White Paper
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Next Generation Wireless
Evolution, Advancements and Considerations for Deployment

Nexans

Where We Are and Where We're Going

The global proliferation of wireless devices continues to drive data consumption at an impressive rate. As the industry standards entities continue to take steps to enable faster data transmission, multiple options are presented to infrastructure owners on how to best implement the new technology developments. New developments in BASE-T, combined with Power over Ethernet, will add further demands upon the copper infrastructure that supports wireless access points. Those options must be carefully weighed in order for the owners to successfully implement the next steps and place themselves in the most advantageous position for future generations of wireless deployment. Deploying a robust cabling infrastructure today using Category 6A or higher components will continue to yield future dividends through minimized disruptions and increased flexibility for the next generation of wireless deployments.

Rapid Growth Leads to Rapid Advancement

Wireless consumption continues on a path of rapid growth. As new technologies evolve and are adopted, the expectations and stresses upon the WiFi infrastructure will grow exponentially. Cisco recently updated (2016) its Visual Networking Index: Global Mobile Data Traffic Forecast Update, projecting wireless growth between 2015 and 2020. The prognosis is continued strong growth in both wireless and WiFi bandwidth consumption. In 2015, for the first time, more mobile device traffic was offloaded to WiFi than remained on the cellular network. Projections for the next five years are that the average smartphones will create a nearly five-fold increase in overall network traffic, rising from 929 MB per month in 2015 to 4.4 GB per month in 2020.

This growth will continue to be driven in large part by video consumption, which represented 55% of the total data consumed in 2015 and is projected to rise to 75% of total data by 2020. Video consumption tends to be centered in "prime time," unlike more traditional web usage, which will have a dramatic effect on average and peak traffic loads. In 2015, the global peak traffic was 66% higher than the average; by 2020 it is expected that the difference will substantially increase to 88%. This predicted growth in peak and average consumption will place a heavier strain upon WiFi infrastructures.

Concurrently, the expectations placed on WiFi deployments are also increasing. Providing the adequate bandwidth for data-intensive applications, ensuring a strong signal to maximize speeds, and servicing a continually increasing number of devices are now the major factors driving speed and capacity upgrades to ensure clients are served in an acceptable fashion.

IEEE 802.11ac Drives Base-T Expansion

As recently as 2014, a single 1000BASE-T drop was adequate to service the backhaul requirements of most wireless access points. A IEEE 802.11n wireless access point (WAP) is limited to a theoretical maximum of 600MBps, which is well below the capacity of 1000BASE-T. Only in high-density client environments did designers place specialized 802.11n WAPs with multiple 1000BASE-T ports to provide for the data and power demands of multiple antennas on a single platform.

Client device densities that were considered extraordinary prior to 2014 are now more representative of today's average wireless-enabled environment. To address growing demand, IEEE 802.11ac was developed to increase the bandwidth available to each wireless device. Released in waves, the first deployments of 802.11ac continued to be satisfied by a 1000BASE-T drop, as the maximum aggregate capacity of the access points was approximately 850Mbps. However, later generations have seen that number increase above 1GBps, with the expectation that eight antennae WAPs could reach an eventual maximum of 6.9Gbps. This increasing aggregation of throughput is fueling the need for copper backhaul capacity greater than 1Gbps, which the IEEE 802.3, owner of the BASE-T technology, is quickly addressing. However, there are additional technical developments underway that will place further burdens upon the infrastructure.

Next Generations to Push More

Through Air and Copper

Anticipating the continued growth of the wireless market, IEEE 802.11ax is in development with the expectation of providing increased speed, flexibility and capabilities to wireless networks. There are several goals set forward by the task force, but targeting a 4X improvement over 802.11ac in average throughput is high on the priority list. This will be achieved by improving spectral efficiencies. Rather than using new frequencies, the task force will improve the encoding and deliver more bits per Hertz.

Increasing throughput to a client could be achieved through increased received signal power. However, due to the broadcast signal power limitations placed upon the equipment, increasing signal strength to a client is not as simple as "turning up the volume" and will likely require higher densities of access points. Issues being studied include:

1. Access point density: maximizing performance and minimizing interference in high density WAP environments (e.g. between 10-20m)

2. Client density: Efficient transitions between servicing clients becomes more important as the number of devices waiting to broadcast and receive data continues to increase.

