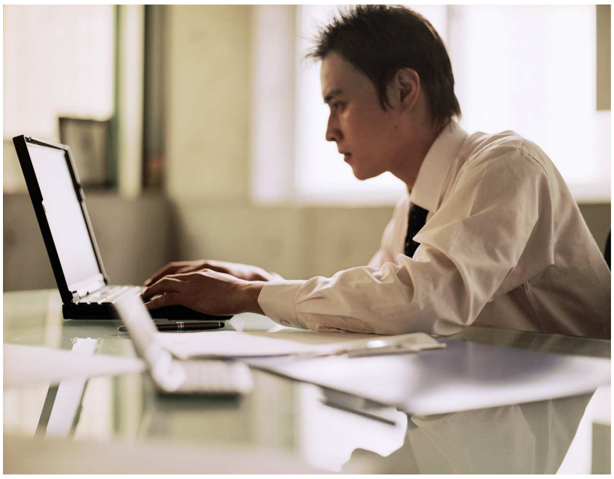
Cabling to Maximize 802.11n Wireless Performance

New IEEE 802.11n wireless networking products offer faster data rates and improved coverage, addressing the drawbacks of legacy wireless networking products. IEEE 802.11n is a proposed amendment to the IEEE 802.11 Standard. The IEEE 802.11n amendment defines a communication protocol and waveform to achieve unprecedented wireless data rates. The amendment was not ratified until September, 2009, but products from numerous vendors, built to the IEEE 802.11n Draft 2 specification, have been successfully fielded for a couple of years.

Wi-Fi Certified™ is a trademark of the Wi-Fi Alliance based on the IEEE 802.11 standards. This certification is intended to verify interoperability between wireless devices from different manufacturers. The Wi-Fi Alliance began testing and certifying 802.11n draft 2.0 products for interoperability in June 2007. Interoperability issues have not arisen since then, and it is not anticipated that the final version of the amendment will introduce interoperability issues, so there is little risk in deploying an 802.11n solution from an interoperability standpoint. However, there is risk that the existing cabled infrastructure is inadequate to handle the higher data rates anticipated with 802.11n products.

802.11n products use advanced RF signal processing (Multiple Input/Multiple Output antennas and beam-forming), channel bonded 40 MHz channels, and frame aggregation to achieve unprecedented wireless data rates. Many wireless access points from leading vendors are capable of operating in 802.11 “a”, “b”, “g” and “n” modes and many of theses products are dual radio, operating in both the 2.4 GHz band and 5 GHz band simultaneously, thereby doubling the traffic through the access point relative to single radio implementations. Although performance varies from vendor to vendor, the data throughput of many of these products may challenge the network operator’s legacy cabling infrastructure.



802.11n access points may be deployed in an existing wireless network. Theoretical 802.11n peak performance will be degraded somewhat by existing 802.11 a/b/g client devices, but, on the other hand, the 802.11a/b/g client devices’ connectivity may be improved. As existing client devices are replaced with 802.11n capable devices, the overall network capability will improve.

Many vendors are recommending that 802.11n be deployed in the 5 GHz band versus the 2.4 GHz band. This is a valid recommendation as there are 21 non-overlapping channels in the 5 GHz band (in the U.S.) versus only 3 non-overlapping channels in the 2.4 GHz band.

OVER THE AIR SIGNALING RATE VERSUS DATA THROUGHPUT RATE

To best understand the implications on the cabling infrastructure from this new wireless technology, a benchmark for data rate should be established, and then comparisons made with the insertion of the new technology. Product vendor's claims for data rate are actually a signaling rate within each radio packet. From the cabling standpoint, the metric of interest is the data throughput rate, which the cabling infrastructure must be capable of transporting. This actual data throughput rate may be quite a bit lower than the advertised "data rate", which is really an over the air signaling rate.

Table I will make a familiar comparison for signaling rate and data throughput rate. As shown, a 100Base-T network will have a 100 Mb/s signaling rate (within the data packets). The 100Base-T measured Ethernet throughput (layer 2) of a file transfer is greater than 90 Mb/s, and perhaps very close to 100 Mb/s. But in the wireless network, the data throughput rate is quite a bit different from the signaling rate. With 802.11b networks, the vendor specified data rate, actually the signaling rate, is 11 Mb/s, but the measured data throughput is more like 5-6 Mb/s at layer 2. This is in a scenario with no contention, i.e. one client device and one access point. Likewise with 802.11a/g and 802.11n products, the actual data throughput, measured at the Ethernet port, will be less than half of the specified signaling rate. However, as shown in Table I, the 802.11n technology will offer about 6 times the actual data throughput that 802.11 a/g offered, and thus the need to consider the impact on the cabling infrastructure.

