building-to-building transmissions, and micro-wave ovens. In comparison, the 300 MHz offered in the U-NII band represents a nearly four-fold increase in spectrum; all the more impressive when considering there is limited wireless traffic in the band today.

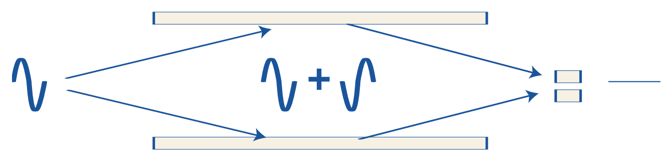
OFDM Modulation Scheme

802.11a uses Orthogonal Frequency Division Multiplexing (OFDM),a new encoding scheme that offers benefits over spread spectrum in channel availability and data rate. Channel availability is significant because the more independent channels that are available,the more scalable the wireless network becomes.The high data rate is accomplished by combining many lower-speed subcarriers to create one high-speed channel. 802.11a uses OFDM to define a total of 8 non-overlapping 20 MHz channels across the 2 lower bands;each of these channels is divided into 52 subcarriers,each approximately 300 KHz wide.By comparison,802.11b uses 3 non-overlapping channels.



A large (wide) channel can transport more information per transmission than a small (narrow) one. As described above, 802.11a utilizes channels that are 20 MHz wide, with 52 subcarriers contained within. The subcarriers are transmitted in "parallel", meaning they are sent and received simultaneously. The receiving device processes these individual signals, each one representing a fraction of the total data that, together, make up the actual signal. With this many subcarriers comprising each channel, a tremendous amount of information can be sent at once.

Multipath interference occurs when reflected signals cancel each other out. 802.11a uses a slower symbol rate to minimize multipath interference.

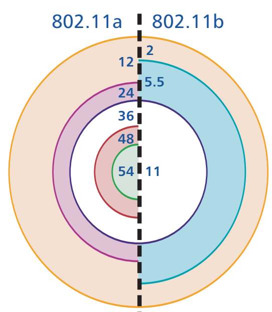


With so much information per transmission, it obviously becomes important to guard against data loss. Forward Error Correction (FEC) was added to the 802.11a specification for this purpose (FEC does not exist in 802.11b). At its simplest, FEC consists of sending a secondary copy along with the primary information. If part of the primary information is lost, insurance then exists to help the receiving device recover (through sophisticated algorithms) the lost data. This way, even if part of the signal is lost, the information can be recovered so the data is received as intended, eliminating the need to retransmit. Because of its high speed, 802.11a can accommodate this overhead with negligible impact on performance.

Another threat to the integrity of the transmission is multipath reflection, also called delay spread. When a radio signal leaves the "sending" antenna, it radiates outward, spreading as it travels. If the signal reflects off a flat surface, the original signal and the reflected signal may reach the "receiving" antenna simultaneously. Depending on how the signals overlap, they can either augment or cancel each other out. A baseband processor, or equalizer, unravels the divergent signals. However, if the delay is long enough, the delayed signal spreads into the next transmission. OFDM specifies a slower symbol rate to reduce the chance a signal will encroach on the following signal, minimizing multipath interference.

Data Rates & Range

Devices utilizing 802.11a are required to support speeds of 6, 12, and 24 Mbps. Optional speeds go up to 54 Mbps, but will also typically include 48, 36, 18, and 9 Mbps. These differences are the result of implementing different modulation techniques and FEC levels. To achieve 54 Mbps, a mechanism called 64-level quadrature amplitude modulation (64QAM) is used to pack the maximum amount of information possible (allowable by the standard) on each subcarrier. Just as with 802.11b, as an 802.11a client device travels farther from its Access Point, the connection will remain intact but speed decreases (falls back). As the following picture illustrates, 802.11a can have a significantly higher signaling rate than 802.11b at most ranges.



Example of range / data rate differences between 802.11a and 802.11b

MAC Layer

802.11a uses the same Media Access Control (MAC) layer technology as 802.11b, carrier sense multiple access with collision avoidance (CSMA-CA). CSMA-CA is a basic protocol used to avoid signals colliding and canceling each other out. It works by requesting authorization to transmit for a specific amount of time prior to sending information. The sending device broadcasts a request to send (RTS) frame with information on the length of its signal. If the receiving device permits it at that moment, it broadcasts a clear to send (CTS) frame. Once the CTS goes out, the sending machine transmits its information.

Any other sending devices in the area that "hear" the CTS realize another device will be transmitting and allow that signal to go out uncontested.

Relation to HiperLAN/2

HiperLAN/2 is a wireless specification developed by ETSI, and has some similarities to 802.11a at the physical layer. It also uses OFDM technology, and operates in the 5 GHz frequency band. The MAC layers are different, however. While 802.11a uses CSMA-CA, HiperLAN/2 utilizes time division multiple access (TDMA). Because the 5 GHz U-NII equivalent bands have been reserved for HiperLAN/2 systems in Europe, 802.11a is not yet certifiable in Europe by ETSI. In an effort to rectify this, two additions to the IEEE 802.11a specification have been proposed to allow both 802.11a and HiperLAN/2 to coexist. Dynamic channel selection (DCS) and transmit power control (TPC) allow clients to detect the most available channels and use only the minimum output power necessary if interference is evident. The implementation of these additions will significantly increase the likelihood of European 802.11a certification.

Compatibilty with 802.11B

While 802.11a and 802.11b share the same MAC layer technology, there are significant differences at the physical layer. 802.11b, using the ISM band, transmits in the 2.4 GHz range, while 802.11a, using the U-NII band, transmits in the 5 GHz range. Because their signals travel in different frequency bands, one significant benefit is that they will not interfere with each other. A related consequence, therefore, is that the two technologies are not compatible. There are various strategies for migrating from 802.11b to 802.11a, or even using both on the same network concurrently. For a detailed examination of this topic, please visit www.proxim.com/products/harmony/whitepapers/migration.html

Summary

802.11a represents the next generation of enterprise-class wireless LAN technology, with many advantages over current options. At speeds of 54 Mbps and greater, it is faster than any other unlicensed solution. 802.11a and 802.11b both have a similar range, but 802.11a provides higher speed throughout the entire coverage area. The 5 GHz band in which it operates is not highly populated, so there is less congestion to cause interference or signal contention. And, the 8 non-overlapping channels allow for a highly scalable and flexible installation. 802.11a is the most reliable and efficient medium by which to accommodate high-bandwidth applications for numerous users. Because of 802.11a's many benefits, Proxim will introduce 802.11a products into the Harmony product family in 2002. Harmony's centrally managed architecture delivers the easiest and most flexible wireless LAN system; the addition of 802.11a's speed, scalability and interference immunity will also make it the highest performing solution.

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