3. Doppler effects: Mobile clients are expected to move within the access point's coverage, causing frequency shifts in the broadcast and received signals. Pedestrians move at approximately 4 km/h but faster-moving vehicles will cause larger shifts in frequency due to physical movement of the client or reflections from their surfaces.

4. Diversity: Not all devices will need a large allocation of wireless capacity. Low speed devices are expected to proliferate, and their periodic status reports will need to be efficiently interleaved with clients with fast response and high bandwidth expectations.

Refinements to existing standards are also expected to lead to new applications and use cases. IEEE 802.11az will utilize and improve upon the existing technologies in 802.11n, 802.11ac and 802.11ad, providing the ability to determine the position of a client within 2 meters. (See Figure 1 for a summary of the 802.11 standards.) Essentially, this would provide ultra-fine positioning capabilities within a building, leading to numerous use cases that could include:

1. Asset tracking in areas such as medical facilities where the ability to quickly and precisely locate equipment may be of vital importance.

2. Delivering personalized data such as directions in a public building to a seat or office and selective video promotions to wearables like glasses and watches based upon client position and facing direction.

3. Optimal product placement or display in a retail environment through analyzing the patterns of customers' movements.

4. Positional home audio that follows the end user by activating or deactivating localized speakers as the end user moves throughout the house.

It is anticipated that many new applications will be enabled through these developing wireless standards. While there is a desire to provide as many new capabilities as possible in the existing deployment architecture, some of these technology improvements will need to reduce the WAP coverage to areas perhaps as small as 100 m^2. However, the addition of new capabilities will lead to increasing data consumption further enforcing the need for a cost effective technology to be rapidly and easily deployed today.

	2017	2018	≈ 2020
	802.11n	802.11ac	802.11ax
Antennas	Access Points Peak Data Rates (theoretical maximum)		
1x1	150 Mb/s	866 Mb/s	≈ 3,4 Gb/s
2x2	300 Mb/s	1.7 Gb/s	≈ 6,8 Gb/s
4x4	450 Mb/s	3.4 Gb/s	≈ 13,6 Gb/s
8x8	600 Mb/s	6.9 Gb/s	≈ 27,6 Gb/s
Reach	~ 70 m	~ 35 m	~ 10 - 20 m

Figure 1: Summary of IEEE 802.11 network standards

The Proliferation of New Technologies

2.5 and 5GBase-T:
The Impact of Alien Crosstalk

The explosion of wireless bandwidth consumption has driven backhaul speeds at the access point beyond 1Gbps. Today, a solution comprising 10GBASE-T silicon with 400MHz capacity and Power over Ethernet (PoE) to power the access point would be too costly for rapid market deployment. One possible way to address this issue would be to deploy multiple 1000GBASE-T cables. However, this would require the access point and switch to include one RJ-45 port for each gigabit of capacity. At 5 Gbps or more of throughput, it quickly becomes apparent that a single RJ-45 solution is more compact and simpler to manage than multiple ports.

A more palatable market solution is to deploy an interim step that reuses existing 10GBASE-T encoding to enable a single jack solution while using simpler and more cost-effective PoE magnetics. 2.5GBASE-T and 5GBASE-T provide this method to increase backhaul capacity, but deployment of these new interim speeds may not be as simple as expected.

There is a strong desire among the standards bodies to make 2.5GBASE-T and 5GBASE-T capable of operating over existing cabling. However, alien crosstalk is proving to be a limiting factor in Category 5e and Category 6 channel reach, as it was never specified for these categories.

The TEK Center at Nexans has performed system testing on various levels of Category cabling to understand the impact of alien crosstalk on cable and system performances in combination with bundling. The test results provide clear indications that alien crosstalk plays a significant role in limiting system reach with cabling not designed for alien crosstalk mitigation (Category 6 and 5e).

While different designs of a cabling can play a role in its capability of supporting 2,5GBASE-T, the results were substantially closer when operating as 5GBASE-T, due to the increased susceptibility of data corruption to alien crosstalk at higher speeds. It is possible that the reach of Category 5e and Category 6 channels could be extended through unbundling. However, the physical isolation of a channel from its neighbors is not always practical and may yield only enough improvement to reach a limited number of additional devices or access points. It is recommended to use Category 6 FTP designs as a minimum to support up to 5GBASE-T.

