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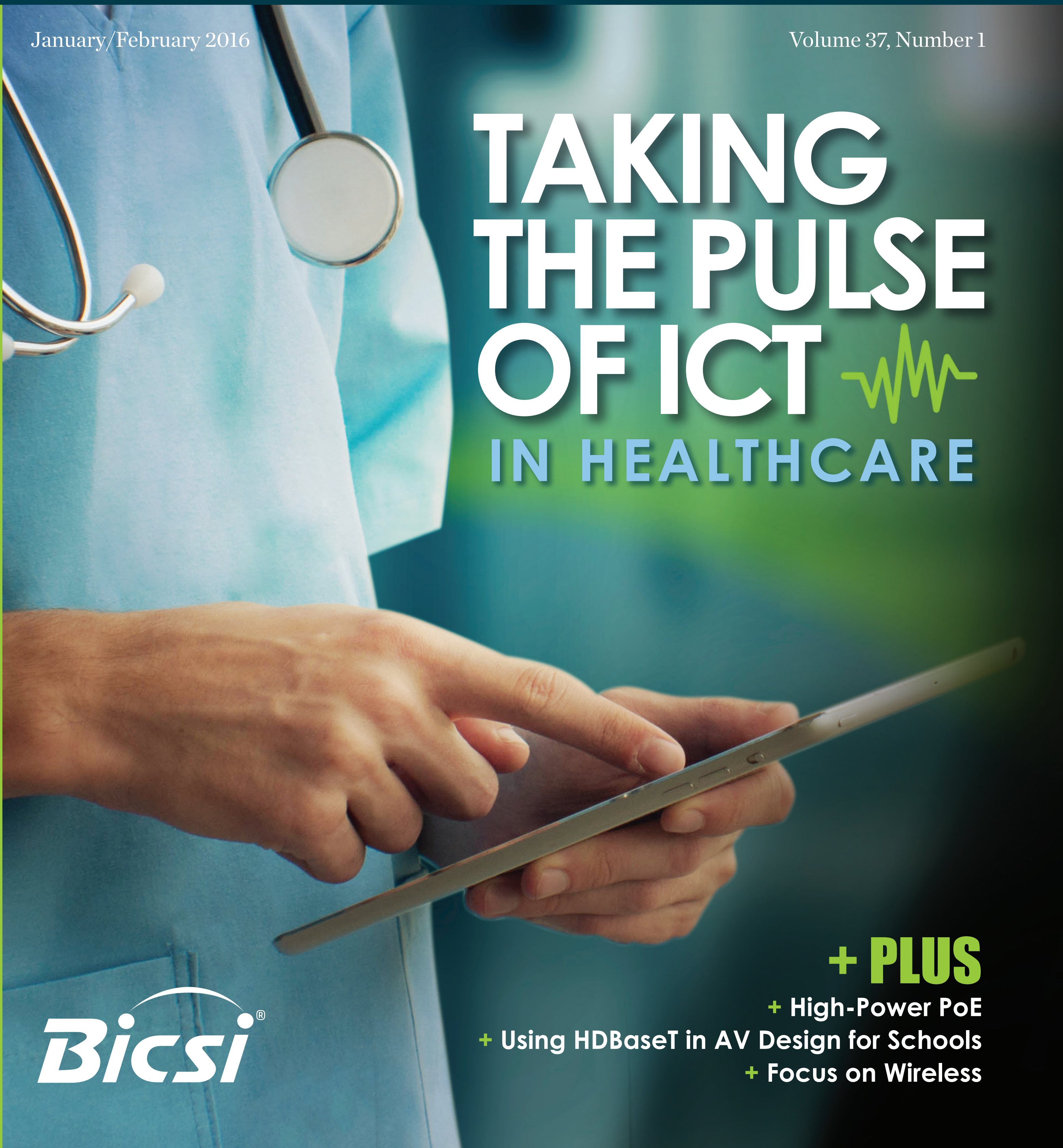

TAKING THE PULSE OF ICT IN HEALTHCARE

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By Ty Estes

High-Power PoE

Technology, Market Drivers and Challenges

For mission-critical deployments, PoE media converters with dual optical fiber ports can also be configured for redundant optical fiber links.

