



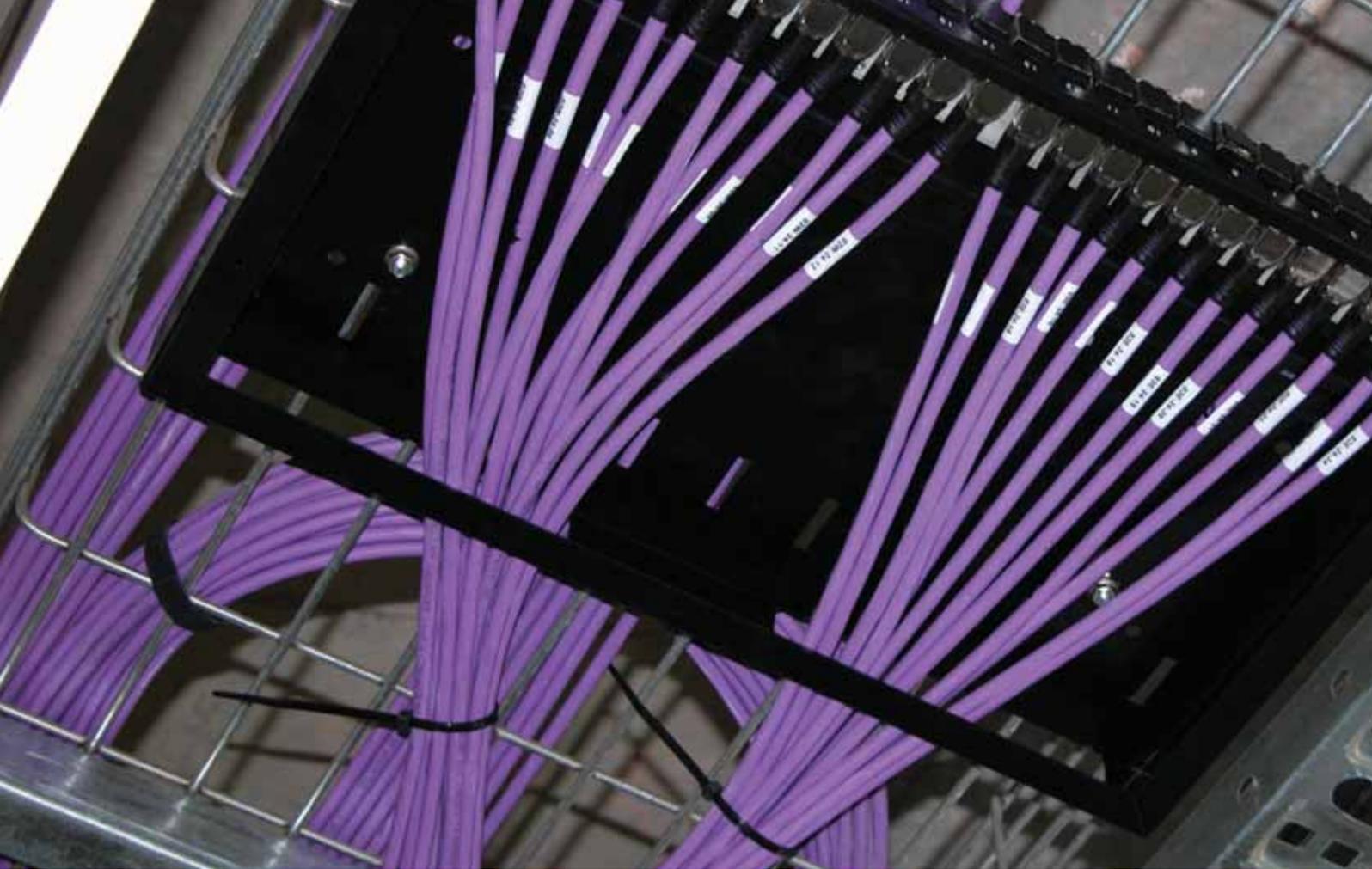
▶ Advanced Network Infrastructure **2015**

Actionable Guidance for Deploying Superior Intelligent Building and Data Center Networks

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Zone Cabling for Cost Savings

Workspaces are becoming increasingly social and flexible and are constantly being re-arranged and updated. To determine how structured cabling can best support this evolving trend, Siemon studied the cost and environmental impact of various structured cabling designs. The results are in: zone cabling deployments provide the optimum balance of performance, flexibility, and efficient use of cabling materials in today's enterprise environments.

What is Zone Cabling?

A zone cabling design (or topology) begins with horizontal cables run from patch panels in the telecommunications room (TR) to connections within a zone enclosure (ZE, sometimes referred to as a zone box), which can be mounted under a raised floor, in the ceiling, or on the wall. Cables are then run from the outlets or connecting blocks in the zone enclosure to telecommunications outlets in the work area (WA), equipment outlets serving BAS devices, or directly to BAS devices. Patch cords are used to connect voice and data equipment to telecommunications outlets and to connect BAS equipment to equipment outlets. Note that the connections in the zone enclosure are made using modular outlets and/or punch down blocks - there is no active equipment in the zone enclosure. When deploying a zone cabling solution, Siemon recommends positioning zone enclosures in the most densely populated areas of the floor space. Figure 1 shows an example of a zone cabling layout .

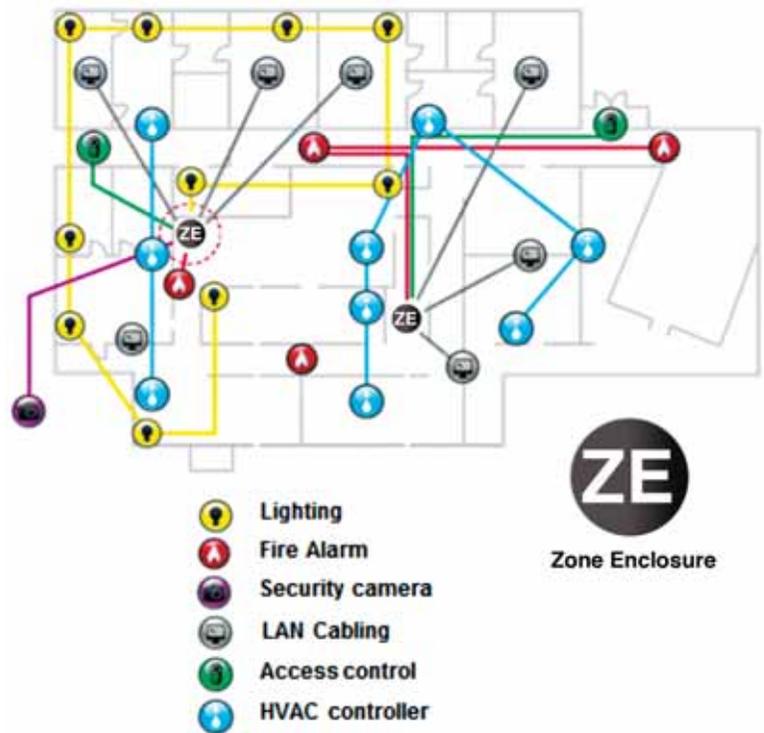


Figure 1: Example zone cabling layout serving voice, data, and BAS applications

Enabling flexible client work spaces that efficiently accommodate moves, adds, and changes (MACs) is a signature element of a zone cabling design. Through analyzing customers' office reconfiguration needs, Siemon observed that zone cabling deployments have the potential to provide significant cost savings benefits compared to traditional "home run" work area to TR cabling. This is because MACs performed on traditional home run topologies require more cabling materials and more installation time to implement.

As an example, Figure 2 shows a traditional home run cabling link and a zone cabling link; both of which are supporting a work area outlet located 200 feet away from the TR. The zone enclosure is pre-cabled from the TR with spare ports available to support new services and is located 50 feet from the work area outlet. If a second cable needs to be deployed, 200 feet of new cable needs to be pulled from the TR with a traditional design, while only 50 feet needs to be pulled when using a zone design. Significantly reduced installation times and minimized client disruption are additional benefits associated with pulling 75% less cable, which all contributes to improved return-on-investment (ROI) when using zone cabling designs.

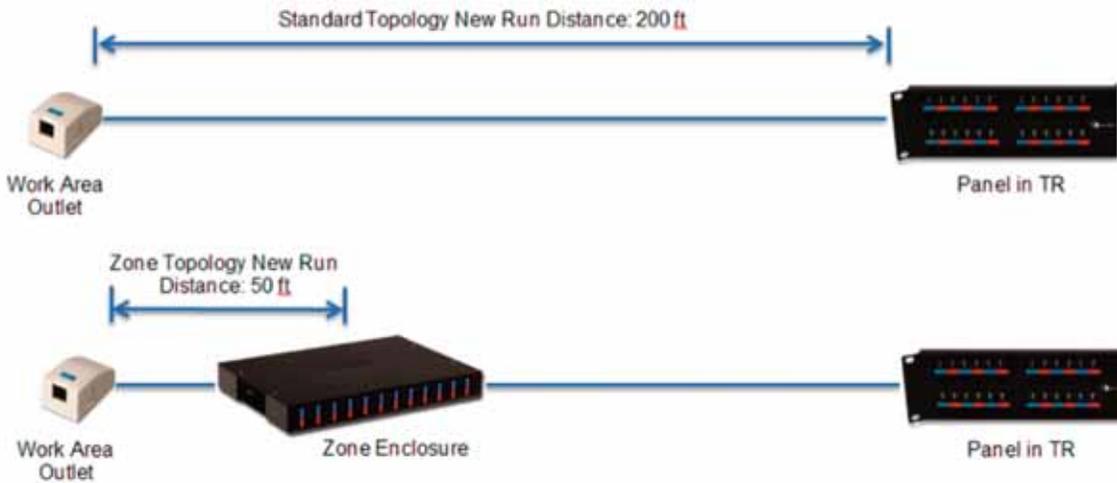


Figure 2: Example 200 foot traditional and zone cabling links depicting new cabling length required to support the addition of a new service

Zone Cabling Designs

Zone cabling systems are easily implemented using a variety of Siemon components, which encompass all categories of cabling and connectivity. The diagrams in Figures 3a, 3b, and 3c depict example zone and traditional cabling channel topologies for a sampling of media types. For demonstration purposes, the connection within the zone enclosure, but not the zone enclosure itself, is shown. The components shown in these figures, with the addition of cable managers (Siemon RS3-RWM-2) and a plenum rated ceiling zone enclosure (Chatsworth A1024-LP), formed the material list used in Siemon’s MAC cost impact study discussed later in this paper.

Figure 3a depicts Siemon’s recommended category 5e and 6 UTP zone cabling topology. Note that Siemon’s category 5e or category 6 connecting block system is the recommended connection in the zone enclosure. This solution eliminates the need to stock factory pre-terminated and tested interconnect cords for connections in the zone enclosure and simplifies cable management by eliminating cable slack. The traditional category 5e and 6 UTP cabling topology is shown for comparison purposes and for use as a reference in the cost comparison analysis.

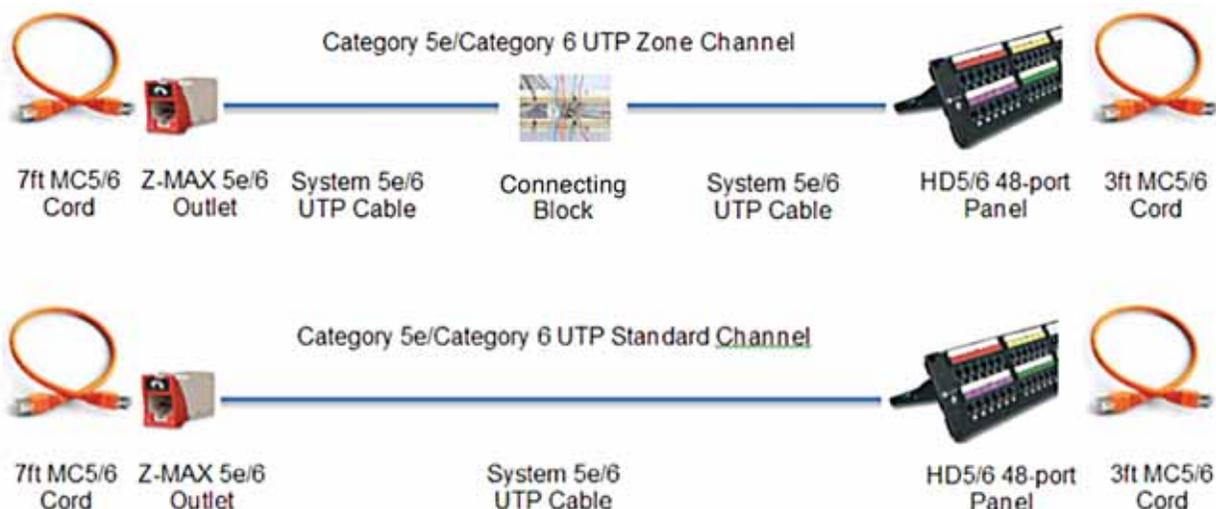


Figure 3a: Siemon’s recommended category 5e and 6 UTP zone cabling topology and reference traditional topology

Figure 3b depicts typical category 6A UTP zone and traditional cabling topologies. These figures are provided for reference and are used in the cost comparison analysis; however, Siemon does not recommend category 6A UTP media for use in zone cabling deployments for both performance and flexibility reasons. UTP cabling may be susceptible to excessive alien crosstalk under certain installation conditions and is not the optimum media for support of remote powering applications carrying 30W and higher power loads. In addition, because category 6A UTP zone deployments rely on modular connections within the zone enclosure, factory pre-terminated and tested interconnect cords for connections must be on hand in order to quickly facilitate MAC requests. Siemon recommends cost effective shielded zone cabling solutions to overcome these concerns.

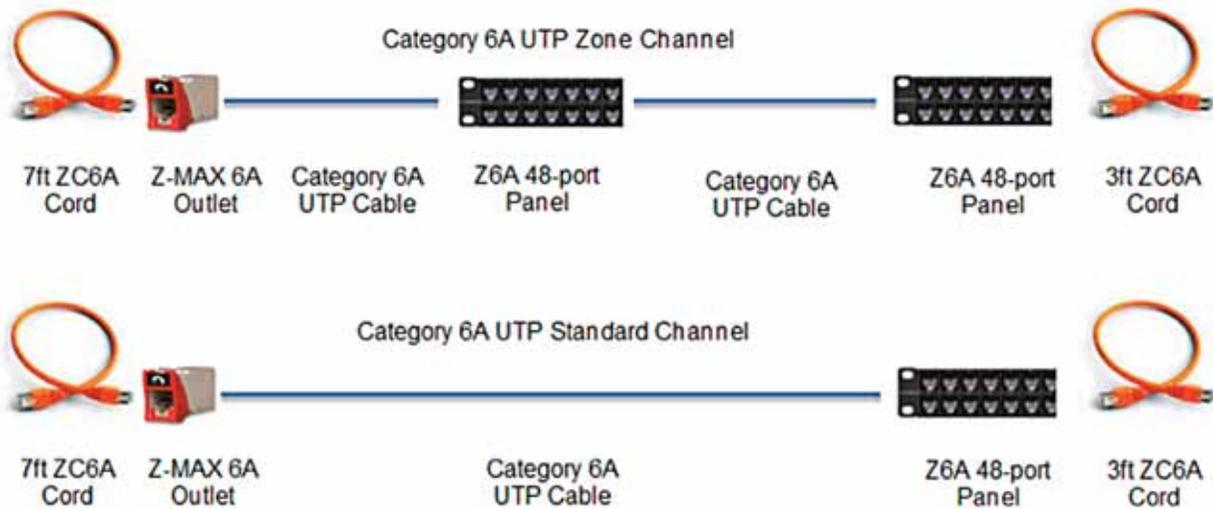


Figure 3b: Reference category 6A UTP zone cabling topology and traditional topology

Figure 3c depicts Siemon’s recommended category 6A zone topology, which is comprised of shielded cables and components. Note that Siemon’s TERA® connector is used in the zone enclosure. Because this shielded modular connector is field-terminatable, it eliminates the need to stock factory pre-terminated and tested interconnect cords and simplifies cable management by eliminating cable slack in the zone enclosure. The traditional category 6A shielded cabling topology is shown for comparison purposes and for use as a reference in the cost comparison analysis.

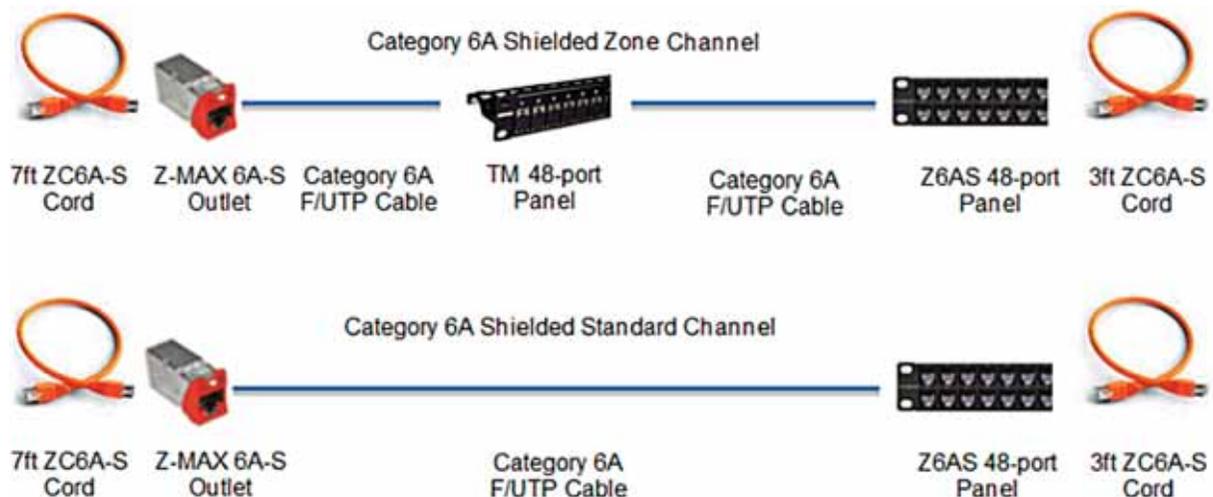


Figure 3c: Siemon's recommended category 6A zone cabling topology and reference traditional topology constructed from shielded components

Quantifying the Cost Savings

Siemon designed traditional and zone cabling layouts for a typical one-floor commercial building space and analyzed the capital and operating costs associated with each design. For the purposes of this analysis, the traditional cabling topology scenario provided two outlets to 36 work areas for a total of 72 cables or “drops” and the zone topology scenario provided two outlets at 36 work areas and 72 connection points in a zone enclosure, plus an additional 24 cables pulled to the zone enclosure to accommodate future expansion.