However the alien crosstalk performance and extended reach margin of Category 6A make it the best solution for wireless deployment. Unlike Category 6 and 5e, whose alien crosstalk performance has not been specified, Category 6A offers ample margins to assure 100m system operation and data integrity regardless of network speed of proximity of adjacent channels.

Power over Ethernet and Heat Rise

Power over Ethernet (PoE) is a convenient method to power remote devices, such as WAPs, through communications cabling. As devices become more sophisticated and applications more complex, power consumption increases. The IEEE 802.3bt group is specifying equipment to supply a maximum of 100W (1 amp per pair). This increased power deployment will result in increased heat generation within the cabling infrastructure. Nexans performed a study to characterize heat rise within a bundle – see figure 2

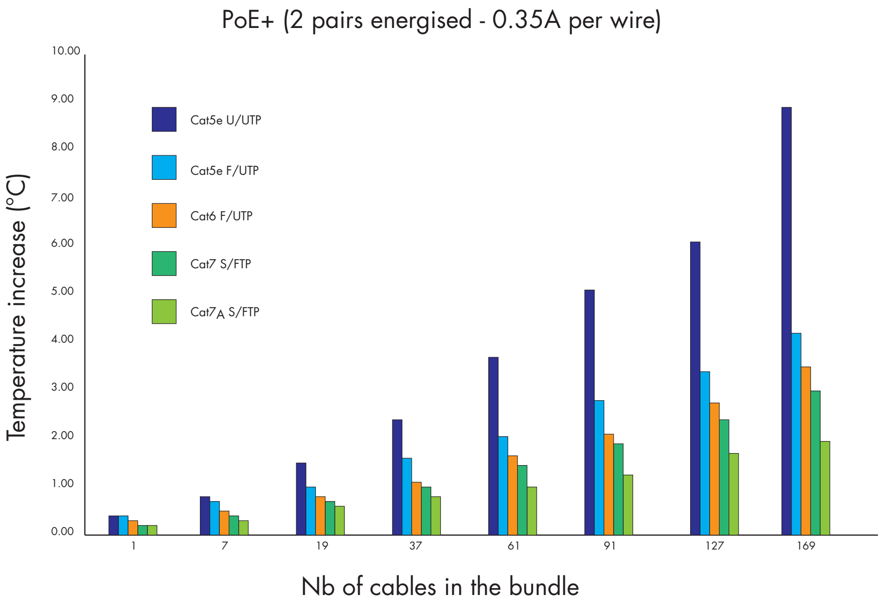

Figure 2: Relationship between bundled number of cables running PoE+ and temperature gains

The TEK Center then extended the heat studies to understand the impact to 2.5BASE-T and 5GBASE-T four-connector channels as they service devices such as WAPs. Testing revealed that the Category 5e and Category 6 channels lost 4-5m of reach at 75°C when compared to their ambient 20°C state. The Category 6A channels also exhibited a proportional reduction in system reach; however due to the excess margin inherent to the design, the system would continue to operate at 100m. This reduction in length is important as most infrastructure validation is performed when the network is off and not operating under the worst case conditions.

Mitigation performed according to TIA TSB-5021 may not be sufficient as it does not take temperature into account when calculating system margins. When the deployed system is operational and drawing power, an increase in the bundle temperature due to ambient temperature rise and/or cable heat generation may cause mitigated Category 5e and Category 6 channels to fail. The result is the end user will have to further mitigate the channel causing additional down time and site disruption. The use of Category 6A cabling as a minimum standard will avoid this issue and provide enough margin to withstand the increased temperatures, delivering data under the duress of increased speeds, alien crosstalk and elevated temperatures

Conclusions and Recommendations

Cable and Infrastructure Recommendations

The continued growth of wireless data consumption has pushed the industry to develop additional methods of increasing capacity. While it is possible that these new technologies may work on existing infrastructures, it is clear that modifications to existing Category 5e or Category 6 wireless infrastructure may be required either in the form of mitigation to improve electrical performance or increased number of drops to increase capacity. The superior network capacity, alien crosstalk performance, resistance to heat generation from PoE, and extended reach margin of Category 6A and 7A cabling, make it the best choice for wireless deployments.