Power over Ethernet (PoE) is a method of safely transferring electrical power along with data to remote devices over standard category 5/6/7 copper cabling using four pairs of wires. In most cases, both the power and data co-exist on the same wire, but are independent and unaffected by the other. This is accomplished using a technique called phantom power.

PoE is a mature technology, with millions of PoE devices already installed, and 25 million PoE ports shipping each quarter. The market is still growing; the drivers for PoE are devices like wireless access points (WAPs) and Internet protocol (IP) surveillance cameras that have increasing power requirements. PoE simplifies the powering of these devices and reduces deployment costs.

PoE requires power sourcing equipment (PSE), which provides the power to the wire pairs. PSE can be an endspan device like a PoE switch located at the end of the Ethernet segment, or a midspan device located somewhere in the middle of the segment. A midspan typically has two ports: one is data only that connects to the network equipment, and the other includes power and connects to the powered device (PD), which is the remote device that draws power from the PSE.

In 2003, IEEE ratified the IEEE 802.3af PoE standard that allows up to 15.4 watts (W) of power per connection. In 2009, the IEEE ratified the 802.3at PoE+ standard, which increased the amount of power to each PD to up to 34.2 W to power devices like 802.11n wireless devices and high-definition surveillance cameras.

The IEEE PoE standards define the detection and classification of PDs. During the detection process, the PSE applies low voltage on the wires. A valid PD will detect the low voltage and present a specific signature to the PSE. If no valid signature is detected, the PSE will not apply power, but it will still pass data. If a valid signature is detected, the PD may present a classification signature that is used to inform the PSE the level of power required by the PD. Upon completion of the signature process, power is supplied by the PSE.

802.3at is backward compatible with 802.3af, enabling an 802.3at PoE+ PSE to be compatible with an 802.3af PoE PD, and supply the required power.

IEEE 802.3af PoE and 802.3at PoE+ include two powering options:

- **Alternative A** – applies the positive direct current (dc) voltage on pins 1 and 2, and the negative dc voltage on pins 3 and 6. For Fast Ethernet, these are also the data pairs. When power is applied to the same pins as the data, it is known as phantom power.
- **Alternative B** – applies the positive dc voltage on pins 4 and 5 and the negative dc voltage on pins 7 and 8. For Fast Ethernet, these are the spare pairs. For Gigabit Ethernet, all four pairs carry the data.

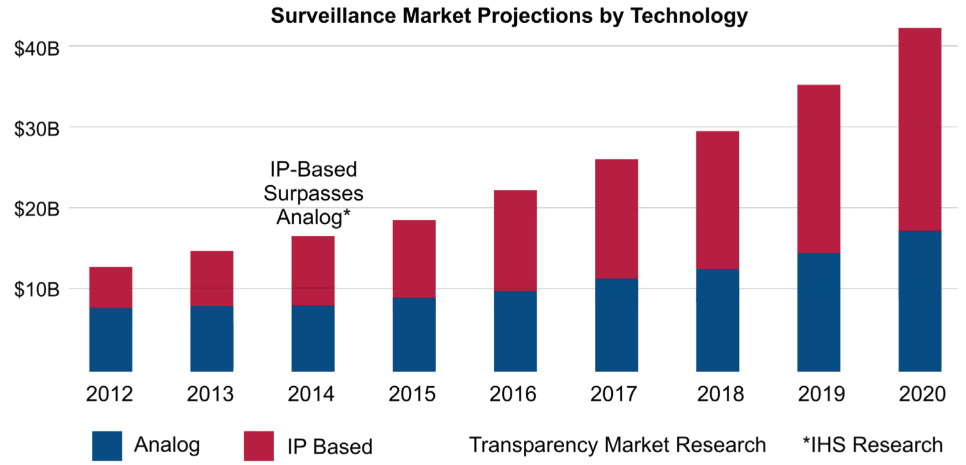

FIGURE 1: Comparison of surveillance video system sales.