To establish a baseline, Siemon first calculated the material and installation costs for the category 5e UTP, category 6 UTP, category 6A UTP, category 6A shielded, and category 7_A shielded traditional (72 drops) and zone (96 drops to the zone enclosure and 72 drops to the work area) cabling designs and plotted the results shown in Figure 4. Since zone cabling is most commonly deployed in the ceiling where air handling spaces are prevalent, media costs were derived using plenum rated materials where applicable. Not surprisingly, the total cost for the zone cabling design is higher than for the traditional design because there is additional connectivity in each channel and some pre-cabling between the TR and zone enclosure is included for future connections. This baseline also clearly demonstrates that Siemon’s recommended shielded category 6A zone cabling design provides the added benefits of performance and termination flexibility at the zone enclosure at virtually no additional cost over a category 6A UTP zone cabling design.

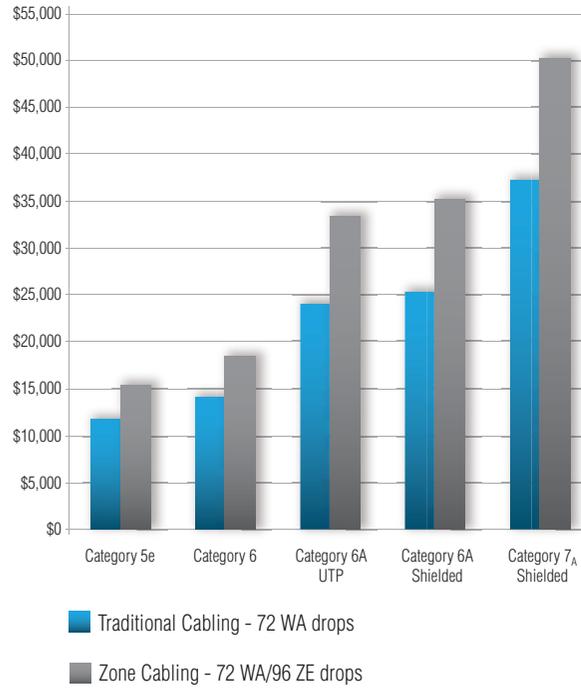


Figure 4: Installation and materials costs (CAPEX) for traditional and zone cabling scenarios

Although additional capital expenditure (“CAPEX”) is required when zone cabling is initially deployed, a more accurate assessment of the total comparative costs of these solutions must include operating expense (“OPEX”). MAC work performed on a cabling plant falls into the category of OPEX and it is in this area that the real cost benefits of a zone cabling solution become apparent. For this analysis, a cabling “add” represents the cost to pull one new cable and a cabling “move” is the cost to pull one new cable and remove the abandoned cable. The table in Figure 5 depicts Siemon’s calculated cost savings per move or add for all of the categories of cabling evaluated and the number of MACs that need to be performed for the combined CAPEX and OPEX cost associated with the traditional cabling design to equal that of the zone cabling design. This tipping point is often referred to as the time when Return-On-Investment (“ROI”) is achieved for a zone cabling design.

Enterprise clients’ information technology needs are dynamic and often require rapid floor space reconfiguration. Due to their enhanced ability to support MACs, building owners can realize a significant ROI benefit with their zone cabling systems within two to five years compared to traditional cabling systems. According to the cost analysis, either 14 moves and 17 adds or 16 moves and 20 adds (depending upon cabling type) will realize a full ROI of the additional CAPEX for a zone cabling solution and each MAC above the ROI threshold yields additional OPEX benefits over a traditional cabling design. Depending on the number of MACs performed, a zone cabling design can pay for itself quickly. Figure 6 shows that the combined CAPEX and OPEX costs for all category zone cabling designs are always lower than for traditional cabling designs after 16 moves and 20 adds are performed and there is still flexibility to add additional services to the zone cabling design!

Category/Topology	\$ Saved per move	\$ Saved per add	MAC’s Until ROI
Any Traditional Topology	\$0	\$0	NO ROI
Zone Category 5e	\$144	\$128	14 Moves & 17 Adds
Zone Category 6	\$163	\$146	14 Moves & 17 Adds
Zone Category 6A UTP	\$265	\$249	16 Moves & 20 Adds
Zone Category 6A Shielded	\$282	\$266	16 Moves & 20 Adds
Zone Category 7 _A Shielded	\$409	\$393	14 Moves & 17 Adds

Figure 5: Cost of work area MACs and ROI for traditional and zone cabling designs

Zone Cabling ROI

The results of this analysis may be extrapolated and applied to small, medium, and large zone cabling installations. While obviously dependent upon the exact number of moves, adds, and changes (MACs) performed per year, typical zone cabling plants of any size planned with 25% spare port availability not only significantly reduce client disruption, but allow the building owner to recoup the cost of the extra port capacity within a two to five year span or after reaching the ROI threshold (i.e. either 14 moves and 17 adds or 16 moves and 20 adds depending upon cabling type) in the example provided in this paper.

Additional Benefits

In addition to the obvious cost benefits, deployment of zone cabling provides the following additional benefits:

- **Factory pre-terminated and tested trunking cables may be used for expedited installation and reduced labor cost.**
- **Spare ports in the zone enclosure allow for the rapid addition of new devices and facilitate moves and changes of existing services.**
- **Pathways are more efficiently utilized throughout the building space.**
- **Deployment of the structured cabling system is faster and less disruptive.**
- **New IP devices, such as WAPs, BAS devices, voice/data security devices, audio/video devices, digital signage, etc. are easily integrated into the existing structured cabling system via connections made at the zone enclosure.**

Going Green?



Zone cabling systems are ideal for use in smart and green building designs. Factory pre-terminated trunking cables can be installed for a reduction in labor costs and on-site waste and the centralized connection location within the zone enclosures allow for more efficient pathway routing throughout the building.

Integrating Siemon's end-to-end category 7_A/class F_A TERA® cabling system into a zone topology allows customers to further take advantage of cable sharing strategies, which maximizes the potential to qualify for LEED credits as issued by the United States Green Building Council (USGBC). Cable sharing supports multiple low-speed, low pair count applications operating over one 4-pair cabling system, which results in more efficient cable and pathway utilization. For example, a standard IP security door deployment configuration typically consists of two category 5e cables (one for an IP camera and the other for access control) installed in a traditional home run topology. By switching to a TERA category 7_A/class F_A TERA cabling system configured in zone topology, a single cable can serve both devices, thereby reducing cabling and pathway materials. Although the CAPEX associated with implementing TERA category 7_A/class F_A TERA cabling may be slightly higher, the benefits realized by obtaining LEED accreditation can justify this additional cost.

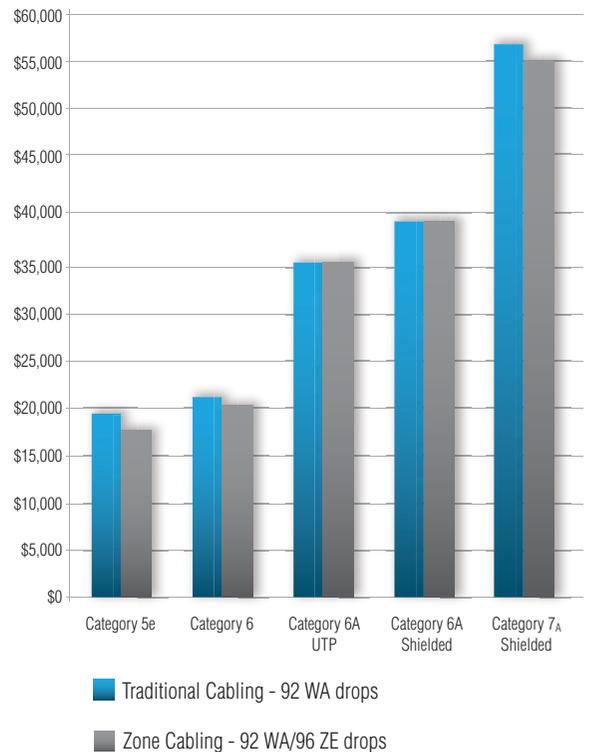


Figure 6: Combined CAPEX and OPEX costs for traditional and zone cabling scenarios after 16 moves and 20 adds

Executive Summary:

- **Today's enterprise workspaces are increasingly more social and flexible and are subject to frequent reconfiguration and updating.**
- **Zone cabling enables flexible client work spaces that can accommodate moves, adds, and changes more quickly and with less disruption than traditional cabling.**
- **Zone cabling supports more efficient utilization of pathways and materials and is ideal for today's smarter green building designs.**
- **Siemon recommends category 6A shielded cabling in zone cabling designs for maximum performance.**
- **Shielded category 6A zone cabling designs provide the added benefits of performance, superior support of remote powering applications, and termination flexibility at the zone enclosure at virtually no additional cost compared to category 6A UTP designs.**
- **Zone cabling plants of any size planned with 25% spare port availability not only significantly reduce client disruption, but typically allow the building owner to recoup the cost of the extra port capacity within a two to five year span or after reaching the ROI threshold.**



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Killer App Alert!

IEEE 802.11ac 5 GHz Wireless Update and Structured Cabling Implications

Killer app alert! The newly published IEEE 802.11ac Very High Throughput wireless LAN standard¹ has far reaching implications with respect to cabling infrastructure design. Users can expect their current wireless speeds to appreciably increase by switching to 802.11ac gear with 1.3 Gb/s data rate capability that is available today. And, 256-QAM modulation, 160 MHz channel bandwidth, and a maximum of eight spatial streams can theoretically deliver 6.93 Gb/s in the future! For the first time, the specification of high performance cabling supporting access layer switches and uplink connections is critical to achieving multi-Gigabit throughput and fully supporting the capacity of next generation wireless access points.

Key cabling design strategies to ensure that the wired network is ready to support 802.11ac wireless LANs addressed in this paper include:

- Specifying category 6A or higher performing horizontal cabling in combination with link aggregation to ensure immediate support of the 1.3 Gb/s theoretically achievable data rate deliverable by 802.11ac 3-stream wireless access points (WAPs) and routers available today
- Installing a minimum of 10 Gb/s capable balanced twisted-pair copper or multimode optical fiber backbone to support increased 802.11ac uplink capacity
- Utilizing a grid-based zone cabling architecture to accommodate additional WAP deployments, allow for rapid reconfiguration of coverage areas, and provide redundant and future-proof connections
- Using solid conductor cords, which exhibit better thermal stability and lower insertion loss than stranded conductor cords, for equipment connections in the ceiling or in plenum spaces where higher temperatures are likely to be encountered
- Recognizing that deploying Type 2 PoE to remotely power 802.11ac wireless access points can cause heat to build up in cable bundles
 - Simon's shielded class E_A/category 6A and class F_A/category 7_A cabling systems inherently exhibit superior heat dissipation and are qualified for mechanical reliability up to 75°C (167°F), which enables support of the Type 2 PoE application over the entire operating temperature range of -20°C to 60°C (-4°F to 140°F)
 - Shielded systems are more thermally stable and support longer channel lengths (i.e. less length de-rating is required at elevated temperatures to satisfy TIA and ISO/IEC insertion loss requirements) when deployed in high temperature environments
 - A larger number of shielded cables may be bundled without concern for excessive heat build-up within the bundle
- Specifying IEC 60512-99-001 compliant connecting hardware ensures that contact seating surfaces are not damaged when plugs and jacks are unmated under 802.11ac remote powering current loads



802.11ac

What's in a name?

The latest 802.11ac wireless LAN technology goes by many names, including:

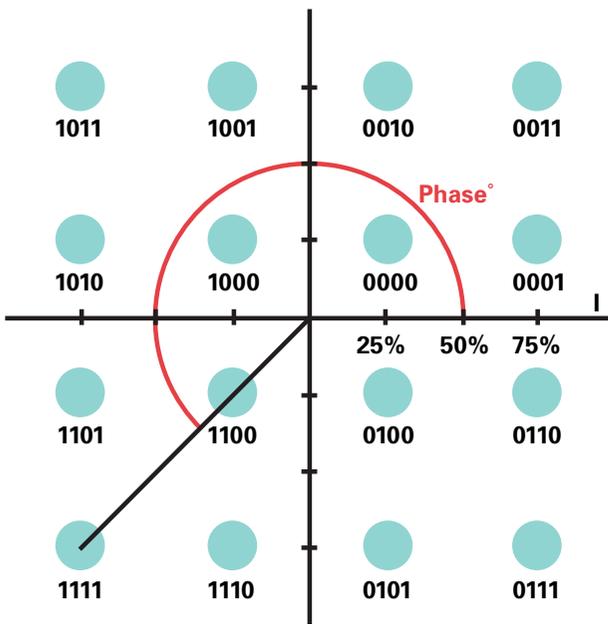
- 5 GHz Wi-Fi – for the transmit frequency
- Gigabit Wi-Fi – for the short range data rate of today's three spatial stream implementation
- 5G Wi-Fi – for 5th generation (i.e. 802.11a, 802.11b, 802.11g, 802.11n, and 802.11ac)
- Very High Throughput Wi-Fi – from the title of the application standard

No matter what you call it, the fact is that the increasing presence and capacity of mobile and handheld devices, the evolution of information content from text to streaming video and multimedia, combined with limits on cellular data plans that encourage users to “off-load” to Wi-Fi are all driving the need for faster Wi-Fi networks. As Wi-Fi becomes the access media of choice, faster wireless LAN equipment will play an important role in minimizing bottlenecks and congestion, increasing capacity, and reducing latency but only if the cabling and equipment connections can support the additional bandwidth required. The Wi-Fi Alliance certified the first wave of production-ready 802.11ac hardware in June 2013 and adoption of 802.11ac is anticipated to occur more rapidly than any of its 802.11 predecessors. Today, 802.11ac routers, gateways, and adapters are widely available to support a range of 802.11ac-ready laptops, tablets, and smart phones. In fact, sales of 802.11ac devices are predicted to cross the 1 billion mark (to total 40% of the entire Wi-Fi enabled device market) by the end of 2015!²

A Technology Evolution

The enhanced throughput of 802.11ac devices is facilitated by an evolution of existing and proven 802.11n³ Wi-Fi communication algorithms. Like 802.11n, 802.11ac wireless transmission utilizes the techniques of beamforming to concentrate signals and transmitting over multiple send and receive antennas to improve communication and minimize interference (often referred to as multiple input, multiple output or MIMO). The signal associated with one transmit and one receive antenna is called a spatial stream and the ability to support multiple spatial streams is a feature of both 802.11ac and 802.11n. Enhanced modulation, wider channel spectrum, and twice as many spatial streams are the three key technology enablers that support faster 802.11ac transmission rates while ensuring backward compatibility with older Wi-Fi technology.

Quadrature amplitude modulation (QAM) is an analog and digital modulation scheme that is used extensively for digital telecommunications systems. Using this scheme, a four quadrant arrangement or “constellation” of symbol points is established with each point representing a short string of bits (e.g. 0’s or 1’s). Sinusoidal carrier waves that are phase shifted by 90° are modulated using amplitude-shift keying (ASK) digital modulation or amplitude modulation (AM) analog modulation schemes and are used to transmit the constellation symbols. Figure 1 depicts a rudimentary example of a 16-QAM constellation for demonstration purposes. Note that there are four points in each quadrant of the 16-QAM constellation and each point equates to four information bits, ranging from 0000 to 1111. The 64-QAM scheme utilized by 802.11n equipment carries 6 bits of information per constellation point and the 256-QAM scheme utilized by 802.11ac equipment carries an amazing 8 bits of information per constellation point!



Amplitude	Phase	Data
25%	45°	0000
75%	22°	0001
75%	45°	0011
75%	68°	0010
25%	135°	1000
75%	112°	1001
75%	135°	1001
75%	158°	1010
25%	225°	1100
75%	202°	1101
75%	225°	1111
75%	248°	1110
25%	315°	0100
75%	292°	0101
75%	315°	0111
75%	337°	0110

Figure 1: Example 16-QAM Constellation and Correlating Symbol Bit Information

802.11ac devices will transmit exclusively in the less crowded 5 GHz spectrum. This spectrum supports higher transmission rates because of more available non-overlapping radio channels. It is considered “cleaner” because there are fewer devices operating in the spectrum and less potential for interference. One disadvantage to operating in this spectrum is that 5 GHz signals have a shorter transmission range and have more difficulty penetrating building materials than 2.4 GHz signals. Designing a flexible cabling infrastructure that can accommodate the addition of future WAPs and enable rapid reconfiguration of coverage areas can save headaches later. Figure 2 depicts a recommended zone cabling approach utilizing enclosures that house consolidation points (CPs) with spare port capacity to facilitate connections to equipment outlets (EOs) that are positioned in a grid pattern. In addition, because most WAPs are located in the ceiling or in plenum spaces where higher temperatures are likely to be encountered, the use of solid conductor cords, which exhibit better thermal stability and lower insertion loss than stranded conductor cords⁴, are recommended for all equipment connec-

tions in high temperature environments. Refer to ISO/IEC 24704⁵ and TIA TSB-162-A⁶ for additional design and installation guidelines describing a grid-based cabling approach that maximizes WAP placement and reconfiguration flexibility.

The Implications of Speed

In 802.11n and 802.11ac, channels that are 20 MHz wide are aggregated to create the “pipe” or “highway” for wireless transmission. 802.11ac technology allows radio transmission over either four or eight bonded 20 MHz channels supporting maximum throughput of 433 Mb/s and 866 Mb/s, respectively. In addition, 802.11ac can accommodate up to eight antennas and their associated spatial streams for an unprecedented maximum theoretical data speed of 6.93 Gb/s! Note that, unlike full duplex balanced twisted-pair BASE-T type Ethernet transmission where throughput is fixed in both the transmit and receive orientations, the speed specified for wireless applications represents the sum of upstream and downstream traffic combined. Figure 3 summarizes the key capability differences between 802.11n and 802.11ac technology.