802.11n products share their transmission medium (the airwaves) and they operate half duplex – somewhat analogously to Ethernet hubs. Contention, interference, and radio frequency noise will degrade both signaling rate and data throughput. Even so, 802.11n offers a rather remarkable increase in wireless data throughput.

TABLE I - Comparison of Signaling Rate to Data Throughput Rate

TECHNOLOGY	"SIGNALING RATE"	NOMINAL DATA THROUGHPUT RATE
100BASE-T Wired Ethernet	100 Mb/s	>90 Mb/s
802.11b Wireless	11 Mb/s	5-6 Mb/s
802.11 a and g	54 Mb/s	20-25 Mb/s
802.11n	300 Mb/s	90-150 Mb/s or 6x performance

The impact of 6x data throughput performance relative to an existing 802.11a/g infrastructure clearly needs to be examined. This means up to 150 Mb/s data throughput rate per radio, and 300 Mb/s for the two-radio access point. This requires cabling for 1000Base-T (Gigabit Ethernet) versus 100Base-TX (Fast Ethernet). The TIA standard 568 C no longer recognizes CAT5 cabling, but re-certifying or testing the installed infrastructure for Gigabit Ethernet is an option. For optimal performance, verify that the wireless access point, switch, and/or controller ports involved are 1000Base-T (gigabit) capable. Oddly enough, many low-end 802.11n access points do not have a Gigabit Ethernet port!

NETWORK DESIGN

The higher 802.11n data rates will impact horizontal cabling to the access point, and it may impact cabling to the access switch, the wireless controllers, network distribution and core areas. An example network is shown in figure 1. Starting with a network comprised of forty-eight 802.11n access points, fully loading a 48-port access switch. The dual radio access point may be capable of up to 300 Mb/s peak throughput on each of 48 ports. Thus, cabling for Gigabit Ethernet between the access points and the switch is required. Now the access switch aggregates this traffic for transport to the wireless controller or network core. But rather than use 48 ports X 300 Mb/s each, which would be 14.4 Gb/s uplink, an over-subscription factor of 20 is applied to establish an uplink of (14.4 Gb/s/20) = 720 Mb/s. The uplink from the access switch to the controller will also be Gigabit Ethernet. Now the master wireless controller may aggregate traffic from multiple controllers in the core, requiring cabling or fiber of greater capability.

What is the "over-subscription" rate? Over-subscription rate takes into account the statistical nature of data networks. For example, although each wireless access point is capable of 300 Mb/s, at any given time the actual service throughput of each access point is much lower than 300 Mb/s, although it may peak at 300 Mb/s periodically. So, why "over design" the network to accommodate every access point peaking at the same time? (This would be described as a 100% non-blocking design, and may be desired in some cases, but will be very costly). Over-subscription of 20 means that the access switches and cabling are designed to handle 1/20 of the peak, simultaneous, data throughput of all of the access points algebraically combined, assuming that the statistical nature of the data will generally not block the data. Over-subscription of 20 is reasonable for a typical office. A higher over-subscription might be used in low traffic networks to reduce cost. A lower over-subscription might be used in heavy use networks where delay and latency is very critical.