Driving PoE Growth

Two key technologies driving the growth in PoE deployments are Wi-Fi and IP surveillance.

According to Transparency Market Research, the security surveillance market will grow to $42.81 billion by 2019, at a compound annual growth rate (CAGR) of 19.1 percent. By system, the IP-based surveillance market will grow at a CAGR of 24.2 percent during the same period (Figure 1). Everyone is familiar with the shift from analog CCTV to IP-network cameras over the past few years. In 2010, many security systems integrators did not work with IP networks, and very few worked with optical fiber. The market shifted from analog to IP in 2014, and data from IHS Research shows that IP video revenues surpassed analog video revenues that year. PoE played a role in this market shift by reducing costs and simplifying IP camera installations, along with the ease of use, lower cost and advantages of digital recording.

Wi-Fi is also driving PoE market growth. In addition to the deployment of WAPs in enterprise and campus networks, cable operators are pushing Wi-Fi as a value-added service to their cable TV subscribers for data roaming. Cable operators are also leasing Wi-Fi access services to mobile network operators (MNOs) who are looking for a cost-effective way to offload 3G and 4G data traffic from cell towers to meet the ever-growing demand from smartphones and tablets.

Juniper Research projects that 60 percent of mobile data traffic will run over Wi-Fi by 2019, compared to just over 50 percent in 2014. To meet the three-fold growth in IP traffic over the next four years, 53 million Wi-Fi hotspots will be deployed globally by 2018, as projected by Cisco's Visual Networking Index. Wi-Fi traffic is typically deployed today as "best effort" Ethernet without Quality of Service.

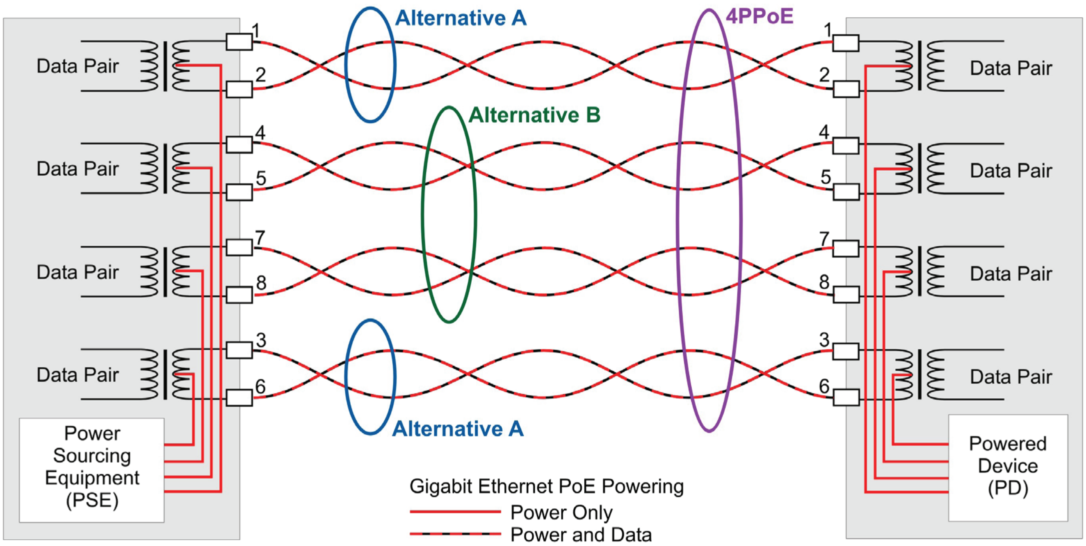

FIGURE 2: Schematic of RJ-45 pinouts with Alternative A and B 2-pair power, and 4-pair PoE (4PPoE) power.