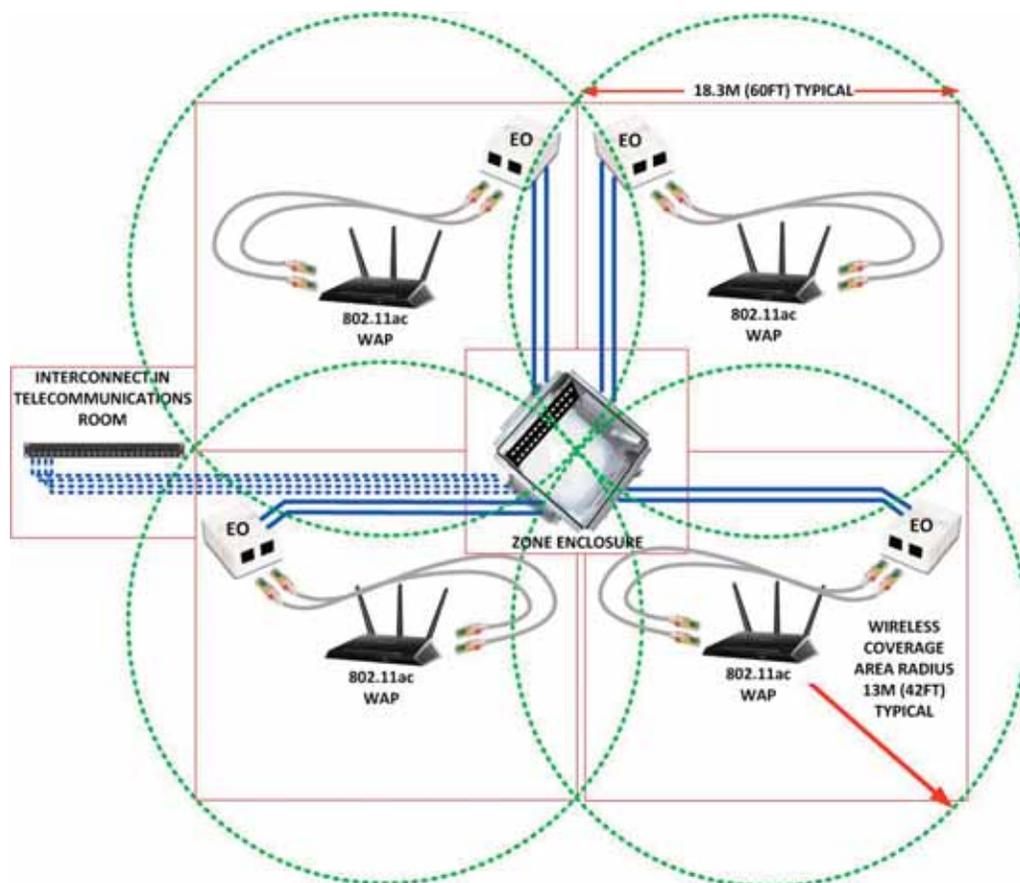


Figure 2: Example Grid-Based WAP Zone Cabling Deployment Design

	802.11n	802.11ac
Transmit Frequency	2.4 or 5 GHz	5 GHz only
Channel Bandwidth	20 or 40 MHz	80 or 160 MHz
Modulation	64-QAM	256-QAM
Maximum Number of Spatial Streams	4	8
Theoretical Maximum Data Rate per Stream	144 Mb/s	866 Mb/s
Theoretical Maximum Data Rate	576 Mb/s	6.93 Gb/s

Figure 3: 802.11n versus 802.11ac Technology Comparison

Channel Bandwidth	Number of Spatial Streams	Maximum Speed	Target Device or Application
First Wave – Products Available Now			
80 MHz	1	433 Mb/s	Dual-band smart phone, nextVoIP handset, or tablet
80 MHz	3	1.3 Gb/s	High-end laptop
Second Wave – Products Available Mid 2015			
80 MHz	2	867 Mb/s	Netbook/low-end laptop
160 MHz	3	2.6 Gb/s	High-end laptop
Possible Future Implementations			
160 MHz	4	3.5 Gb/s	Outdoor or low coverage areas
160 MHz	8	6.9 Gb/s	Specialized

Figure 4: Example 802.11ac Implementation Configurations

Because of the variables of channel bandwidth and number of spatial streams, 802.11ac deployments are highly configurable. In general, the lower end of the throughput range will be targeted for small handheld devices with limited battery capacity such as smart phones, the middle of the throughput range will be targeted towards laptops, and the highest end of the throughput range will be targeted at specialized and outdoor applications where there is less device density compared with indoors. Figure 4 provides examples of currently available first wave and second wave (available mid 2015) 802.11ac implementation configurations with target devices

indicated. Possible future 802.11ac implementations are also shown, but these implementations may not be available for years, if at all. While this may seem surprising, consider that there are no 4-stream implementations of 802.11n even though the technology is standardized. Wireless LAN provider Aruba Networks suggests that manufacturers will leapfrog 4-stream 802.11n products in favor of 802.11ac products. The bottom line is that end-users can reasonably expect their current wireless speeds to at least double by switching to 802.11ac gear that is available today and more than quadruple when second wave products become available.

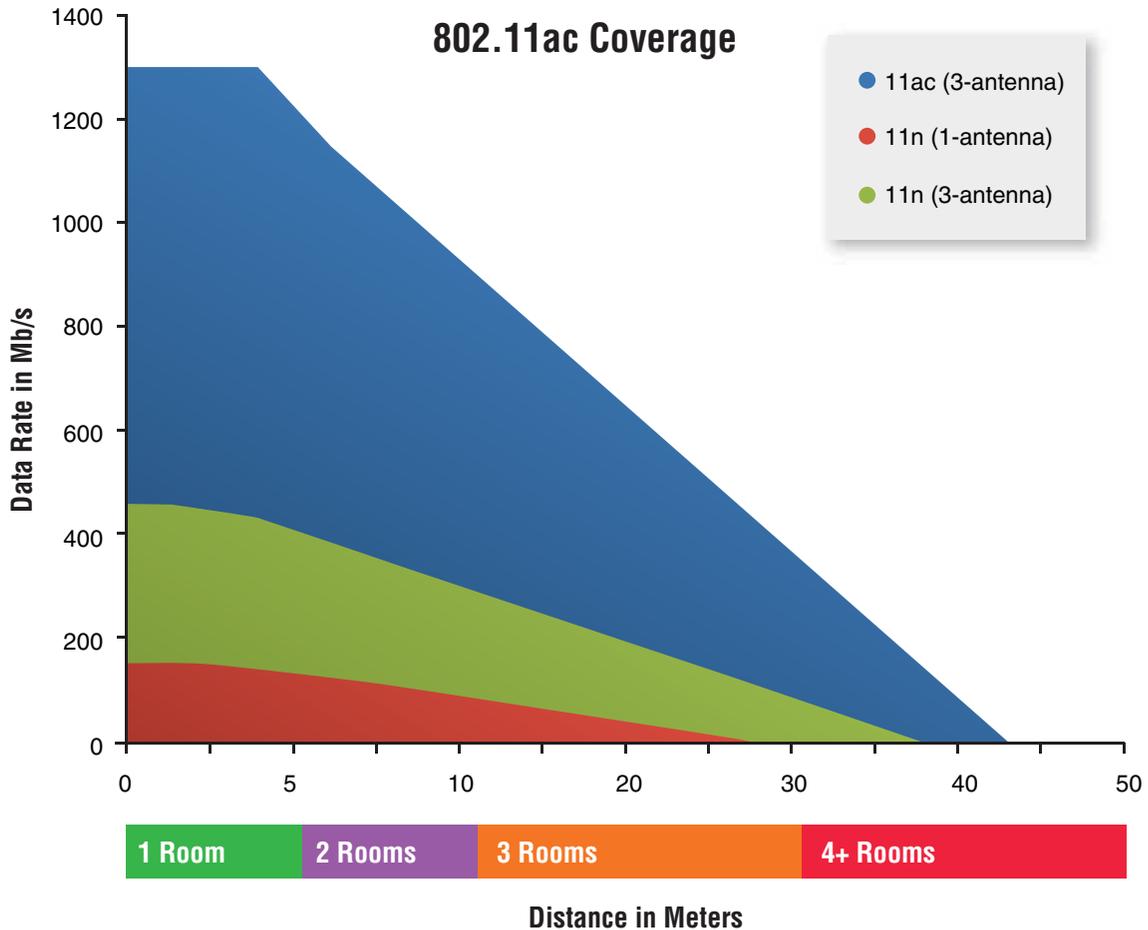


Figure 5: Data Rate versus Coverage Radius (provided courtesy of Broadcom)

When comparing wireless capabilities, it's important to keep in mind that the maximum realizable data rate is impacted by the number of wireless users, protocol overhead, and the spatial distribution of end-user devices from the access point. The image in figure 5 illustrates how data rate decreases as distance from the WAP transmitter increases for a commonly available 802.11ac 3-stream 80 MHz transmitter and 802.11n 1- and 3-stream transmitters. The chart shows that 1.3 Gb/s data rates are theoretically achievable within a coverage radius of 5m (16.4 ft) from an 802.11ac 3-stream WAP. Transfer data collected for first generation wireless products confirms that the 802.11ac 3-stream data rate at relatively close range to a single device is roughly on par with that achievable with a wired Gigabit Ethernet (1000BASE-T) link. In some cases, the 802.11ac wireless data transfer rate was fast enough to saturate the 1000BASE-T copper balanced twisted-pair cabling link provided between the 802.11ac router and the server!¹⁷

Greater than 1 Gb/s wireless data rate capability has serious implications related to wired media selection for router to server and other uplink connections. For example, two 1000BASE-T connections may be required to support a single 802.11ac WAP (this is often referred to as link aggregation) if 10GBASE-T uplink capacity is not supported by existing equipment (refer to figure 2, which depicts two horizontal link connections to each equipment outlet). As 802.11ac equipment matures to support 2.6 Gb/s and even higher data rates, 10 Gb/s uplink capacity will become even more critical. Moreover, access layer switches supporting 802.11ac deployments must have a minimum of 10 Gb/s uplink capacity to the core of the network in order to sufficiently accommodate multiple WAPs.

Power Consumption

Although 802.11ac radio chips are more efficient than prior generation wireless chips, they are doing significantly more complex signal processing and the amount of power required to energize 802.11ac devices is higher than for any previous 802.11 implementation. In fact, 802.11ac WAP's are unable to

work within the 13-watt budget of Type 1 Power over Ethernet (PoE) and must be supported by either a direct DC power adapter or 30-watt Type 2 PoE remote power. (Note that some 802.11ac products may be able to draw power from two Type 1 PoE connections, but this is an impractical and fairly uncommon implementation.) While safe for humans, Type 2 PoE remote power delivery, at an applied current of 600mA per pair, can produce up to 10°C (22°F) temperature rise in cable bundles⁸ and create electrical arcing that can damage connector contacts. Heat rise within bundles has the potential to cause bit errors because insertion loss is directly proportional to temperature. In extreme environments, temperature rise and contact arcing can cause irreversible damage to cable and connectors. Fortunately, the proper selection of network cabling, as described next, can eliminate these risks.

The Wired Infrastructure

Existing wireless access devices, client devices and the back end network and cabling infrastructure may need to be upgraded in order to fully support 802.11ac and Type 2 power delivery. In addition, 802.11ac's 5 GHz transmission band requires relatively dense WAP coverage areas and existing 802.11n grid placement layouts may not be sufficient. For both new and existing wireless deployments, now is the time to seriously consider the wired cabling uplink infrastructure.

Under all circumstances, the equipment outlets, patch panels, and other connecting hardware used in the channel should comply with IEC 60512-99-001⁹ to ensure that critical contact seating surfaces are not damaged when plugs and jacks are unmated under 802.11ac remote powering current loads. In addition, the use of Siemon shielded class E_A/category 6A and class F_A/category 7_A cabling systems, which support longer channel lengths (i.e. less length de-rating is required at elevated temperatures to satisfy TIA and ISO/IEC insertion loss requirements) and are qualified for mechanical reliability up to 75°C (167°F), are recommended for Type 2 PoE remote powering applications in locations having an ambient temperature greater than 20°C (68°F). Furthermore, larger numbers of shielded cables may be bundled without concern for excessive heat build-up within the bundle.

Designing a cabling infrastructure to robustly support 802.11ac deployment requires consideration of the switch, server, and device connection speeds commonly available today as well as strategies to support redundancy, equipment upgrades, and future wireless technologies. A grid-based cat-

egory 6A zone cabling approach using consolidation points housed in zone enclosures is an ideal way to provide sufficient spare port density to support 1000BASE-T link aggregation to each 802.11ac WAP as necessary, while also allowing for more efficient port utilization when 10GBASE-T equipment connections become available. Zone cabling is highly flexible and enables rapid reconfiguration of coverage areas and conveniently provides additional capacity to accommodate next generation technology, which may require 10GBASE-T link aggregation. Additional WAPs can be easily incorporated into the wireless network to enhance coverage with minimal disruption when spare connection points in a zone cabling system are available. This architecture is especially suited for deployment in financial, medical, and other critical data-intensive environments because redundant 10GBASE-T data and backup power connections provided to each WAP can safeguard against outages.

Siemon recommends that each zone enclosure support a coverage radius of 13m (42.7 ft) with 24 port pre-cabled consolidation points available to facilitate plug and play device connectivity. For planning purposes, an initial spare port capacity of 50% (i.e. 12 ports unallocated) is recommended. Spare port availability may need to be increased and/or coverage radius decreased if the zone enclosure is also providing service to building automation system (BAS) devices and telecommunications outlets (TOs). Backbone cabling should be a minimum design of 10 Gb/s capable balanced twisted-pair copper or multimode optical fiber media to support 802.11ac uplink capacity.

Conclusion:

A killer app forces consumers to stop and question legacy views about broadly deployed operating platforms or systems. IEEE 802.11ac is a dual-edged killer app in that it requires both 10GBASE-T and Type 2 remote powering for optimum performance – swiftly making the wait-and-see stance concerning 10GBASE-T adoption in support of LAN applications a position of the past. A properly designed and deployed zone cabling architecture utilizing thermally stable shielded category 6A or higher cabling products engineered to withstand the maximum TIA and ISO/IEC ambient temperature of 60°C (140°F) plus the associated heat rise generated by 600mA Type 2 PoE current loads will ensure that your cabling infrastructure is a killer app enabler.

Footnotes:

¹ IEEE Std 802.11ac™-2013, "IEEE Standard for Information technology – Telecommunications and information exchange between systems Local and metropolitan area networks Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 4: Enhancements for Very High Throughput for Operation in Bands below 6 GHz", December 11, 2013

² Strategy Analytics' Connected Home Devices (CHD) service report, "Embedded WLAN (Wi-Fi) CE Devices: Global Market Forecast"

³ IEEE Std 802.11n™-2009, "IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Higher Throughput", October 29, 2009

⁴ Siemon white paper, "Advantages of Using Siemon Shielded Cabling Systems to Power Remote Network Devices", 2013

⁵ ISO/IEC TR 24704, "Information technology – Customer premises cabling for wireless access points", July, 2004

⁶ TIA TSB-194-A, "Telecommunications Cabling Guidelines for Wireless Access Points", November, 2013

⁷ APC, "Five Things to Know about 802.11ac", May, 2013

⁸ Siemon white paper, "IEEE 802.3at PoE Plus Operating Efficiency: How to Keep a Hot Application Running Cool", 2010

⁹ IEC 60512-99-001, "Connectors for Electronic Equipment – Tests and Measurements – Part 99-001: Test Schedule for Engaging and Separating Connectors Under Electrical Load – Test 99A: Connectors Used in Twisted Pair Communication Cabling with Remote Power", 2012

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Advantages of Using Siemon Shielded Cabling Systems To Power Remote Network Devices

Remote powering applications utilize the copper balanced twisted-pair IT cabling infrastructure to deliver dc power to IP-enabled devices. The popularity of this technology and the interest in expanding its capabilities is staggering. Consider:

- Over 100 million Power over Ethernet (PoE) enabled ports are shipping annually
- Cisco® 60W Universal PoE (UPOE) technology is driving the adoption of virtual desktop infrastructure (VDI) and, when paired with Cisco's EnergyWise IOS-based intelligent energy management solution, supports using the IT network to monitor and control power consumption as well as turn devices on and off remotely to save power when the devices are not being used
- Published, but not yet commercially available, Power over HDBaseT (POH)¹ technology can deliver up to 100W over twisted-pair cable to support full HD digital video, audio, 100BASE-T, and control signals in television and display applications
- The IEEE 802.3 4-Pair Power over Ethernet (PoE) Study Group has been formed to investigate developing a new remote powering application that will provide superior energy efficiency than a 2-pair application and expand the market for PoE systems.

In less than a decade, remote powering technology has revolutionized the look and feel of the IT world. Now, devices such as surveillance cameras, wireless access points, RFID readers, digital displays, IP phones, and other equipment all share network bandwidth that was once exclusively allocated for computers. It's common knowledge that the networking of remotely powered devices for autonomous data transmission and collection is driving the need for larger data center infrastructures and storage networks. However, many IT managers aren't aware that remote power delivery produces temperature rise in cable bundles and electrical arcing damage to connector contacts. Heat rise within bundles has the potential to cause higher bit errors because insertion loss is directly proportionate to temperature. In extreme environments, temperature rise and contact arcing can cause irreversible damage to cable and connectors. Fortunately, the proper selection of network cabling can completely eliminate these risks.

Choosing qualified shielded category 6A and category 7A cabling systems provides the following advantages that ensure a "future-proof" cabling infrastructure capable of supporting remote powering technology for a wide range of topologies and operating environments:

- Assurance that critical connecting hardware contact mating surfaces are not damaged when plugs and jacks are cycled under remote powering current loads
- Higher maximum operating temperature for IEEE 802.3 Type 2² PoE Plus applications
- Fully compliant transmission performance for a wider range of channel configurations in environments having an ambient temperature greater than 20°C (68°F)
- An option to support remote powering currents up to 600mA applied to all four pairs and all networking applications up to and including 10GBASE-T in 70°C (158°F) environments over a full 4 connector, 100 meter channel topology
- Reliable and thermally stable patching solutions for converged zone cabling connections (e.g. device to horizontal connection point) in hot environments

Protecting your connections

Telecommunications modular plug and jack contacts are carefully engineered and plated (typically with gold or palladium) to ensure a reliable, low resistance mating surface. Today's remote powering applications offer some

protection to these critical connection points by ensuring that dc power is not applied over the structured cabling plant until a remotely powered device (PD) is sensed by the power sourcing equipment (PSE). Unfortunately, unless the PD is shut off beforehand, the PSE will not discontinue power delivery if the modular plug-jack connection is disengaged. This condition, commonly referred to as, "unmating under load", produces an arc as the applied current transitions from flowing through conductive metal to air before becoming an open circuit. While the current level associated with this arc poses no risk to humans, arcing creates an electrical breakdown of gases in the surrounding environment that results in corrosion and pitting damage on the plated contact surface at the arcing location.