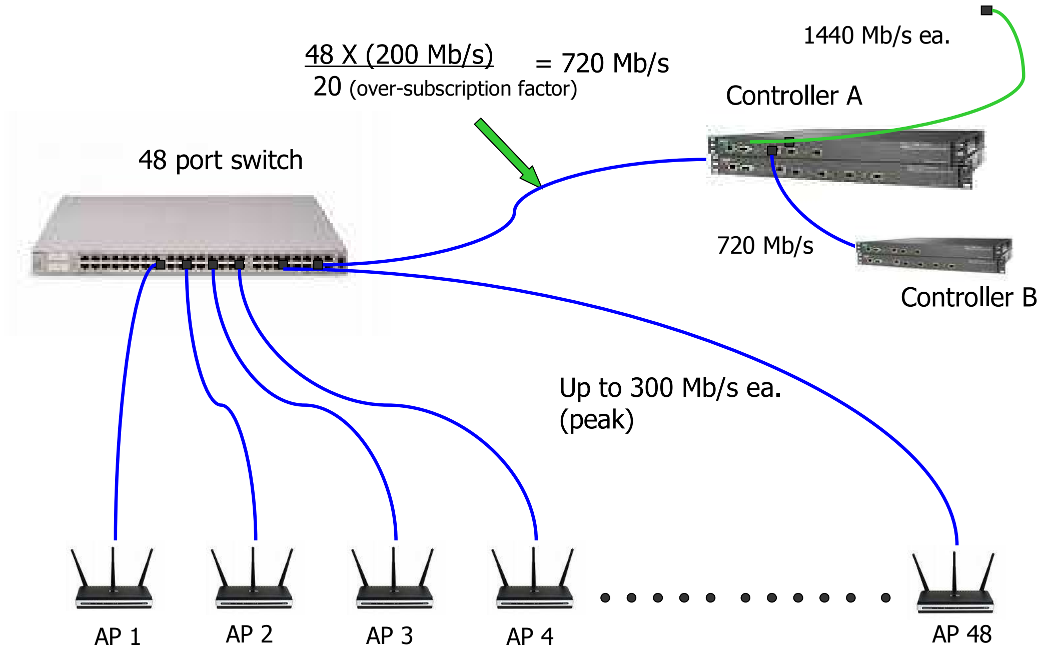


Figure 1 – Cabling to 802.11n wireless access points

TIA STANDARDS

The TIA's Telecommunications Systems Bulletin TSB-162 *Telecommunications Cabling Guidelines for Wireless Access Points* provides guidelines on the topology, design, installation, and testing of cabling infrastructure for supporting wireless local area networks (WLANs) in compliance with the ANSI/TIA/EIA-568-B.1 and TIA-569-B standards for supporting wireless LAN in customer premises.TSB-162 was created by the TIA TR-42 engineering committee and released in March of 2006. TSB-162 is not a standard, but rather contains technical material that may be useful to industry and users. TIA-568-B.1 and – B.2 are now incorporated into the newly released ANSI/TIA-568-C family of standards, but the guidelines of TSB-162 remain unaffected.

TSB-162 states that cabling should be installed and performance tested per existing 568-B.2 standards. Determination of exact cell size and placement of the AP is outside the scope of the TSB-162. The Guideline does recommend the use of an RF planner (either a physical site survey or simulation) to establish coverage. TSB-162 includes wall-mount above the drop ceiling, wall-mount below the drop ceiling, and in-grid ceiling mount. Telecommunications Enclosures (TEs) can be mounted in a ceiling panel to provide locked security or aesthetics for APs

The TSB-162 recommends a square cell with a Telecommunications Outlet (TO) placed at the center of the square, with a patch cord running to the wireless access points. The guideline includes an example of a 60-foot by 60-foot square building cell. This 3,600 sq.ft. cell is a typical commercial building bay size, and agrees reasonably well with wireless vendor recommendations for 3,000 sq. ft. cell sizes to support wireless voice over IP. The TO is located near the center of this square cell. Then, pending completion of a wireless site survey and design, the wireless access point can be located anywhere within the building cell. As shown in figure 2, a 42 foot patch cable will permit the wireless AP to be located anywhere within the 60' x 60' square cell. The TO is connected to the Telecommunications Room (TR), and subsequently to the equipment. This approach satisfies both the TIA 568-B cable length restrictions and the wireless LAN design criterion for AP location.