High-Power PoE

A new generation of PoE devices has emerged on the market that requires more power than the 34.2 W specified by 802.3at PoE+. These include high-definition outdoor IP cameras with blowers and heaters, as well as WAPs with dual bands (3x3 multiple-input, multiple-output [MIMO] and 3 spatial streams, and 2x2 MIMO and 2 spatial streams) that can require up to 60 W of power.

IEEE 802.3af PoE and 802.3at PoE+ apply power to two of the four wire pairs with Alternative A or Alternative B. To meet the higher power requirements, 60 W PoE applies power to all four pairs of wires; this is also referred to as 4PPoE (Figure 2).

60 W PoE is now available for these power-hungry devices. Integrated circuit manufacturers are providing high-power PoE chips, and PoE switch manufacturers are providing 60 W PSEs. The technology market is moving faster than standards organizations, so there is no ratified standard for 60 W PoE. The IEEE standard for 60 W (also known as PoE++) is currently in development with the IEEE 802.3bt Type 3 Work Group and is projected to be ratified in 2016.

There are two commercial PoE technologies that provide 60 W of PoE: Universal PoE (UPoE) from Cisco and High Power over Ethernet (HPoE) from Microsemi. Both are backward compatible with IEEE 802.3af PoE and IEEE 802.3at PoE+, but they use different proprietary detection methods for the 60 W capability, so equipment interoperability is not guaranteed.

60 W PoE delivers power for new IP cameras, WAPs and other devices like electronic signs and thin clients. There are no known heat or safety issues with 60 W PoE, even in large bundles of 100 cables or more.

In addition to IP surveillance and WAPs, there are emerging technologies like small cells that require higher PoE power levels. The small cell market is exploding, with a rapid growth in deployments, and will be a market driver for high-power PoE. Infonetics Research projects that the small cell market will nearly quadruple by 2018, and three million small cells will be shipped by the end of 2016.

Small cells are deployed in a telecommunications heterogeneous wireless network (HetNet). The traditional cell tower network has a base station controller (BSC), or radio network controller (RNC), installed as a node on an optical fiber ring with access links distributed to NodeB equipment for 3G, or eNodeB equipment at cell towers for 4G/LTE. Mobile data proliferation and the ever-growing bandwidth demand is overwhelming cell tower networks, creating the need for additional coverage for heavy use areas within the range of the cell tower, called hot spots, and coverage to areas outside the cell tower range, called not spots. Small cells are deployed in hot spots and not spots to provide more coverage at a lower cost than building new cell towers (Figure 3).

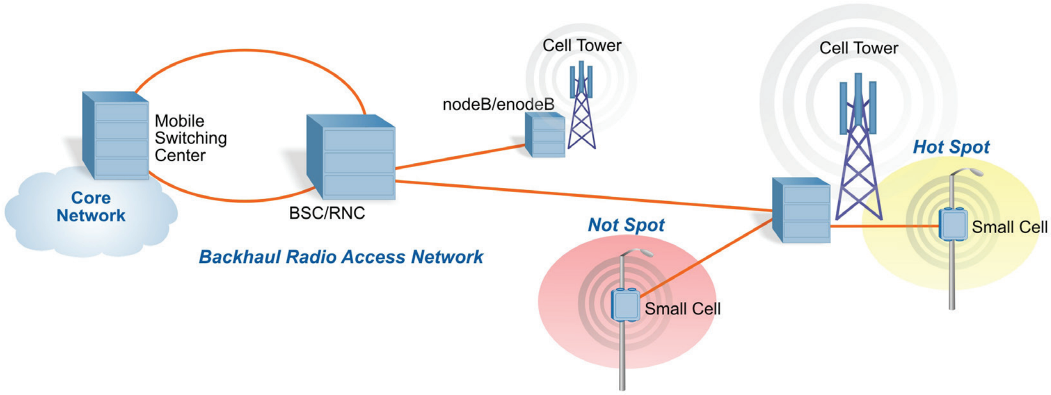

FIGURE 3: HetNet backhaul access network with small cell hot spots and not spots.