While it's important to remember that arcing and subsequent contact surface damage is unavoidable under certain mating and unmating conditions - contacts can be designed in such a way as to ensure that arcing will occur in the initial contact "wipe" area and not affect mating integrity in the final seated contact position. Figure 1 depicts an example of such a design that features a distinct "make-first, break-last" zone that is separated by at least 2mm from the "fully mated" contact zone on both the plug and outlet contacts. Note that any potential damage due to arcing will occur well away from the final contact mating position for this design.-

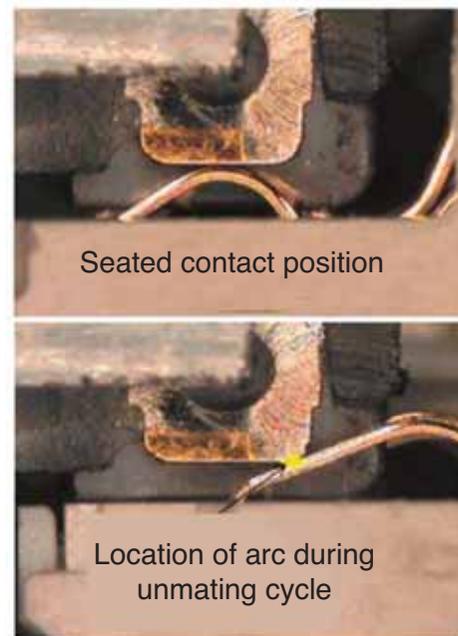


Figure 1: Arc location in "wipe" area occurs outside of final seated Z-MAX® contact position

To ensure reliable performance and contact integrity, Siemon recommends that only connecting hardware that is independently certified for compliance to IEC-60512-99-001³ be used to support remote powering applications. This standard was specifically developed to ensure reliable connections for remote powering applications deployed over balanced twisted pair cabling. It specifies the maximum allowable resistance change that mated connections can exhibit after being subjected to 100 insertion and removal cycles under a load condition of 55V dc and 600mA applied to each of the eight separate plug/outlet connections.

All Siemon Z-MAX[®] and TERA[®] connecting hardware has been certified by an independent test lab to be in full compliance with IEC 60512-99-001.

Keeping it cool

The standard ISO/IEC operating environment for structured cabling is -20°C to 60°C (-4°F to 140°F). Compliance to industry standards ensures reliable long term mechanical and electrical operation of cables and connectors in environments within these temperature limits. Exceeding the specified operating range can result in degradation of the jacket materials and loss of mechanical integrity that may have an irreversible effect on transmission performance that is not covered by a manufacturer's product warranty. Since deployment of certain remote powering applications can result in a temperature rise of up to 10°C (50°F) within bundled cables (refer to Table A.1 in TIA TSB-184⁴ and Table 1 in ISO/IEC TR 29125⁵), the typical rule of thumb is to not install minimally compliant cables in environments above 50°C (122°F).

This restriction can be problematic in regions such as the American southwest, the Middle East, or Australia's Northern Territory, where temperatures in enclosed ceiling, plenum, and riser shaft spaces can easily exceed 50°C (122°F). To overcome this obstacle, Siemon recommends the use of shielded category 6A and 7_A cables that are qualified for mechanical reliability up to 75°C (167°F). Not only do these cables inherently exhibit superior heat dissipation (refer to Siemon's white paper, "IEEE 802.3 at PoE Plus Operating Efficiency: How to Keep a Hot Application Running Cool⁶⁹"), but they may be installed in high temperature environments up to the maximum 60°C (140°F) specified by TIA and ISO/IEC structured cabling standards without experiencing mechanical degradation caused by the combined effects of high temperature environments and heat build-up inside cable bundles due to remote power delivery.

Maximizing reach

Awareness of the amount of heat build-up inside the cable bundle due to remote power delivery is important because cable insertion loss increases (signals attenuate more) in proportion to temperature. The performance requirements specified in all industry standards are based on an operating temperature of 20°C. The temperature dependence of cables is recognized in cabling standards and both TIA and ISO specify an insertion loss de-rating factor for use in determining the maximum channel length at temperatures above

20°C (68°F). The temperature dependence is different for unshielded and shielded cables and the de-rating coefficient for UTP cable is actually three times greater than shielded cable above 40°C (104°F) (refer to Annex G in ANSI/TIA-568-C.2⁷ and Table 21 in ISO/IEC 11801, 2nd edition⁸). For example, at 60°C (140°F), the standard-specified length reduction for category 6A UTP horizontal cables is 18 meters. In this case, the maximum permanent link length must be reduced from 90 meters to 72 meters to offset increased insertion loss due to temperature. For minimally compliant category 6A F/UTP horizontal cables, the length reduction is 7 meters at 60°C (140°F), which means reducing maximum link length from 90 meters to 83 meters. The key takeaway is that shielded cabling systems have more stable transmission performance at elevated temperatures and are best suited to support remote powering applications and installation in hot environments.

Siemon's category 6A and 7_A shielded cables exhibit extremely stable transmission performance at elevated temperatures and require less length reduction than specified by TIA and ISO/IEC standards to satisfy insertion loss requirements; thus, providing the cabling designer with significantly more flexibility to reach the largest number of work areas and devices in "converged" building environments. As shown in figure 2, the length reduction for Siemon 6A F/UTP horizontal cable at 60°C (140°F) is 3 meters, which means reducing maximum link length from 90 meters to 87 meters. Furthermore, Siemon 6A F/UTP horizontal cable may be used to support remote powering currents up to

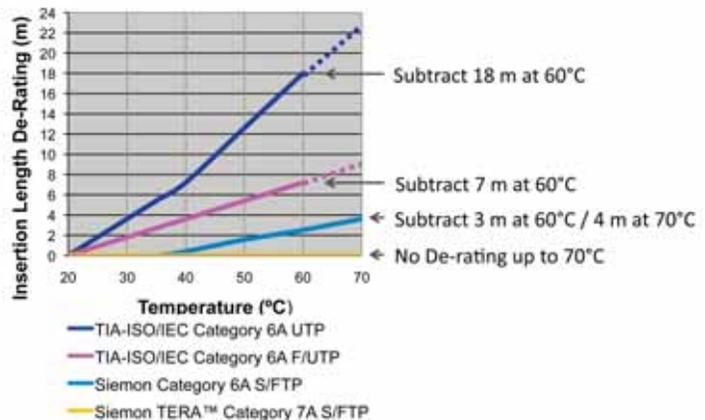


Figure 2: Horizontal cable length de-rating versus temperature for application speeds up to 10GBASE-T

600mA applied to all four pairs up to 60°C (140°F). In this case, the maximum link length must be reduced from 90 meters to 86 meters. Note that the TIA and ISO/IEC profiles from 60°C to 70°C (140°F to 150°F) are extrapolated assuming that the de-rating coefficients do not change and are provided for reference only. Due to their superior and stable insertion loss performance, Siemon's fully-shielded category 7_A cables do not require any length de-rating to support remote powering currents up to 600mA applied to all four pairs and all networking applications up to and including 10GBASE-T over a full 4-connector, 100-meter channel topology in environments up to 70°C (150°F)!

A better patching solution

While TIA and ISO/IEC temperature dependence characterization focuses on the performance of solid conductor cables, it is well known that the stranded conductor cables used to construct patch cords exhibit significantly greater insertion loss rise due to elevated temperature than do solid conductor cables. To maximize flexibility and minimize disruptions when device moves, adds, and changes are made, a zoned cabling solution is the topology of choice for the building automation systems (BAS) most likely to take advantage of remote powering solutions. However, most BAS horizontal connection points in a zoned topology are located in the ceiling or in plenum spaces where high temperatures are most likely to be encountered. Fortunately, the risk of performance degradation due to elevated temperatures in zone cabling environments can be mitigated by using solid conductor cords for equipment connections. Equipment cords constructed from Siemon shielded category 6A solid conductor cable are recommended for support of remote powering applications in environments up to 60°C (140°F) and equipment cords constructed from Siemon shielded category 7_A solid conductor cable are recommended for support of remote powering applications in environments up to 70°C (150°F).

The future of remote powering applications:

The advent of remote powering technology has significantly increased the number of networked devices, with surveillance cameras, IP phones, and wireless access points driving the market for PoE chipsets today. As the PD market matures, new and emerging remote powering technology continues to evolve to support advanced applications, improved efficiency, and increased power delivery. Power over HDBaseT, UPOE, and the work of the IEEE 802.3 4-Pair Power over Ethernet Study Group formed to investigate more efficient power injection schemes are enabling remote powering applications that will support new families of devices, such as lighting fixtures, high definition displays, digital signage, and point-of-sale (POS) devices that can consume more than 30W of power. All trends indicate that four pair power delivery is the future of remote powering technology. Choosing connectors and cables that are specifically designed to handle remote powering current loads, associated heat build-up, and contact arcing are important steps that can be taken to minimize the risk of component damage and transmission errors.

Conclusions:

As the market for remotely powered IP-devices grows and more advanced powering technology is developed, the ability of cables and connectors to operate in higher temperature environments and perform under dc load conditions will emerge as critical factors in the long term reliability of cabling infrastructure used to support PoE and other low voltage applications that deliver power over twisted-pairs. Fortunately, cabling products designed to operate under demanding environmental and remote powering conditions are already available today. Siemon's shielded category 6A and category 7_A cabling systems provide the following implementation advantages when deploying remote powering technology:

- Siemon's Z-MAX® and TERA® connecting hardware complies with IEC 60512-99-001, which ensures that critical contact seating surfaces are not damaged when plugs and jacks are mated and unmated under remote powering current loads
- Siemon's Z-MAX shielded category 6A and TERA category 7_A cabling solutions support the IEEE 802.3 Type 2 PoE Plus application over the entire ISO/IEC operating temperature range of -20°C to 60°C (-4°F to 140°F)
- Siemon's Z-MAX shielded category 6A cabling solutions require less than one-fifth the length de-rating than minimally compliant category 6A UTP cables at 60°C (140°F)
- Siemon's TERA category 7_A cabling solutions support data rates up to at least 10GBASE-T in 70°C (150°F) environments over a full 4-connector, 100-meter channel topology - no length de-rating required
- Siemon's shielded category 6A and 7_A solid equipment cords are uniquely capable of maintaining highly reliable and stable performance with no mechanical degradation when used for converged zone cabling connections in hot environments.

References:

¹ HDBaseT Alliance, "Power Over HDBaseT Addendum to the HDBaseT 1.0 Specification", 2011

² IEEE Std 802.3™-2012, "IEEE Standard for Ethernet", 2012

³ IEC 60512-99-001, "Connectors for Electronic Equipment - Tests and Measurements - Part 99-001: Test Schedule for Engaging and Separating Connectors Under Electrical Load - Test 99A: Connectors Used in Twisted Pair Communication Cabling with Remote Power", 2012

⁴ TIA TSB-184, "Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling", 2009

⁵ ISO/IEC TR 29125, "Information Technology – Telecommunications Cabling Requirements for Remote Powering of Terminal Equipment", 2010

⁶ Siemon white paper, "IEEE 802.3at PoE Plus Operating Efficiency: How to Keep a Hot Application Running Cool", 2010

⁷ ANSI/TIA-568-C.2, "Balanced Twisted-Pair Telecommunications Cabling and Components Standards", 2009

⁸ ISO/IEC 11801, 2nd edition, "Information technology – Generic cabling for customer premises", 2002

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Data Center Storage Evolution

Executive Summary

Data is growing at explosive rates in today's businesses. Big Data is increasing storage demands in a way that could only be imagined just a few short years ago. A typical data record has tripled if not quadrupled in size in just the last five years, however this data now has many forms including structured, semi-structured and non-structured. In fact, according to a recent IBM® study, 2.5 quintillion bytes of data are written every day and 90% of global data has been created in the last two years alone. It is glaringly apparent that the size of databases is growing exponentially.

Aside from a company's human resources, data has become the most valuable corporate asset both tangibly and intangibly. How to effectively store, access, protect and manage critical data is a new challenge facing IT departments. A Storage Area Network (SAN) applies a networking model to storage in the data center. The SANs operate behind the servers to provide a common path between servers and storage devices. Unlike server-based Direct Attached Storage (DAS) and file-oriented Network Attached Storage (NAS) solutions, SANs provide block-level or file level access to data that is shared among computing and personnel resources. The predominant SAN technology is implemented in a Fibre Channel (FC) configuration, although new configurations are becoming popular including iSCSI and Fibre Channel over Ethernet (FCoE). The media on which the data is stored is also changing.

With the growth of SANs and the worldwide domination of Internet Protocol (IP), using IP networks to transport storage traffic is in the forefront of technical development. IP networks provide increasing levels of manageability, interoperability and cost-effectiveness. By converging the storage with the existing IP networks (LANs/MANs/WANs) immediate benefits are seen through storage consolidation, virtualization, mirroring, backup, and management. The convergence also provides increased capacities, flexibility, expandability and scalability.

The two main standards utilizing the IP protocol are FCoE (Fibre Channel over Ethernet), and iSCSI (ip Small Computer System Interface). Both carry either Fibre Channel or SCSI commands incorporated into an IP datagram. FCoE is different in that Fibre Channel commands are encapsulated into IP traffic, but this requires a converged network adapter (CNA) that is capable of speaking both Fibre Channel and Ethernet for encapsulation. iSCSI operates over standard Ethernet networks and standard Ethernet adapters at the edge device called the initiator.

Today, 10Gigabit Ethernet is becoming increasingly popular as the horizontal application of choice in corporate data centers. Gaining a competitive edge from deploying 10 Gigabit Ethernet in the enterprise requires a robust IT infrastructure. Increasingly, 10GBASE-T and 10Gb SFP+ applications provide a reliable foundation for data centers' networking components and SAN networking. With a structured cabling

system capable of 10GBASE-T, users are provided with an open and industry standards-based infrastructure that can support multiple converged applications.

This paper provides some useful insight into both existing and new storage.

Storage Technologies

With the advent of the Internet, Big Data, corporate intranets, e-mail, e-commerce, business-to-business (B2B), ERP (Enterprise Resource Planning), Customer Resource Management (CRM), data warehousing, CAD/CAM, rich media streaming, voice/video/data convergence, and many other real time applications, the demands on the enterprise storage capacity has grown by leaps and bounds. The data itself is as important to a business's successful operation as its personnel and systems. The need to protect this strategic asset has far exceeded the capabilities of a tape backup. Tape access and capacities can simply not address the growing demands. Growing data stores meant having to implement tape libraries. Even then, there are inherent issues with tape media that could only be addressed with either supplemental storage or replacement of the media altogether.

Downtime is one critical factor in today's businesses. Based on a recently published study by Dun & Bradstreet, 59% of Fortune 500 companies experience a minimum of 1.6 hours of downtime per week. Wages alone levy a downtime cost of \$896,000 per week or just over \$46 million per year. A recent conservative Gartner study lists downtime costs at \$42,000 per hour. A USA today survey of 200 data center managers found that over 80% reported that their downtime costs exceed \$50,000 per hour, and another 20% said they exceed \$500,000 per hour. These costs alone have pushed the storage industry to provide redundancy and high-availability. Further, Federal mandates for the medical and financial industry have created yet another mandate for security and high availability due to compliance requirements.

Storage network technology has developed in the following three main configurations: Direct Attached Storage (DAS), Network Attached Storage (NAS), and Storage Area Networks (SAN).

Direct Attached Storage (DAS)

DAS is the traditional method of locally attaching storage devices to servers via a direct communication path between the server and storage devices. As shown in Figure 1, the connectivity between the server and the storage devices are on a dedicated path separate from the network cabling. Access is provided via an intelligent controller. The storage can only be accessed through the directly attached server. This method was developed primarily to address shortcomings in drive-bays on the host computer systems. When a server needed more drive space, a storage unit was attached. This method also allowed for one server to mirror another. The mirroring functionality may also be accomplished via directly attached server to server interfaces.

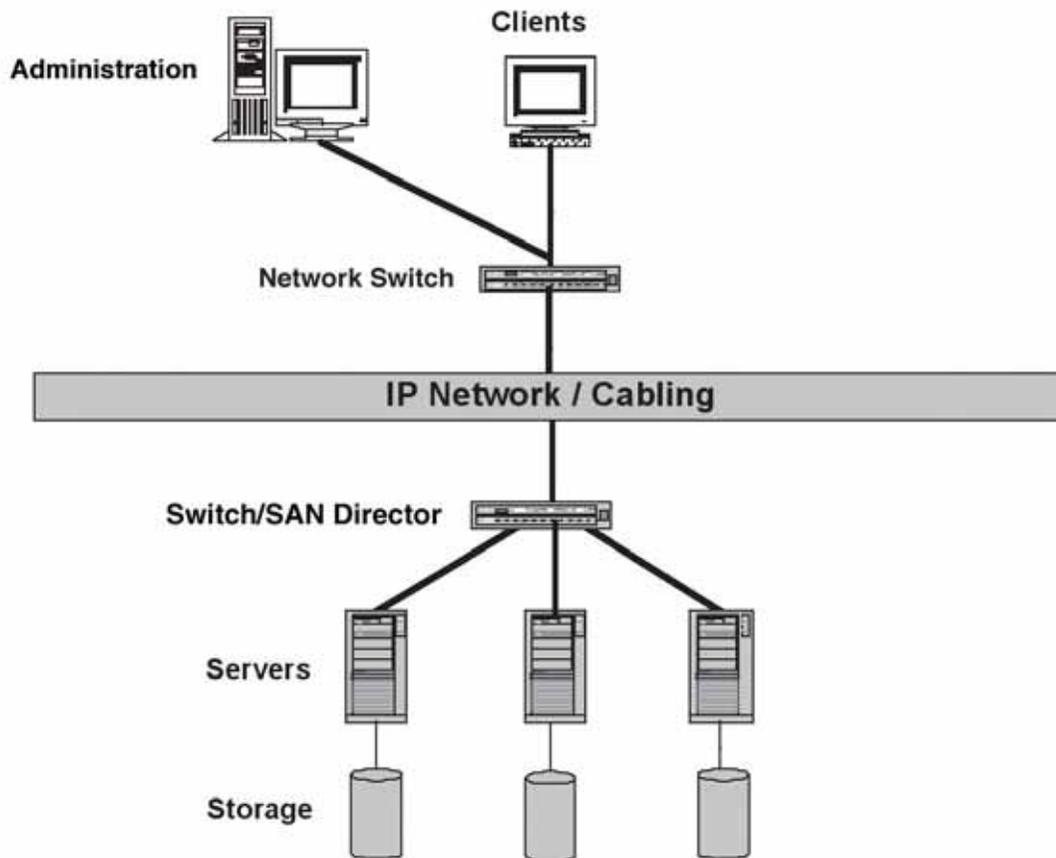


Figure 1: A Simple DAS Diagram

Network Attached Storage (NAS)

NAS is a file-level access storage architecture with storage elements attached directly to a LAN. It provides file access to heterogeneous computer systems. Unlike other storage systems the storage is accessed directly via the network as shown in Figure 2. An additional layer is added to address the shared storage files. This system typically uses NFS (Network File System) or CIFS (Common Internet File System) both of which are IP applications. A separate computer usually acts as the "filer" which is basically a traffic and security access controller for the storage which may be incorporated into the unit itself. The advantage to this method is that several servers can share storage on a separate unit. Unlike DAS, each server does not need its own dedicated storage which enables more efficient utilization of available storage capacity. The servers can be different platforms as long as they all use the IP protocol.