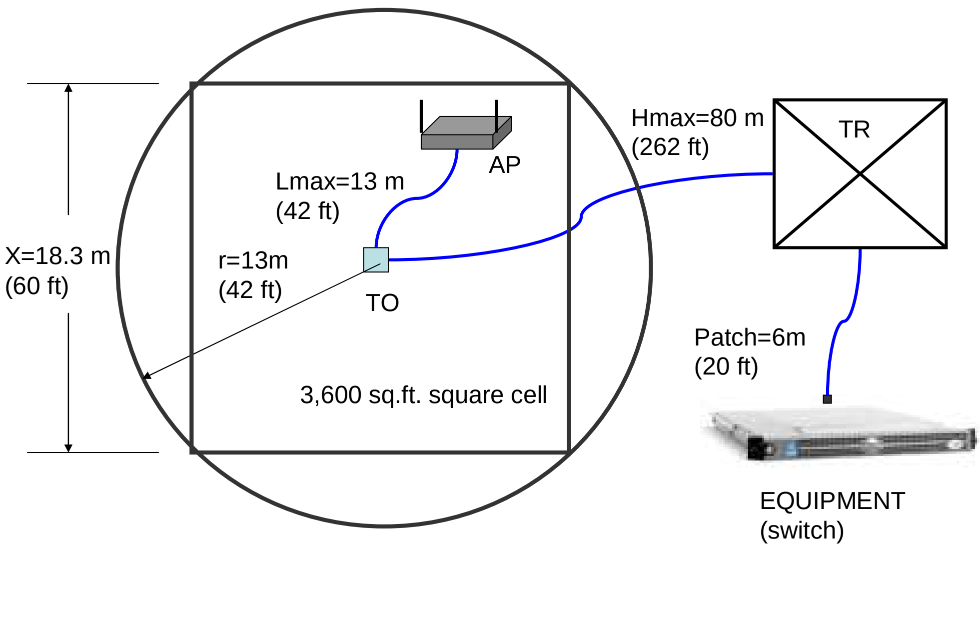
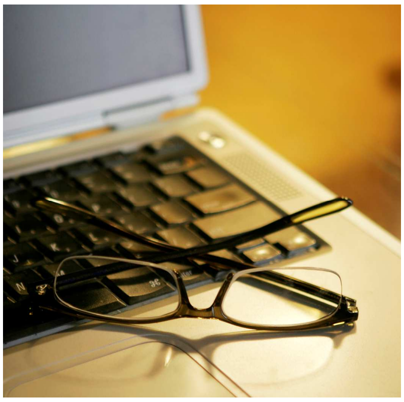


Figure 2- Wireless access point installation in a 60' x 60' building cell

The TSB-162 guideline describes both local powering and remote powering via IEEE802.3af compliant power over balanced twisted pair. Most vendor wireless access points can be powered by IEEE 802.3af PoE. There are some exceptions, requiring 802.3at (*PoE Plus)*. 802.11n products typically require close to the 12.95 W delivered by 802.3af sources, if both radios are used. AC power supplies should not be installed above the ceiling, except in an approved ceiling access enclosure.



Per the TIA 569 standard, a Telecommunications Enclosure (TE) may be used to enclose wireless access points. The use of suspended ceiling space for horizontal connection points may be acceptable, provided that the space is accessible without moving building fixtures, equipment or heavy furniture. Access to the TE shall be controlled against unauthorized access. Cables that enter the TE shall be protected from sheath abrasion and conductor deformation by means of grommets, bushings and suitable cable management hardware. A TE should serve an area not greater than 3,600 sq. ft. A minimum of 3" clear vertical space shall be available above the ceiling tiles for horizontal cabling and pathway.

Although 802.11n is capable of providing coverage over larger areas, many vendors recommend using the same density of access points used in 802.11a/b/g network. This is consistent with TIA standards, vendor recommendations, and anticipates applications requiring a higher signal to noise ratio than simple data applications.

802.11n access points may require three to six antennas. Some access points have non-detachable or integrated antennas. Ideally, antennas are unobstructed by ceiling tiles and other objects. 2.4 GHz and 5 GHz antennas should be spaced about 4" and 2" apart, respectively, or greater. Beyond a minimum spacing, there is no advantage in "spacing in increments of a wavelength". In ceiling installations a suitably rated coaxial antenna cable, such as UL Type CL2P, should be used.

NATIONAL ELECTRIC CODE (NEC)

From the standpoint of radio frequency coverage, the ideal location for the access point's antenna is in the ceiling. The National Electric Code (NEC) provides some guidance on installation in, or above, a suspended ceiling. The NEC differentiates a "ducted" air distribution system, which it calls a plenum, from an air-handling space above a hung ceiling system. The NEC precludes installation in the ducted plenum air distribution system, but permits electrical equipment in the air-handling space over a hung ceiling if the equipment is installed in a metal (or otherwise listed) enclosure. The NEC also states that "*cables, race-ways and equipment installed behind panels, including suspended ceiling tiles, shall be arranged and secured so as to allow removal of panels and access to the equipment.*"

And finally, as always, cable for the future, and be aware of industry specific requirements. For example, in hospitals, the Joint Commission in Healthcare Accreditation has established Infection Control Risk Assessment (ICRA) requirements for mitigating the spread of infectious disease and contaminants. These guidelines may restrict access to the air-handling space above a suspended ceiling. The TIA is expected to release the TIA-1179 Healthcare Facility Telecommunications Cabling Standard in 2009. This standard will provide guidance for healthcare cabling. Also, consider the need for securing the infrastructure by locking access points, and providing for other wireless services such as RFID, asset location and tracking, building automation, sensors, and cellular.

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