100 W PoE and Safety Issues

PoE is climbing to 90 and 100 W, with up to one amp on each pair of wires—a lot of power for unshielded twisted-pair (UTP) cables. For implementations greater than 60 W, the IEEE 802.3bt PoE Type 4 work group is defining the standard for 100 W PoE. It is in the early stages of development and is targeted for ratification in late 2016.

HDBaseT is another 100 W technology that enables up to 10.2 gigabits per second of uncompressed video, audio, Ethernet, control signals and power all sharing the same cable. The HDBaseT Alliance is an industry organization with nearly 150 member companies that promotes the adoption of HDBaseT to provide video, audio and power to HDTVs over a single cable. HDBaseT uses standard RJ-45 connectors, and the cabling can reach distances up to 100 meters (m [328 feet (ft)]). This technology utilizes an HDBaseT hub that powers audio and video equipment. HDBaseT equipment is typically deployed as video extenders (taking advantage of category 5 distance), and HDBaseT connections to video matrix switches. Applications for HDBase-T include control rooms, sports bars and electronics retailers.

With 90 and 100 W PoE, there are heat and safety issues associated with high power on all four wire pairs. These include overheating when installed in large cable bundles, and arcing and sparking when removing RJ-45 jacks under full power.

To address heat issues and safely deploy 100 watt PoE, it is recommended to use category 6A cables with a minimum of 23 gauge wire to future-proof for both 100 W PoE and 10 G data rate. It is important that the temperature of any single cable in the bundle does not exceed the temperature rating for the cable, so cables with the highest operating temperature rating for maximum design flexibility are recommended.

Manufacturers are suggesting breaking bundles of 96 and 100 cables down to smaller bundles of 24 cables for 100 W deployments, and network designers and cable installers should take into consideration heat dissipation and ambient temperature rise. Adjacent bundles in the same pathway are acceptable, as long as there is a 15 millimeter gap between bundles (see Figure 4 on page 20). For brownfield deployments with existing category 5 cable bundles, temperature can be mitigated by mixing powered and unpowered cables in the bundles.

These safety issues have garnered the attention of the National Fire Protection Association (NFPA), the producers of the *National Electrical Code*® (*NEC*®), which covers fire safety for electrical installations. The 2017 edition is under development, and Article 804.61 will include language on installing PoE cabling. There is a risk that 90 and 100 W PoE have killed the golden goose, and the *NEC* will require electricians to install high-power PoE.

UL has submitted hundreds of pages of test data in the comments phase of the 2017 *NEC*. Major PoE product manufacturers are also submitting comments. This will be decided soon, with second draft ballots in January 2016. The probable outcome is the *NEC* will include 100 W PoE design recommendations but not require electricians to install the cables.

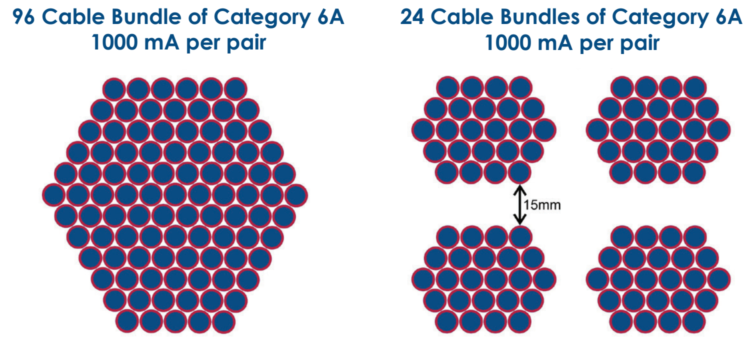

FIGURE 4: Reducing cable bundle sizes for 100 watt PoE.