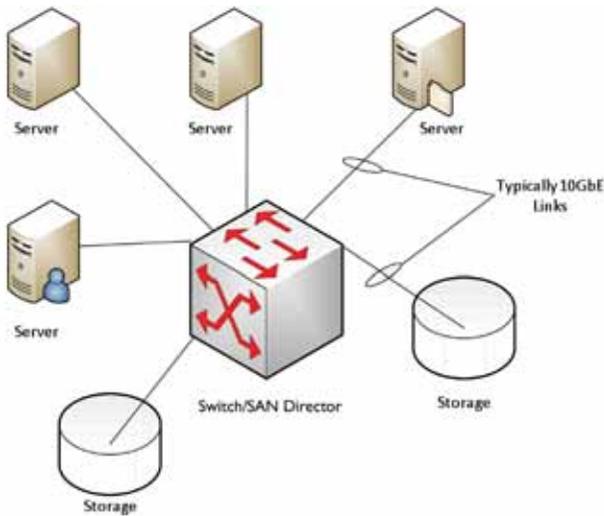


Figure 2: Simple NAS Architecture

Storage Area Networks (SANs)

Like DAS, a SAN is connected behind the servers. SANs provide block-level access to shared data storage. Block level access refers to the specific blocks of data on a storage device as opposed to file level access. One file will contain several blocks. SANs provide high availability and robust business continuity for critical data environments. SANs are typically switched fabric architectures using Fibre Channel (FC) for connectivity. As shown in Figure 3 the term switched fabric refers to each storage unit being connected to each server via multiple SAN switches also called SAN directors which provide redundancy within the paths to the storage units. This provides additional paths for communications and eliminates one central switch as a single point of failure.

Ethernet has many advantages similar to Fibre Channel for supporting SANs. Some of these include high speed, support of a switched fabric topology, widespread interoperability, and a large set of management tools. In a storage network application, the switch is the key element. With the significant number of Gigabit and 10 Gigabit Ethernet ports shipped, leveraging IP and Ethernet for storage is a natural progression for some environments.

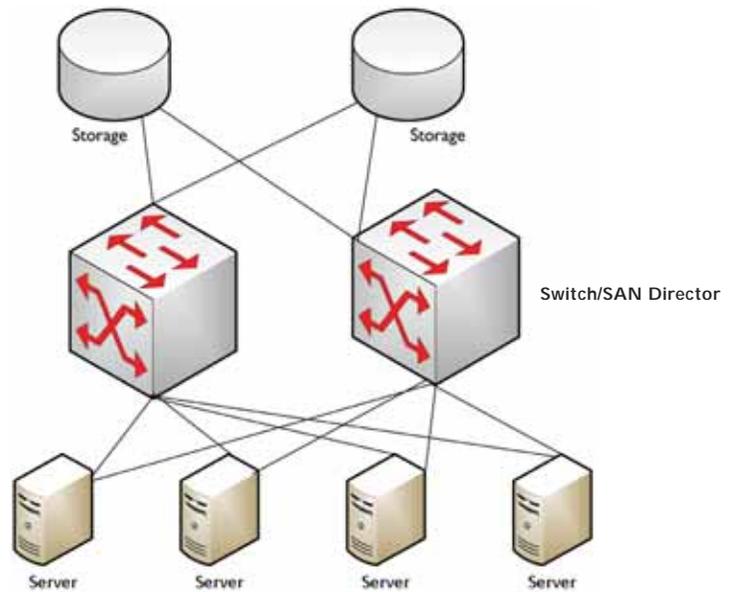


Figure 3: Meshed SAN Architecture

SAN over IP

IP was developed as an open standard with complete interoperability of components. Two new IP storage network technologies are Fibre Channel over Ethernet (FCoE) and SCSI over IP (iSCSI). IP communication across a standard IP network via Fibre Channel Tunneling or storage tunneling has the benefit of utilizing storage in locations that may exceed the directly attached limit of nearly 10 km when using fiber as the transport medium. Internal to the data center, legacy Fibre Channel can also be run over coaxial cable or twisted pair cabling, but at significantly shorter distances. The incorporation of the IP standard into these storage systems offers performance benefits through speed, greater availability, fault tolerance and scalability. These solutions, properly implemented, can almost guaranty 100% availability of data. The IP based management protocols also provide network managers with a new set of tools, warnings and triggers that were proprietary in previous generations of storage technology. Security and encryption solutions are also greatly enhanced. With 10G gaining popularity and the availability of new faster WAN links, these solutions can offer true storage on demand.

Fibre Channel (FC) and Fibre Channel over Ethernet (FCoE)

Native FC is a standards-based SAN interconnection technology within and between data centers limited by geography. It is an open, high-speed serial interface for interconnecting servers to storage devices (discs, tape libraries or CD jukeboxes) or servers to servers. FC has large addressing capabilities. Similar to SCSI, each device receives a number on the channel. It is the dominant storage-networking interface today. The Fibre Channel can be fully meshed providing excellent redundancy. FC can operate at the following speeds: 1, 2, 4, 8, 16 and 32 Gb/s with 8Gb/s to 16 Gb/s currently being predominant. The transmission distances vary with the speed and media. With FCoE, the packets are processed with the lengths and distances afforded by an Ethernet Network and again, vary according to speed and media. According to the IEEE 802.3ae standard for 10Gigabit Ethernet over fiber, when using singlemode optical fiber cables, the distance supported is 10 kilometers, up to 300m when using laser optimized 50 micron OM3 multimode fiber and up to 400m with OM4 as compared to native Fibre Channel with a distance of only 130m. Laser optimized OM3 and OM4 fiber is an important consideration in fiber selection for 10Gb/s transmission.

FC Topology

Native Fibre Channel supports three different connection topologies: point-to-point, arbitrated loop, and switched fabric. Switched fabric, as the name implies, is the better solution as it allows for a mesh within the Fibre Channel. It may also be configured in what is known as fabric islands. Fabric islands connect geographically diverse Fibre Channel fabrics. These fabrics may be anywhere within the range of the medium without IP. With IP, the fabric can reach greater distances as it is extended by routers and links outside of the fabric. They may also comprise different topologies (cascaded, ring, mesh, or core-to-edge), but may require additional connectivity for shared data access, resource consolidation, data backup, remote mirroring, or disaster recovery.

FCoE Topology

Fibre Channel is accomplished on a separate network than the Ethernet network. With Fibre Channel over Ethernet, Converged Network Adapters are used in place of Ethernet adapters and allow a single channel to pass both Ethernet and Fibre Channel encapsulated packets across a standard IP network extending distance over an entire enterprise, regardless of geography via Ethernet routers and bridges. For replication between storage systems over a wide area network, FCoE provides a mechanism to interconnect islands of FC SAN or FCoE SANs over the IP infrastructure (LANs/MANs/WANs) to form a single, unified FC SAN fabric.

Native Fibre Channel SAN Typical Component and Elements

Fibre Channel hardware interconnects storage devices with servers and forms the Fibre Channel fabric through the connection of the following:

- Interconnect device: switches, directors
- Translation devices: Host bus adapters (HBAs) installed in server, adapters, bridges, routers, and gateways
- Storage devices: non-RAID or RAID (Redundant Array of Independent Disks) disk arrays, tape libraries
- Servers: The server is the initiator in the Fibre Channel SAN and provides the interface to an IP network. Servers interact with the Fibre Channel fabric through the HBA.
- Physical layer/media: Coax, twisted-pair and/or fiber-optic cables, however fiber is the most predominant.

The FC SAN switches are classified as either switches or directors. A SAN fabric switch contains a low to medium port count, while a director is a high port count switch (generally above 64 ports). Fibre Channel switches can be networked together to build larger storage networks. The HBA is more complex than a traditional Ethernet card. It connects the Fibre Channel network to the IP network via the networking cabling subsystem. A bridge may be used to connect legacy SCSI or ESCON (Enterprise System Connection) storage devices to the Fibre Channel network. The bridge will serve to translate and/or encapsulate the various protocols allowing communication with legacy storage devices via the SAN.

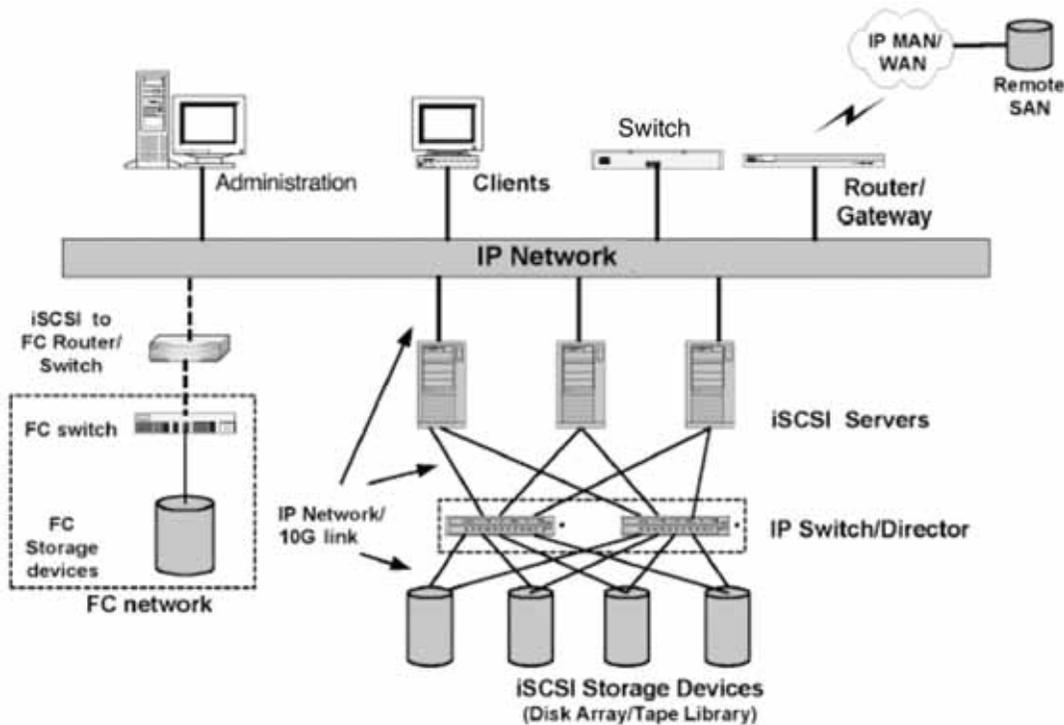


Figure 4: iSCSI SAN Diagram

Small Computer Systems Interface (SCSI) over IP (iSCSI)

The iSCSI protocol unites storage and IP networking. iSCSI uses existing Ethernet devices and the IP protocol to carry and manage data stored in a SCSI SAN. It is a simple, high speed, low-cost, long distance storage solution. One problem with traditional SCSI attached devices was the distance limitation. By using existing network components and exploiting the advantages of IP networking such as network management and other tools for LANs, MANs and WANs, iSCSI is expanding in the storage market and extending SAN connectivity without distance limitations. It is more cost effective due to its use of existing equipment and infrastructure. With a 10x increase from existing 1Gigabit to 10Gigabit Ethernet, it will become a major force in the SAN market. Using 10Gigabit Ethernet, SANs are reaching the highest storage transportation speeds ever.

iSCSI Typical Component/Elements:

- iSCSI Host Bus Adapter (HBA) or NIC (installed in server)
- Storage devices disk arrays or tape libraries
- Servers
- Standard IP Ethernet Switches and Routers
- Storage Switches and Routers
- Gateways
- Physical layer media - Fiber, twisted-pair

Generally, to deploy an iSCSI storage network in a data center, connectivity is provided via iSCSI Host Bus Adapters (HBAs) or storage NIC which connects the storage resources to existing Ethernet via IP Ethernet switches or IP Storage switches and routers. Specified storage IP routers and switches have a combination of iSCSI interfaces and other storage interfaces such as SCSI or Fibre Channel, they provide multi-protocol connectivity not available in conventional IP and Ethernet switches.

When connecting to FC SANs, an IP storage switch or router is needed to convert the FC protocol to iSCSI. IP storage routers and switches extend the reach of the FC SAN and bridge FC SANs to iSCSI SANs. For example, an IP storage switch allows users to perform FC-to-FC switching, FC-to-iSCSI switching, or FC-to-Ethernet switching in addition to Ethernet to Ethernet switching.

Mixed Architectures Storage Networks

Flexibility and low cost are the important driving factors for implementing an iSCSI approach, especially for long distance storage. In addition, as Ethernet speeds are continually increasing, it is believed that the 10 Gigabit Ethernet based iSCSI will be widely used for SANs in data centers. A number of devices have been developed to address the large installed base of native FC storage solutions in place today. In order to protect an organization's current investment in storage technology, SAN installations may evolve from a single specific storage network to a mix of Fibre Channel and iSCSI products.

Furthermore, a convergence or integration of NAS and SANs is expected and multilingual (combination) Fibre Channel and Ethernet switches are expected to evolve. The integrated SAN and NAS network will be scaleable and cost-effective, it will support multiple protocols and interfaces. This integration will enable customers to optimize their native Fibre Channel SANs by providing reliable connections over long distances using existing electronics by providing a convergence between Ethernet, Fibre Channel and iSCSI protocols.

Evolving Standards for SANs

FC standards are developed by the technical subcommittee NCITS/T11 of the National Committee for Information Technology Standards (NCITS). The original FC standards were approved by the ANSI X.3230 in 1994. The first SCSI standard was ratified by ANSI in 1986. Since then, there have been multiple amendments mirroring changes within the industry.

The Internet Engineering Task Force (IETF) is expanding on these standards through IP protocol enhancements to the existing interface and operational standards above. In February, 2003, the iSCSI specification was officially approved as a "proposed standard" by the IETF. Additionally, the Storage Networking Industry Association (SNIA), the Fibre Channel Industry Association (FCIA), and other industry groups are also working on the SAN standard's implementation and development. The data center is the critical infrastructure hub of an organization. Besides the SAN /NAS components, a typical data center includes a

variety of other components and connectivity. To address the evolutions of data centers, the TIA TR-42.1.1 group developed the "Telecommunications Infrastructure Standard for Data Centers" published as ANSI/TIA/EIA-942 and later amended and published as TIA 942-A. The standard covers the cabling system design, pathway, and spaces. Likewise, ISO developed ISO 24764 international cabling standard for data centers.

Cabling Considerations and Design Factors for SANs are most prevalent in data centers, but they also include video, voice, and other converged applications. A robust network cabling foundation is essential. In a data center environment the basic requirements for the cabling system are:

- Standards-based open system
- Support for 10GbE, 8, 16 and 32Gb/s FC
- Support for multiple types of SAN / NAS and protocols
- Support for cumulative bandwidth demands for converged applications
- High Reliability
- Redundancy
- Flexible, scaleable and provides mechanisms for easy deployment of MACs
 - It is highly desirable to use the highest performing fiber with low loss connectors to allow reconfigurations without running new fiber.

To meet all above requirement, 10GbE copper and laser optimized multimode fiber are the first choices. TIA recommends category 6A as a minimum copper cabling standard and now OM4 as the minimum fiber standard. ISO 24764 recommends 6A as a minimum for copper and OM3 for fiber. A 10GbE capable infrastructure is predominant in data centers today, with 40 and 100GbE fast approaching for backbone applications. In order to improve the reliability of the communications infrastructure, redundancy is a principal design consideration in a data center. The redundancy can be achieved by providing physically separated services, cross-connected areas and pathways, or by providing redundant electronic devices in fabric topologies.

Conclusion

Storage Area Networks are but one component of converged applications that traverse today's networks. The benefits of these systems are not only numerous, but completely essential to a business. Providing the bandwidth necessary for all networked applications using a high performance structured cabling infrastructure will ensure their functionality for years to come. Upgrading or replacing your infrastructure reactively is costly. Industry experts agree that cabling infrastructure should be planned to carry data for at least 10 years.

Storage solutions are plentiful and there is no one size fits all for today's data centers. In fact some data centers utilize a variety of storage architectures depending on the application requirements. While Fibre Channel in native form is the predominant architecture for storage, iSCSI and FCoE are gaining some momentum. When fibre channel SANs complement Ethernet networks, dual paths for moving data are provided. Converging fibre channel over Ethernet decreases the number of connections required, but doubles the traffic over the used channels. Increasing bandwidth from gigabit to 10GbE provides more bandwidth for these applications. When increasing the horizontal server to switch speed, uplink ports also need to increase in speed, generally using multiple 10GbE links or newer 40/100GbE speeds. Siemon's data center design assistance experts can help design a storage and network architecture to support your business needs.

The Siemon Company is a global market leader specializing in high performance, high quality cabling systems. Siemon offers a broad range of copper and fiber cable, connectivity and cable management systems for Data Centers including Storage Area Networks and beyond. Siemon's LightStack™ Fiber Plug and Play system combines superior performance with ultra high density (144 LC and 864 MTP fibers in 1U) and best in class accessibility. Siemon cabling systems are backed by an extended warranty covering product quality, performance headroom and applications assurance for up to 20 years. For more information on Siemon Data Center solutions please visit: www.siemon.com/datacenter.