The Case for Zone Cabling

ISO/IEC published 11801-6 and European Norm 50173-6 – Generic cabling Systems for Distributed Building Services - will be revised in line, to provide directions for cabling in anticipation of growing wireless deployments as well as growing number of other IP based devices and sensors. IEEE 802.11ac was given specific consideration by selecting a cell size of maximum 3,600 sq. ft. (or 325 m2) and suggesting a centralized drop configuration (see **Figure 3, Option 1**). However, Nexans has always recommended two Category 6A drops so additional WAP density could be added with minimal disturbance.

It is anticipated that future wireless technology deployments may need a higher density of WAPs, so zone cabling with Category 6A cabling should also be considered as a design option. Zone cabling (see **Figure 3, Option 2**) is the concept of dropping multiple cables to a centralized location in order to provide additional capacity, which can be used in the form of:

1. WAP Aggregation: Multiple cable drops are utilized for a single WAP.
2. Increased PoE: In the case of large WAPs, power delivery can be made more efficient through the use of more copper pairs.
3. Higher WAP density: Deployment of more WAPs within the cell to reduce the coverage area per WAP.

While some of these new wireless use cases and applications are anticipated to work within today's 802.11ac WAP density, many applications that utilize positioning functions will benefit from an increased WAP density. Deploying a robust zone cabling infrastructure today using Category 6A or higher components, such as Nexans LANmark-6A or 7A, will continue to yield future dividends through minimized disruptions and increased flexibility for the deployment of the next generation of access points.

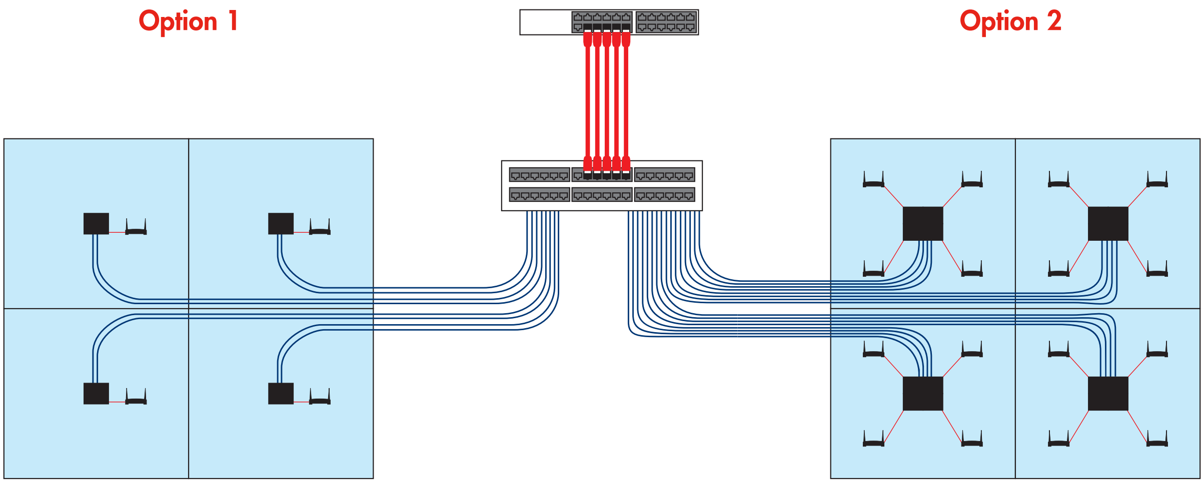

Figure 3:
Examples of Typical Zone Cabling Designs

Option 1

Nexans has recommended at least two Category 6A cables to each WAP. This allows the end user to either swap out WAPs when needed without a rip and replace of the network infrastructure. Additionally, if another WAP is eventually needed to provide adequate coverage and bandwidth, it is a very easy transition.

Option 2

With the rapid changes and explosive growth in wireless technology, Berk-Tek is now recommending doubling the number of cables to four. With 802.11ax and az now in development, two WAPs may not be sufficient if total cost of ownership is top of mind. As bandwidth speeds increase, the range of each WAP will decrease, so more WAPs will be needed to provide satisfactory service over the same coverage area. Additionally, with positioning and locating capabilities coming to WiFi in the future, WAP density will need to substantially increase to fully realize its potential.

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