Distance Challenges with High-Power PoE Deployments

High-power PoE is a useful technology in powering remote devices, but as with any copper network cable, the challenge lies in the limited distance and bandwidth of copper UTP cabling. The maximum length for an Ethernet copper cable segment is 100 m (328 ft), which limits the placement of remote PoE PDs like surveillance cameras, WAPs and small cells. PSE power injectors and midspans do not increase the distance of the copper cabling network.

There are several solutions available to extend the distances of PoE network links, including LAN extenders that convert Ethernet to DSL, UTP-to-coaxial converters, and wireless technology. Optical fiber cabling provides several distinct advantages to these technologies including longer distances, more bandwidth capacity, higher security, and noise and lightning immunity.

PoE media converters can be used to enable optical fiber distance extension to remote PoE PDs (Figure 5, page 21). Since dc power cannot be conducted over optical fiber, the PoE media converter is used to convert the optical fiber to copper and inject up to 60 W PoE on the RJ-45 port. PoE media converters are available in Gigabit Ethernet and Fast Ethernet speeds, support PoE, PoE+, and high power (60 W), and can be compatible with both HPoE and UPoE proprietary high-power PoE technologies. PoE media converters are temperature-hardened for outdoor deployments, and support advanced features like remote PoE power reset and link fault propagation modes with DIP-switch configuration.

PoE media converters are installed at the remote ends of optical fiber runs, with a distance up to 160 kilometers (100 miles), where the converter functions as a PSE and injects PoE power over the copper UTP cable. They are installed near alternating current (ac) or dc power sources, and are powered with direct dc power 3-position terminal connectors or ac-to-dc power supplies (100 to 240 volts ac) that connect via a barrel connector. PoE PDs are installed at the other end of the copper cable, up to 100 m (328 ft) away from the PoE media converter.

In the IP surveillance camera application shown in Figure 6 on page 21, optical fiber links are distributed from an Ethernet switch that also provides connectivity to digital video recording equipment in a security control room. A point-to-point optical fiber run is terminated with a PoE media converter that provides copper to optical fiber conversion and powers an IP camera with 60 W PoE.

For mission-critical deployments, PoE media converters with dual optical fiber ports can also be configured for redundant optical fiber links. At the remote end of the redundant optical fiber links, a PoE media converter is deployed to provide distance extension to two IP surveillance cameras, and the power is protected with an uninterruptible power supply (UPS) battery. In the event an optical fiber link is cut, and the power is cut, the camera will continue transmitting video to the control room. Redundant links can also be achieved with two PoE media converters deployed in a bookend configuration, with one connected to a copper switch at the head end, and the other to the PDs at the remote end.

In this wireless application shown in Figure 7 on page 22, Wi-Fi access points are installed throughout a business complex for 3G and 4G data offloading. Optical fiber is distributed from a copper switch using managed media converters installed in high-density rack-mount chassis. The media converters are also used to provide a managed demarcation point for an MNO. Across the top of the diagram, office buildings are connected with point-to-point optical fiber runs. Each media converter provides data and power to two WAPs installed up to 100 m (328 ft) from the converters.

At the bottom of the diagram, PoE media converters with dual

FIGURE 5: PoE media converters with 60 W PoE.

optical fiber ports are installed in NEMA enclosures on light poles. PoE media converters that feature dual optical fiber ports can be configured for daisy chain (linear bus) topologies that can also be deployed in other linear applications such as railroads, subways, highways and border fences. One optical fiber port is the optical fiber uplink, and the other is the optical fiber downlink. It is important to note that the total aggregate bandwidth required for all the PDs must not exceed the total data rate supported by the optical fiber switch port—either 100 megabits per second or Gigabit Ethernet. PoE media converters are temperature-hardened for all-weather outdoor deployments, and each PoE media converter provides data and power to a WAP on each light pole. Since these are outdoor Wi-Fi access points with multiple streams, 60 W PoE is required.