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- FCIA, Fibre Channel Industry Association, www.fibrechannel.org

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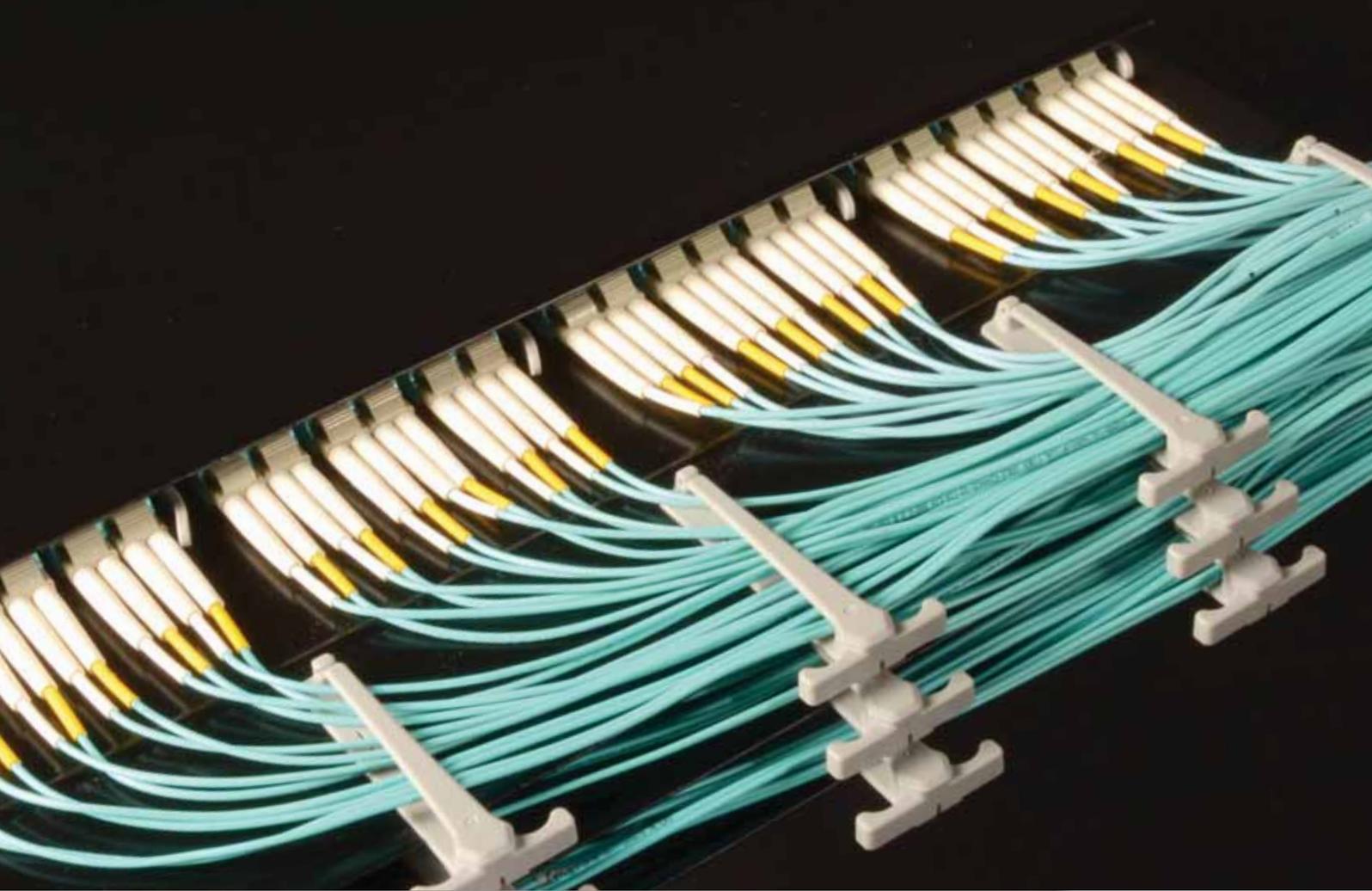
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The Need for Low-Loss Multifiber Connectivity In Today's Data Center

Optical insertion loss budgets are now one of the top concerns among data center managers, especially in today's large virtualized server environments with longer-distance 40 and 100 gigabit Ethernet (GbE) backbone switch-to-switch deployments for networking and storage area networks (SANs). In fact, loss budgets need to be carefully considered during the early design stages of any data center—staying within the loss budget is essential for ensuring that optical data signals can properly transmit from one switch to another without high bit error rates and performance degradation.

With the length and type of the fiber cable and number of connectors and splices all contributing to the link loss, data center managers are faced with the challenge of calculating each connection point and segment within their fiber channels. Multi-fiber push on (MPO) or mechanical transfer push on (MTP) connectors are rapidly becoming the norm for switch-to-switch connections due to their preterminated plug and play benefits and ease of scalability from 10 to 40 and 100 gigabit speeds. Unfortunately, typical MPO/MTP module insertion loss may not allow for having more than two mated connections in a fiber channel, which significantly limits design flexibility and data center management. Low loss, rather than standard loss, MPO/MTP connectors better support multiple mated connections for flexibility over a wide range of distances and configurations while remaining within the loss budget.

Evolving Data Center Architectures Impact Loss

Traditional three-tier Layer 3 switch architectures have been common practice in the data center environment for several years. These traditional architectures consist of core network and SAN switches located in the main distribution area (MDA); aggregation switches located in the MDA, intermediate distribution area (IDA) or horizontal distribution area (HDA); and access switches located in the HDA (see Figure 1).

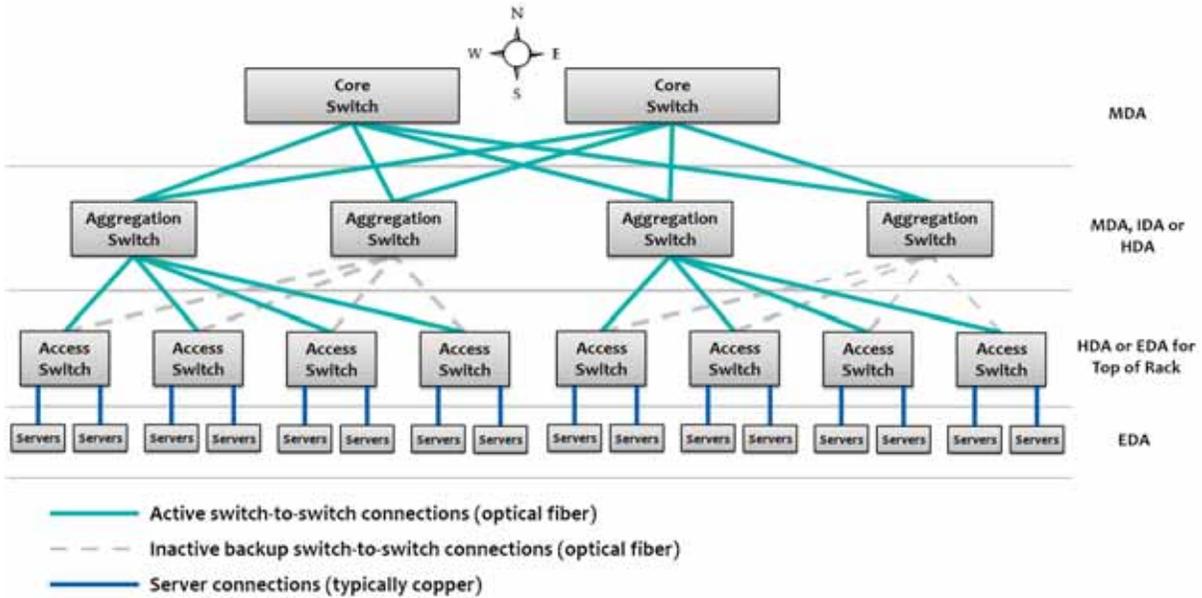


Figure 1: Traditional three-tier switch architecture per TIA-942 data center standards.

With multiple switch tiers and fiber backbone speeds of 10 gigabits per second (Gb/s), the distance and data rates between switches have remained short enough for most data centers to maintain two or more connectors without exceeding optical link loss budgets. However, traditional three-tier architectures are no longer ideal for large virtualized data centers.

While the traditional three-tier architecture was well suited for data traffic between servers that reside on the same access switch, it does not adequately support the non-blocking, low-latency, high-bandwidth requirements of today's large virtualized data centers that divide single physical servers into multiple isolated virtual environments. Non-blocking refers to having sufficient bandwidth so that any port can communicate with any other port at the full bandwidth capacity of the port, while latency refers to the amount of time it takes for a data packet to travel from its source to its destination. With equipment now located anywhere in the data center, data traffic between two access switches in a three-tier architecture may have to traverse in a north-south traffic pattern through multiple aggregation and core switches, resulting in an increased number of switch hops and increased latency.

In a high-bandwidth, virtualized environment, the traditional north-south traffic pattern (switch to switch) causes the problem of links not having enough bandwidth to support the traffic.

This has many data centers moving to switch fabric architectures that use only two tiers of switches with fewer switch-to-switch hops. Switch fabrics provide lower latency and greater bandwidth between any two points by taking advantage of wire-speed transmissions on the backplanes (port to port) of switches as opposed to uplinks from lower level switch to higher level switch). This enables dynamic east-west server-to-server traffic where it is needed, eliminating the need for communication between two servers to travel north-south through multiple switch layers.

Fat-tree switch fabrics, also referred to as a leaf and spine architectures, are one of the most common switch fabrics being deployed in today's virtualized data center. The fat-tree architecture consists of interconnection (spine) switches placed in the MDA and access (leaf) switches placed in the HDA or EDA that each connect, or uplink, to every interconnection switch in a mesh, typically via optical fiber (see Figure 2).

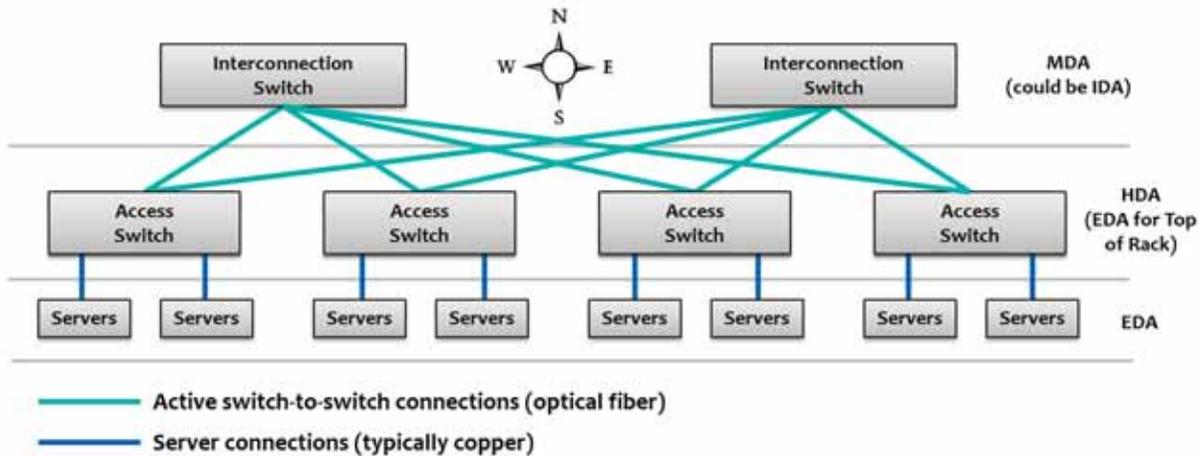


Figure 2: Fat-tree switch fabric architecture per the TIA-942-A addendum.

While the fat-tree flattened architecture leverages the reach of standards-based optical fiber cabling to establish large numbers of active connections between fewer switches, these new data center designs often result in longer distances between interconnection and access switches. These longer fiber runs can be difficult to deploy in data center pathways, and adding new access switches presents the challenge of adding additional long fiber runs to already populated pathways. To maintain flexibility and manageability, ease deployments and upgrades, and limit access to critical switches, many data center managers are looking to deploy multiple mated pairs that support distribution points or convenient fiber patching areas (cross connects).

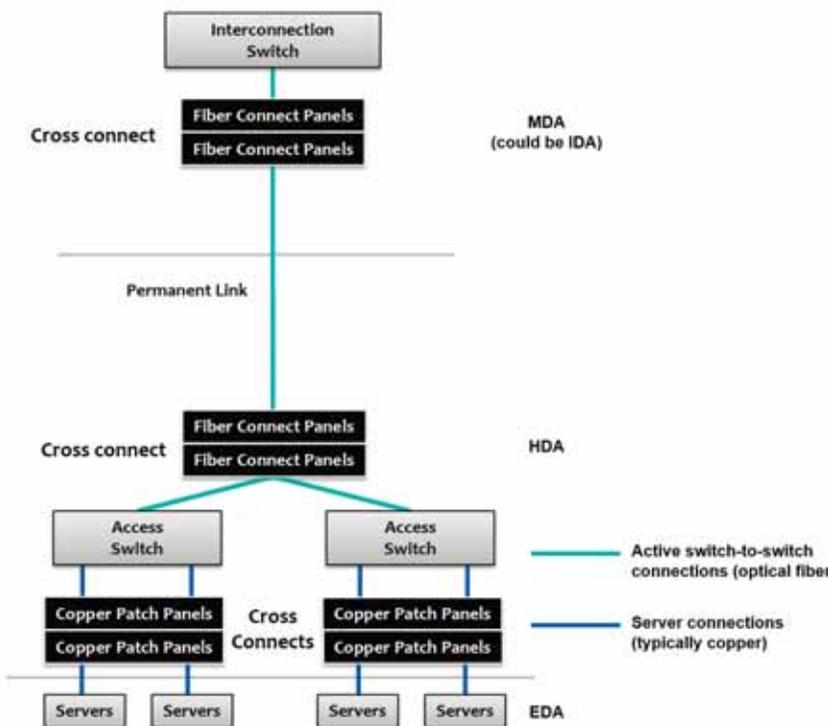


Figure 3: Cross connects can be deployed for ease of manageability, flexibility and/or keeping switches secure. However, the extra mated connections in the backbone channel may require low loss optical fiber connectivity.

Convenient patching areas include the use of fiber connect panels that mirror interconnection switch ports and connect via permanent, or fixed, links to fiber connect panels that mirror access switch ports (see Figure 3). These panels can be located in separate cabinets, which allows the switches to remain untouched and secure. They also enable easier moves, adds and changes (MACs) by creating an “any to all” configuration where any switch port can be connected to any other switch port by simply repositioning fiber jumper connections at the patching area.

Ideal for larger data centers or when optical fiber is distributed to multiple functional areas or zones, the use of cross connects at interconnection and/or access switches can also allow for one-time deployment of permanent high-fiber-count cabling from the MDA to the HDA. This allows for the fiber backbone cabling to be used for various purposes (networking or SAN) without multiple MACs and simplifies the process of adding new access switches and equipment to the data center. For example, all it takes to swap a server's fiber connection from a network connection to a SAN connection is a simple fiber jumper change at the cross connect located at the end of each row (see Figure 4).

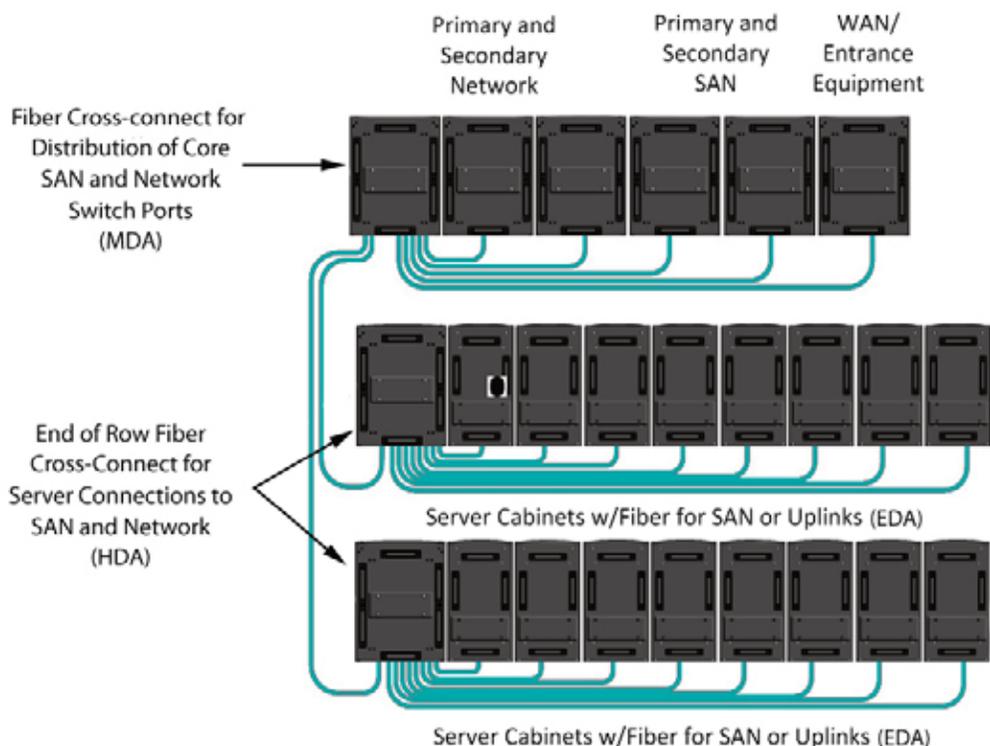


Figure 4: Top-view of a data center showing the use of cross connects for core SAN and network switch connections in the MDA and servers and access switches in the HDA. A server's fiber connection can easily be switched from network to SAN via a simple fiber jumper change at the end of row cross connect.

Unfortunately, the use of these valuable cross connects adds additional connection points and subsequent loss in a fiber channel. Consequently, standard loss MPO/MTP insertion loss values can put data center managers at risk of exceeding their optical link loss budgets, often preventing the use of cross connects and requiring continued use of long fiber runs that significantly limit flexibility and complicate MACs and upgrades.

Higher Bandwidth Speeds Impact Loss

One of the key driving factors that is making fiber loss budgets a growing concern in the data center environment is the migration of transmission speeds from 1 Gb/s, to 10 Gb/s, to now 40 and 100 Gb/s for Ethernet-based networks and from 8 Gb/s, to 16 Gb/s, to now 32 Gb/s for Fibre Channel-based SANs.

As speeds increase, insertion loss requirements become more stringent than ever, making the use of cross connects more difficult in most scenarios where standard insertion loss values are used. A closer look at the evolution of Ethernet standards demonstrates the impact of speed on insertion loss.

The Institute of Electrical and Electronics Engineers (IEEE) 1000BASE-SX standard (1 GbE) allows for a maximum channel loss of 4.5 dB over 1000 meters of OM3 multimode fiber and 4.8 dB over 1100 meters of OM4. The maximum channel loss for 10GBASE-SR (10 GbE) was reduced to 2.6 dB over 300 meters of OM3 fiber and 2.9 dB over 400 meters of OM4.

Based on the 0.75 dB maximum acceptable connector loss and the 3.5dB/km maximum fiber loss specified in TIA-568-C.0-2 standards, the loss values for 10 GbE assume two connection points in the channel with connector pairs contributing a total of 1.5 dB allocated for insertion loss and the fiber contributing a total of 1.1 dB for OM3 and 1.4 dB for OM4, respectively. For example, Figure 5 shows a two-connector 10 GbE channel using OM3 fiber and maximum loss values per the TIA and IEEE standards.

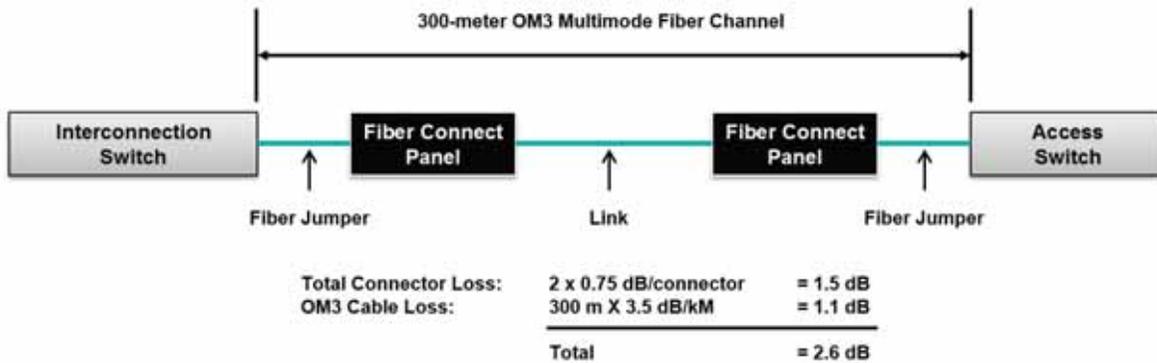


Figure 5: Per IEEE 802.3ae, a 10 gigabit channel over OM3 fiber has a maximum distance of 300 meters with a maximum loss budget of 2.6 dB.