Small cells are deployed in hot spots and not spots to increase coverage for 4G voice and data. Since a small cell is basically a miniature cell tower, an Ethernet Virtual Connection (EVC) with Quality of Service, performance monitoring and timing synchronization is required to ensure quality connections. This requires Carrier Ethernet service demarcation with a Network Interface Device, or NID (Figure 8). NIDs are Carrier Ethernet devices with integrated management and support a variety of performance monitoring, fault management, traffic management, timing and protection switching capabilities.

Small cells typically require 60 W of power, and may require up to 100 W in the future. NIDs provide high-power PoE to small cells, which eliminates the need to deploy a midspan at each small cell location (similar to PoE media converters). NIDs have up to four RJ-45 PoE ports to power multiple small cells, WAPs and surveillance cameras.

In the small cell application shown in Figure 9, a PoE NID is deployed on a light pole inside a NEMA enclosure. It terminates a point-to-point optical fiber run and provides data and 60 W of power to a small cell, a Wi-Fi access point and an IP camera. Three EVCs are transported over the optical fiber link, and the NID assigns each EVC to the appropriate port for connectivity to the PDs. PoE NIDs also feature dual optical fiber ports for daisy chains and redundant links, and can also support optical fiber rings with protection switching.

Conclusion

One of the challenges with PoE deployments (for all power levels) is the distance limitation of copper cabling. Media converters and NIDs have provided reliable solutions in the deployment of IP cameras, WAPs and small cells.

PoE is growing in popularity, and the amount of power over twisted-pair cabling is also growing. 60 W PoE may be the sweet spot, providing enough power for today's PoE devices while remaining safe and not increasing cabling temperatures. IEEE will be ratifying the 802.3bt Type 3 standard for 60 W PoE in the near future, guaranteeing interoperability and helping market adoption with predictability.

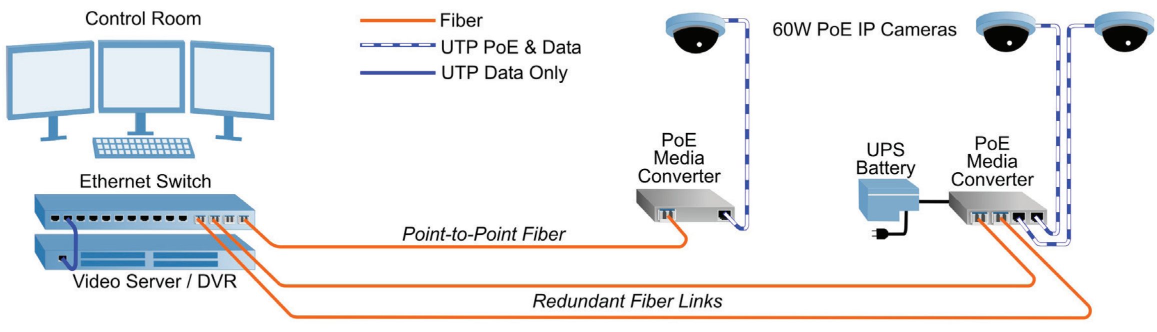

FIGURE 6: Fiber distance extension to IP cameras with PoE media converters.

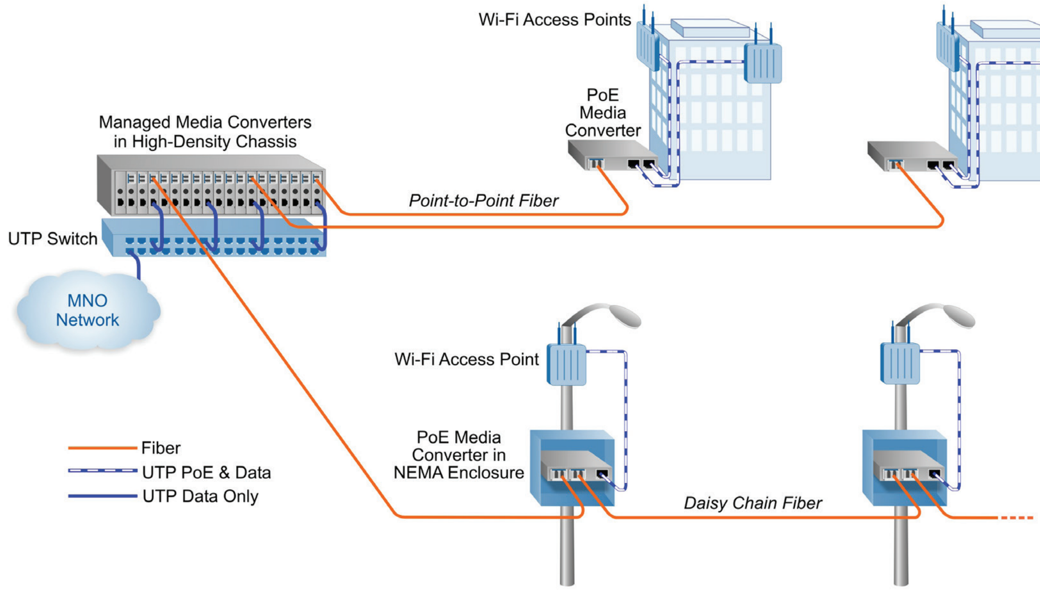

FIGURE 7: Optical fiber distance extension to WAPs with PoE media converters.

FIGURE 8: Carrier Ethernet Network Interface Devices with 60 W PoE.

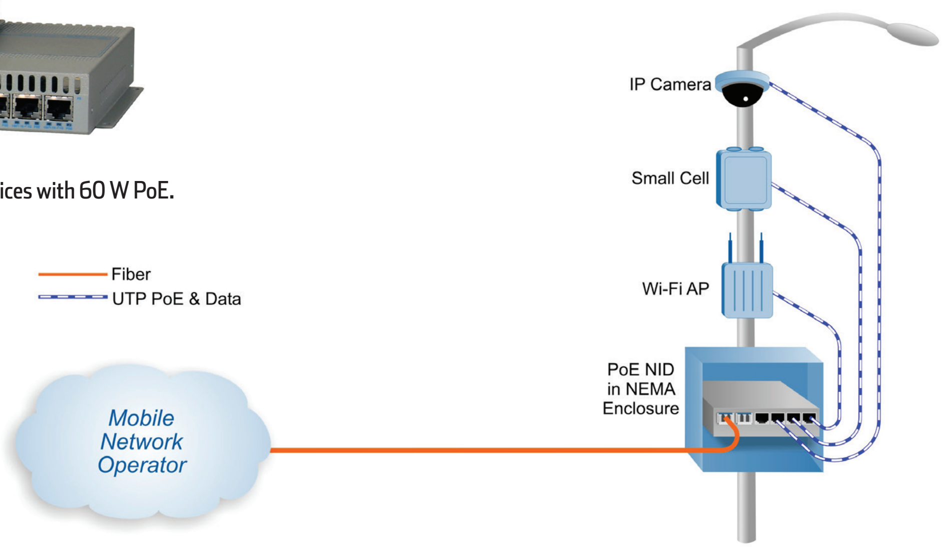

FIGURE 9: Carrier Ethernet optical fiber backhaul for multiple devices with PoE NID.

The future is not so clear for 90 and 100 W PoE. Heat and safety issues, while easily mitigated with cable gauge and bundle sizes, have raised concerns with the NFPA. These higher power levels may introduce electricians into the cabling landscape, and probably new design recommendations in the *NEC*.

What is certain is that PoE provides tangible benefits and, as a result, has become big business. Millions of PoE-powered devices will be shipped in the coming years, along with an exponential number of PoE-powering ports and double-digit growth for PoE shipments and deployments. ◀

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