IEEE 40GBASE-SR4 and 100GBASE-SR10 standards for 40 and 100 GbE over multimode fiber with an 850 nm source now have more stringent loss requirements for the fiber, which lowers the overall channel loss. As shown in Table 1, for OM3 fiber cabling, the 40 and 100 GbE standards allows for a channel distance of 100 meters with a maximum channel loss of 1.9 dB, including a maximum connector loss of 1.5 dB. For OM4 fiber cabling, the distance is increased to 150 meters but with a maximum channel loss of 1.5 dB, including a maximum connector loss of 1.0 dB.

Fiber Type	1000BASE-SX (1 Gb/s)		10GBASE-SR (10 Gb/s)		40GBASE-SR4 (40 Gb/s) 100GBASE-SR10 (100 Gb/s)	
	Distance (m)	Channel Loss (dB)	Distance (m)	Channel Loss (dB)	Distance (m)	Channel Loss (dB)
OM3	1000	4.5	300	2.6	100	1.9
OM4	1100	4.8	400	2.9	150	1.5

Table 1: As speeds have increased from 1 Gb/s to 40 and 100 Gb/s, maximum channel distance and loss has decreased significantly

It should be noted that current TIA and ISO standards require a minimum of OM3 fiber, while TIA recommends the use of OM4 due to its longer transmission capabilities. In fact, the upcoming 100GBASE-SR4 standard that will use eight fibers (i.e., four transmitting and four receiving) at 25 Gb/s is anticipated to be supported by OM4 fiber to 100 meters, but to only 70 meters using OM3.

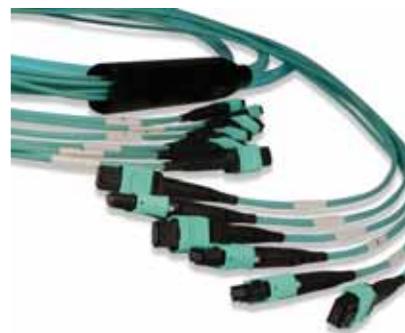
Typical MPO/MTP connectors, which are required for 40 and 100 GbE deployments have insertion loss values that range from 0.3 dB to 0.5 dB. Typical LC multimode fiber connectors have loss values that range from 0.3 dB to 0.5 dB. While better than the allowed 0.75 dB TIA value, typical connector loss still limits how many connections can be deployed in 10, 40 and 100 GbE channels. For example, with an LC connector loss of 0.5 dB, a 300-meter 10 GbE channel over OM3 fiber can include only three connectors with no headroom. Having just two or three connections prevents the use of cross connects at both interconnection (MDA) and access switches (HDA).

Low Loss Fiber Connectivity to the Rescue

Due to improvements in connector technology and manufacturing techniques, Siemon has succeeded in lowering the loss to 0.20 dB for MTP connectors and to 0.15 dB (0.1 dB typical) for LC and SC connectors, well below the industry standard of 0.75 dB and loss values offered by other manufacturers.

For 10 GbE, Siemon low loss LC BladePatch fiber jumpers offer a loss of 0.15 dB (typical 0.1 dB) and Siemon low loss plug and play MTP to LC or SC modules offer a loss of 0.35 dB (typical 0.25 dB). For 40 and 100 GbE, Siemon MTP to MTP pass-through adapter plates and MTP fiber jumpers offer a loss of 0.2 dB. These lower loss values allow data center managers to deploy more connection points in fiber channels, enabling the use of distribution points or cross connects that significantly increase flexible configuration options.

Table 2 below provides an example of how many connections can be deployed in 10, 40 and 100 GbE channels over OM3 and OM4 multimode fiber using Siemon low loss MTP to LC modules for 10 GbE and low loss MTP to MTP pass-through adapters for 40 and 100 GbE versus standard loss solutions.



Application	Distance (meters)	Max Channel Loss /Connector Loss	Fiber Attenuation (3.0 dB/km)	# of MTP to LC Adapters		# of MTP to MTP Adapters	
				Standard Loss (0.65 dB)	Siemon Low-Loss (0.35 dB)	Standard Loss (0.4 dB)	Siemon Low-Loss (0.2 dB)
10 GbE OM3 @ 850 nm	300	2.6 dB/NA	0.9 dB	2	4		
40/100 GbE OM3 @ 850 nm	100	1.9 dB/1.5 dB	0.30 dB			4	8
10 GbE OM4 @ 850 nm	400	2.9 dB/NA	1.2 dB	2	4		
40/100 GbE OM4 @ 850 nm	150	1.5 dB/1.0 dB	0.4 dB			2	5

Table 2: Siemon low loss multifiber connectivity allows for more connectors in 10, 40 and 100 Gb/s channels over multimode fiber at the 850 nm wavelength.

As indicated in Table 2, the use of low loss connectivity allows for four connections in a 10 GbE OM3 or OM4 channel compared to just two when using standard loss connectivity. Low loss connectivity allows for eight connections in a 100-meter 40/100 GbE channel over OM3 versus just four connections using standard loss, and five connections in a 150-meter 40/100 GbE channel over OM4 fiber compared to just two connections using standard loss. Deploying cross connects between interconnection and access switches requires a minimum of four connections, depending on the configuration. Therefore, cross connects in a full-distance optical channel are simply not feasible without low loss connectivity.

Figures 6, 7 and 8 shows some example scenarios for deploying cross connects in 10 GbE and 40/100 GbE channels over OM3 and OM4 fiber using Siemon low loss fiber connectivity. In Figure 6, all changes are made at the cross connect with LC fiber jumpers. The switches remain separate and the permanent MTP trunk cables need only be installed once. The cross connect can be placed anywhere within the channel to maximize ease of deployment and manageability.

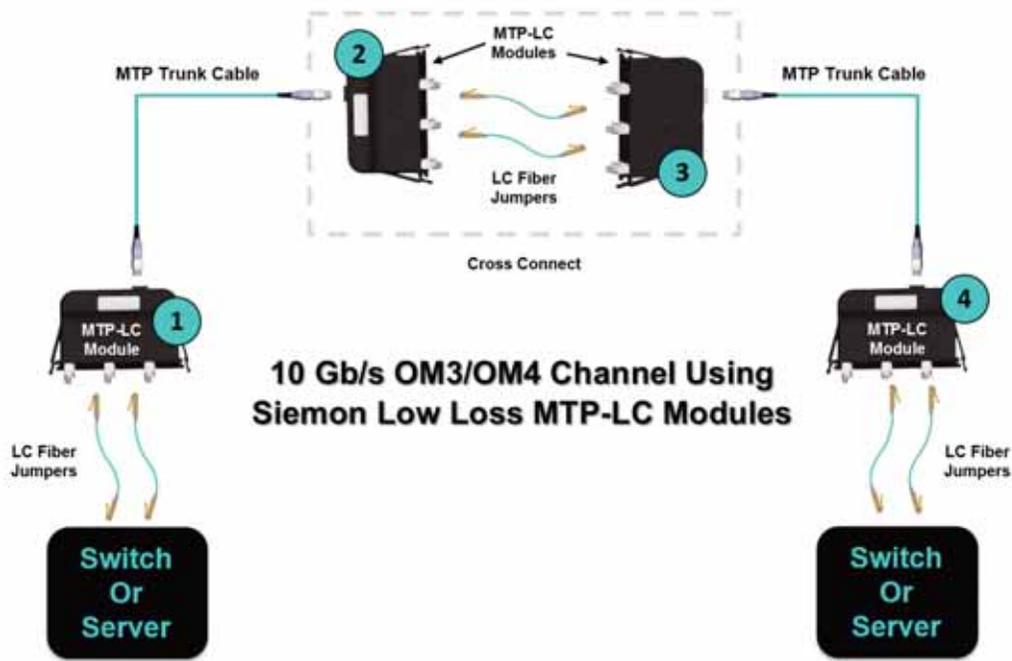


Figure 6: Four Siemon Low Loss MTP-LC Modules can be deployed in a 10 GbE channel, enabling a cross connect for superior flexibility and manageability.

Figure 7. shows an OM3 40/100 GbE channel with six Siemon low loss MTP-MTP pass-through adapter plates and low loss trunks. This scenario offers 0.4 dB of headroom and provides even better manageability and security. All changes are made at the cross connects via MTP fiber jumpers, switches remain separate, and the MTP trunk cables need only be installed once. Once again, the cross connects can be located anywhere in the data center for maximum flexibility. This allows for one-time deployment of high fiber-count cabling from the cross connect at the interconnection switch to the cross connect at the access switch. Adding additional access switches can be accomplished with short fiber runs from the cross connect.

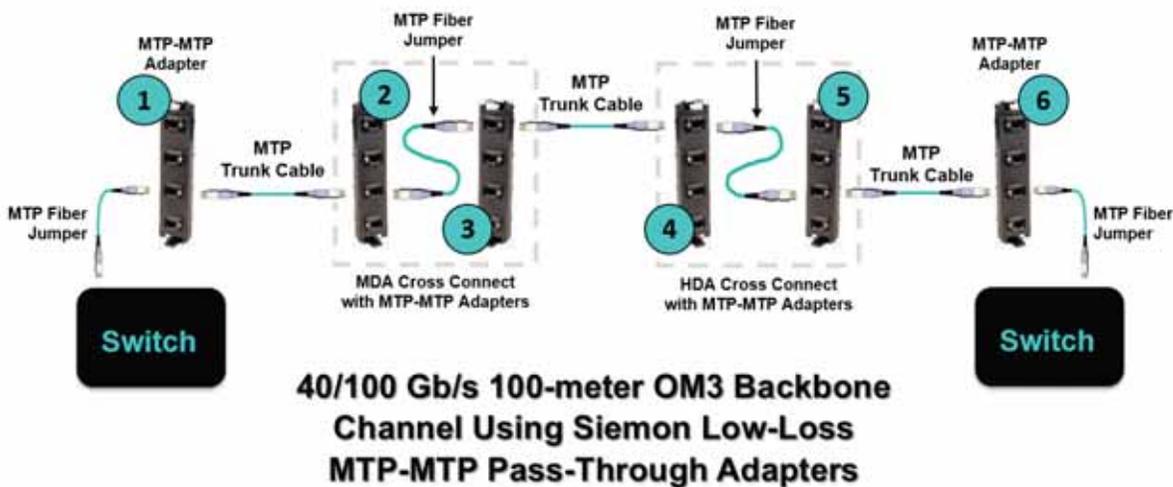
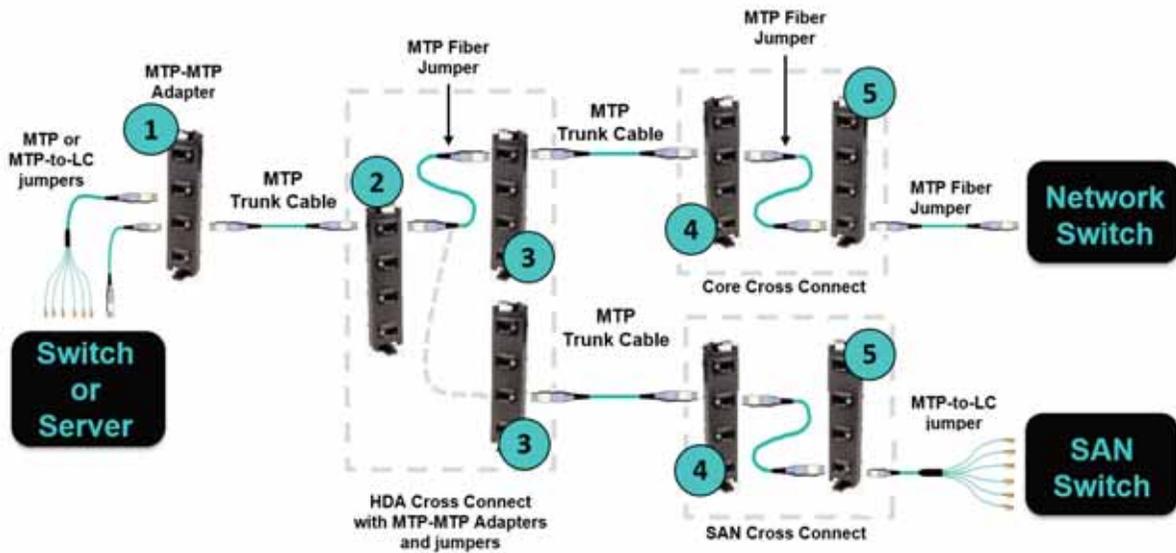


Figure 7: For maximum flexibility, manageability and security, up to eight Siemon low loss MTP-MTP pass-through adapters can be deployed using low loss trunks in a 100-meter 40/100 GbE switch-to-switch backbone channel over OM3 fiber.

If the loss budget does not permit deploying six MTP to MTP adapters, one option is to deploy MTP to LC or MTP to MTP jumpers from the cross connect to the equipment, depending on the equipment interface. For example, if using OM4 fiber to extend the channel distance to 150 meters, up to five Siemon Low Loss MTP-MTP pass through adapters can be deployed as shown in Figure 8.



40/100 Gb/s 150-meter OM4 Channel Using Siemon Low-Loss MTP-MTP Pass-Through Adapters

Figure 8: Low loss connectivity allows for two cross connects within a 150-meter 40/100 GbE channel over OM4 fiber to easily change from a network uplink port to a SAN port via a jumper change at the cross connect.

In addition to enabling more connections in 10, 40 and 100 gigabit Ethernet channels, low loss connectivity provides the same benefits for Fibre Channel deployments in SANs. For example, a 150-meter 8 Gb/s Fibre Channel (GFC) deployment allows for up to four Siemon low loss MTP to LC modules yet allows for only two modules when using standard loss components. Using low loss connectivity to deploy cross connects therefore makes it easy to change server connections from a network uplink port to a SAN port and vice versa by simply changing a jumper at the cross connect as shown in Figure 9.

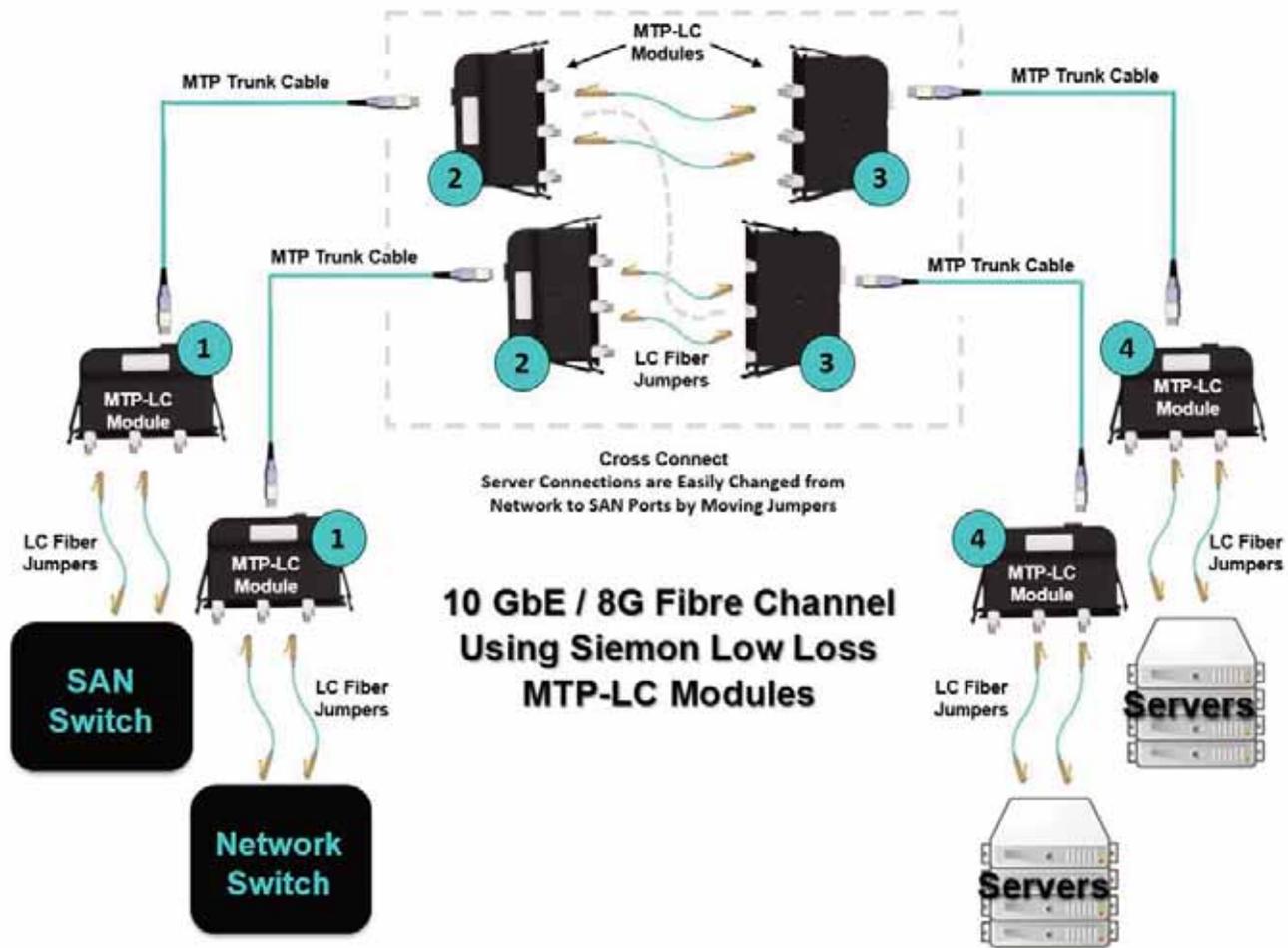


Figure 9: Low loss connectivity also supports additional connection points for Fibre Channel, making it easy to change from a network uplink port to a SAN port by changing a jumper at the cross connect.

Table 3 below provides a detailed summary of several Ethernet and Fibre Channel scenarios using Siemon low loss connectivity versus standard loss connectivity. The blue areas indicate that the loss is within the standards requirements, while red indicates over budget. As indicated, the maximum operating distance is impacted by the number of connections. However, low loss connectivity clearly enables more connections in both Ethernet and Fibre Channel fiber links.

ETHERNET														
Siemon Fiber Type	Connector Grade	Max MTP Cassette Loss (dB)	Max MTP Adapter Plate Loss (dB)	Cable Attenuation (dB/km)	Data Rate	Number of MTP modules and/or adapter-plates and maximum operation distance(m) at 850 nm						Maximum Standard Distance (m)	Maximum Channel Loss (dB)	
						2	3	4	5	6	7			8
OM3 XGLO*	Low loss	0.35		3.0	1 GbE	1000	1000	1000	910	800	680	560	1000	4.50
		0.35		3.0	10 GbE	300	300	300	283				300	2.60
			0.20	3.0	40/100 GbE	100	100	100	100	100	100	100	100	1.90
	Standard	0.65		3.0	1 GbE	1000	850	630	410	200			1000	4.50
		0.65		3.0	10 GbE	300	210						300	2.60
			0.40	3.0	40/100 GbE	100	100	100					100	1.90
OM4 XGLO*	Low loss	0.35		3.0	1 GbE	1100	1100	1100	1000	900	780	650	1100	4.80
		0.35		3.0	10 GbE	550	550	550	450	350			550*	2.90
			0.20	3.0	40/100 GbE	150	150	150	150	100	32		150	1.50
	Standard	0.65		3.0	1 GbE	1100	950	730	510				1100	4.80
		0.65		3.0	10 GbE	550	300	90					550	3.15
			0.40	3.0	40/100 GbE	150	15						150	1.50
Fibre Channel														
Siemon System	Connector Grade	Max MTP Cassette Loss (dB)	Max MTP Adapter Plate Loss (dB)	Cable Attenuation (dB/km)	Data Rate	Number of MTP modules and/or adapter-plates and maximum operation distance(m) at 850 nm						Maximum Standard Distance** (m)	Maximum Channel Loss (dB)	
						2	3	4	5	6	7			8
OM3 XGLO*	Low loss	0.35		3.0	8GFC	180	150	150	125	110	35	35	180	Fibre Channel loss: budget is dependent of connection loss values per FC-P15 table B.3 and FC-P16 table B.1
		0.35		3.0	16GFC	120	100	100	75	40	40		120	
		0.35		3.0	32GFC	80	70	70	60	45	15	15	80	
	Standard	0.65		3.0	8GFC	150	125	35					150	
		0.65		3.0	16GFC	100	75						70	
			0.40	3.0	32GFC	80	70	60	60	45	15		80	
OM4 XGLO*	Low loss	0.35		3.0	8GFC	220	190	190	160	120	120	50	220	
		0.35		3.0	16GFC	150	125	125	100	50	50		150	
		0.35		3.0	32GFC	110	100	100	80	65	20	20	110	
			0.20	3.0	32GFC	110	110	110	110	100	100	80	110	
	Standard	0.65		3.0	8GFC	190	160	50					190	
		0.65		3.0	16GFC	125	100						125	
		0.65		3.0	32GFC	100	80	20					100	
			0.40	3.0	32GFC	110	100	80	80	65	20		110	

Table 3: Siemon low loss fiber enables multiple mated pairs in Ethernet and Fibre Channel applications.
 * 550 meters is beyond the standard for OM4 but supported by most of today's equipment
 ** 0.5 meters is the minimum distance for all Ethernet and FC applications

Additional Considerations

In addition to considering low loss connectivity for more connection points in switch-to-switch and server-to-switch fiber links, it is important to remember that not all MPO connectors are the same.

Siemon's MTP connector interface offers higher performance than generic MPO connectors. It features advanced engineering and design enhancements that offer ease of use, including the ability to re-polish connectors and change connector gender in the field. The MTP connector also offers improved mechanical performance to maintain physical contact under load, enhanced guide pins that provide for better alignment and a metal pin clamp for centering the push spring and eliminating fiber damage from the spring.

Data center managers should also consider ferrule material when selecting fiber connectivity. Siemon uses high precision Zirconia ceramic ferrules for optical performance over metal or lower-cost plastic. Zirconia ceramic offers better durability and dimensional control, which enables more efficient polishing with repeatable results and a finer finish. Using advanced precision molding techniques, Zirconia ceramic ferrules also provide better physical contact of fibers than other materials. This provides accurate fiber alignment, which when combined with the benefits of the MTP connector, allows for the best overall performance with minimal loss.

Summary

With today's flattened switch architectures and shrinking optical insertion loss budgets, Siemon low loss fiber connectivity enables more connection points in both Ethernet and Fibre Channel applications in the data center. These additional connection points allow for the use of distribution points and cross connects in fiber network and SAN channels to:

- Deploy shorter fiber runs
- Prevent access to critical switches
- Make easy changes with an "any to all" configuration
- Use fiber backbone cabling for various purposes without having to run new fiber
- Simplify the process of adding new equipment

With loss budgets needing to be carefully considered during the early design stages of any data center, data center managers can turn to Siemon low loss fiber connectivity to support more connections in 10, 40 and 100 GbE applications or in 8, 16 and 32 GFC SAN applications. Contact Siemon today for more information about how our low loss LC BladePatch fiber jumpers, plug and play MTP to LC or SC modules, MTP to MTP pass-through adapter plates and MTP fiber jumpers and trunks can help you stay within your loss budgets and provide flexibility over a wide range of distances and future proof configurations.

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Considerations for Choosing Top of Rack in Today's Fat-Tree Switch Fabric Configurations

Three-tier switch architectures have been common practice in the data center environment for several years. However, this architecture does not adequately support the low-latency, high-bandwidth requirements of large virtualized data centers. With equipment now located anywhere in the data center, data traffic between two servers in a three-tier architecture may have to traverse in a north-south traffic (i.e., switch to switch) pattern through multiple switch layers, resulting in increased latency and network complexity. This has many data centers moving to switch fabric architectures that are limited to just one or two tiers of switches. With fewer tiers of switches, server to server communications is improved by eliminating the need for communication to travel through multiple switch layers.

Fat-tree switch fabrics, also referred to as leaf and spine, are one of the most common switch fabrics being deployed in today's data center. In a fat-tree switch fabric, data center managers are faced with multiple configuration options that require decisions regarding application, cabling and where to place access switches that connect to servers. In a fat-tree switch fabric, access switches can reside in traditional centralized network distribution areas, middle of row (MoR) positions or end of row (EoR) positions—all of which use structured cabling to connect to the servers. Alternatively, they can be placed in a top of rack (ToR) position using point-to-point cabling within the cabinet for connecting to the servers.

There is no single ideal configuration for every data center, and real-world implementation of newer fat-tree switch fabric architectures warrants CIOs, data center professionals and IT managers taking a closer look at the pros and cons of each option based on their specific needs within the data center ecosystem. Undertaking a study that looks at the impact of the various configurations, applications and cabling on manageability, cooling, scalability, and total cost of ownership (TCO) will help facilities and data center managers ultimately make the best educated decision as they move from traditional three-tier switch architectures to newer fat-tree switch fabrics.

A Closer Look at the Options

In April 2013, the Telecommunications Industry Association (TIA) released ANSI/TIA-942-A-1, an addendum to the ANSI/TIA-942-A data center standard that provides cabling guidelines for switch fabrics. The fat-tree switch fabric outlined in the addendum consists of interconnection (spine) switches placed in the main distribution area (MDA) and access (leaf) switches placed in the horizontal distribution area (HDA) and/or equipment distribution area (EDA). Each access switch connects to every interconnection switch in a mesh topology, typically via optical fiber (see Figure 1).

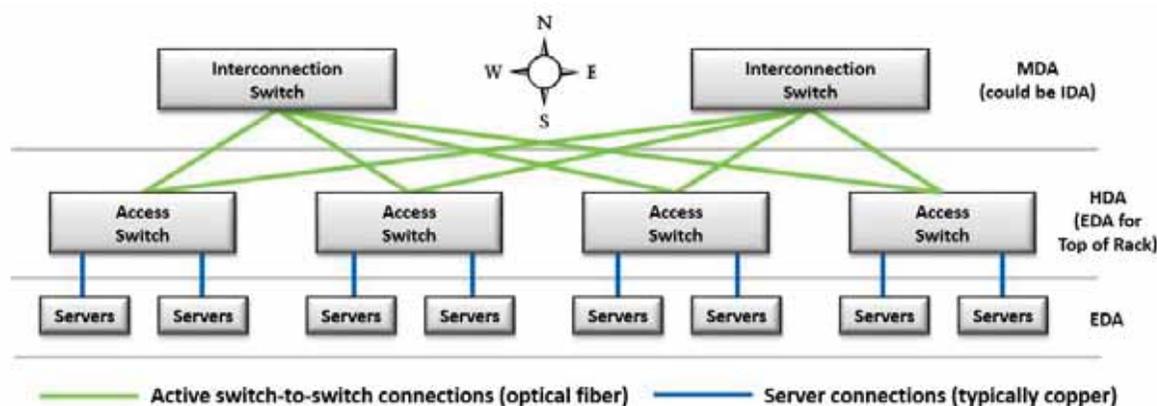


Figure 1: Fat-tree switch architecture. Source: ANSI/TIA-942-A-1

In a fat-tree switch fabric, access switches that connect to servers and storage equipment in rows can be located at the MoR or EoR position to serve the equipment in that row, or they can be located in a separate dedicated area to serve multiple rows of cabinets (see Figure 2). MoR and EoR configurations, which function in the same manner, are popular for data center environments where each row of cabinets is dedicated to a specific purpose, and growth is accomplished on a row-by-row basis. For the purposes of this article, we will concentrate on the more popular EoR configuration.

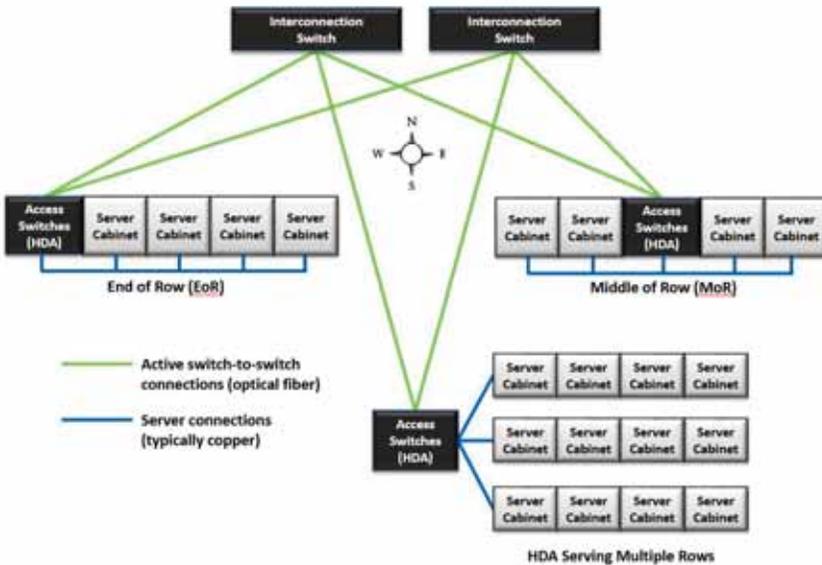


Figure 2: In a fat-tree architecture, the access switches (HDA) can be located in MoR or EoR positions to serve equipment in rows, or they can be located in separated dedicated areas to serve multiple rows.

EoR configurations that place access switches at the end of each row use structured cabling with passive patch panels to serve as the connection point between the access switches and servers. Patch panels that mirror the switch and server ports (cross connect) at the EoR location connect to corresponding patch panels at the access switch and in server cabinets using permanent links. The connections between switch and server ports are made at the cross connect via patch cords.

The alternative to placing access switches in the EoR position is to place them in the ToR position. In this scenario, fiber cabling runs from each interconnection switch in the MDA to smaller (1RU to 2 RU) access switches placed in each cabinet. Instead of access switches, active port extenders can be deployed in each cabinet. Port extenders, sometimes referred to as fabric extenders, are essentially physical extensions of their parent access switches. For the purposes of this article, we will refer to ToR switches in general to represent both access switches and port extenders placed in the ToR position.

Within each cabinet, the ToR switches connect directly to the servers in that cabinet using point-to-point copper cabling often via short preterminated small form-factor pluggable (e.g., SFP+ and QSFP) twinaxial cable assemblies, active optical cable assemblies or RJ-45 modular patch cords (see Figure 3).

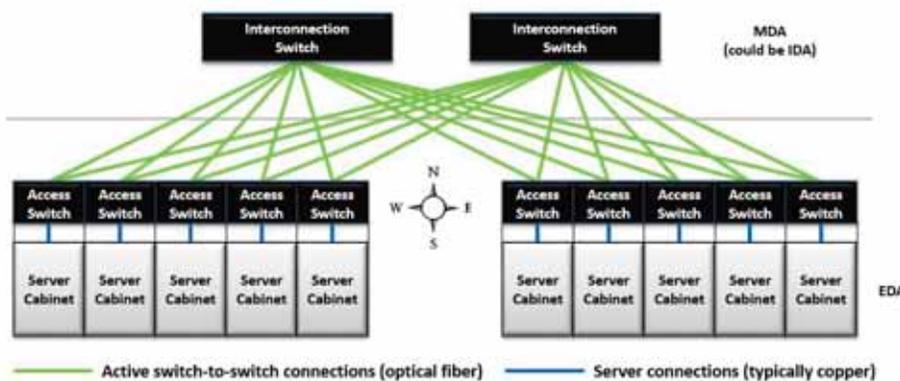


Figure 3: In a ToR configuration, small access switches placed in the top of each cabinet connect directly to the equipment in the cabinet via point-to-point cabling. Source: TIA-942-A-1

ToR configurations are geared towards dense 1 rack unit (1RU) server environments, enabling fast server-to-server connections within a rack versus within a row. ToR is ideal for data centers that require a cabinet-at-a-time deployment and cabinet-level management.

The use of a ToR configuration places the access switch in the EDA, eliminating the HDA and patching area for making connections between switches and servers. In fact, ToR is often positioned as a replacement for and reduction of structured cabling. However, structured cabling offers several benefits, including improved manageability and scalability, and overall reduced TCO. These factors should be considered when evaluating ToR and structured cabling configurations in today's fat-tree switch fabric environments.

Manageability Considerations

With structured cabling where connections between active equipment are made at patch panels that mirror the equipment ports, all moves, adds and changes (MACs) are accomplished at the patching area. Any equipment port can be connected to any other equipment port by simply repositioning patch cord connections, creating an “any-to-all” configuration.

Because ToR switches connect directly to the servers in the same cabinet, all changes must be made within each individual cabinet rather than at a convenient patching area. Depending on the size of the data center, making changes in each cabinet can become complicated and time consuming. Imagine having to make changes in hundreds of server cabinets versus being able to make all your changes at the patching area in each EoR location. Figure 4 provides a visual representation of the difference between structured cabling and ToR.

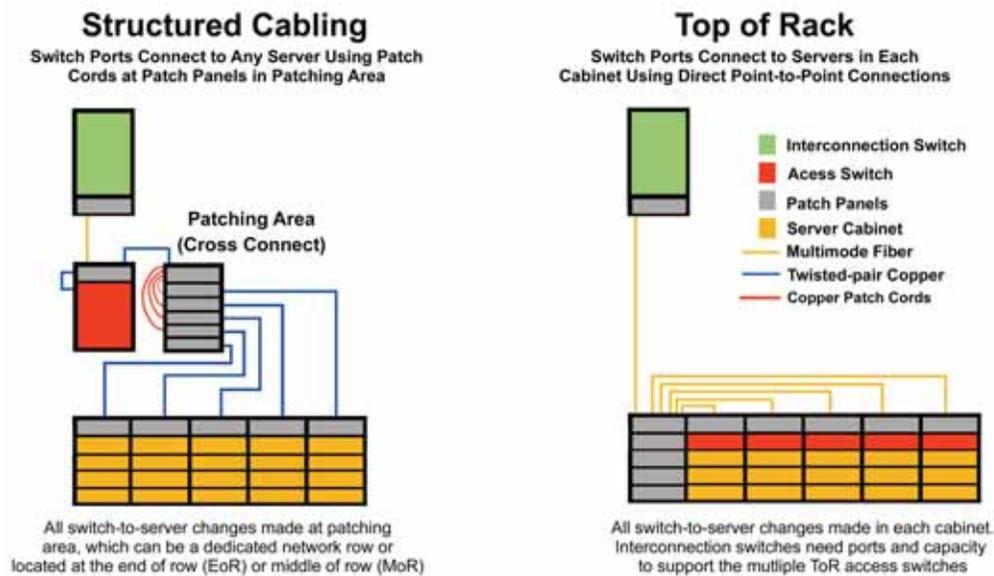


Figure 4 Structured Cabling vs. ToR Topology. ToR eliminates the convenient patching area for making changes.

With structured cabling, the patch panels that mirror active equipment ports connect to the corresponding panels in patching areas using permanent, or fixed, links. With all MACs made at the patching area, the permanent portion of the channel remains unchanged, which allows the active equipment to be left untouched and secure. As shown in Figure 4, the patching area can reside in a completely separate cabinet so there is no need to access the switch cabinet. This scenario can be ideal for when switches and servers need to be managed by separate resources or departments.

ToR configurations do not allow for physically segregating switches and servers into separate cabinets, and MACs require touching critical switch ports. The ToR configuration can be ideal when there is a need to manage a group of servers and their corresponding switch by application.

Another manageability consideration is the ability for servers across multiple cabinets to “talk” to each other. While ToR enables fast server-to-server connections within a rack, communication from one cabinet to another requires switch-to-switch transmission. One advantage of the EoR approach is that any two servers in a row, rather than in a cabinet, can experience low-latency communication because they are connected to the same switch.

Cabling distance limitations can also impact manageability. For ToR configurations, ANSI/TIA-942-A-1 specifies that the point-to-point cabling should be no greater than 10 m (33 ft). Moreover, the SFP+ twinaxial cable assemblies often used with ToR switches limit the distance between the switches and the servers to a length of 7 meters in passive mode. The cabling channel lengths with structured cabling can be up to 100 meters, which allows for more flexible equipment placement throughout the life of the data center.

Cooling Considerations

ToR configurations can also land-lock equipment placement due to the short cabling lengths of SFP+ cable assemblies and data center policies that do not allow patching from cabinet to cabinet. This can prevent placing equipment where it makes the most sense for power and cooling within a row or set of rows.

For example, if the networking budget does not allow for outfitting another cabinet with a ToR switch to accommodate new servers, placement of the new servers may be limited to where network ports are available. This can lead to hot spots, which can adversely impact neighboring equipment within the same cooling zone and, in some cases, require supplemental cooling. Structured cabling configurations avoid these problems.

A ToR switch can technically be placed in the middle or bottom of a cabinet, but they are most often placed at the top for easier accessibility and manageability. According to the Uptime Institute, the failure rate for equipment placed in the top third of the cabinet is three times greater than that of equipment located in the lower two thirds. In a structured cabling configuration, the passive patch panels are generally placed in the upper position, leaving the cooler space for the equipment.

Scalability Considerations

ToR configurations allow for cabinet-at-time scalability, which can be a preference for some data centers, depending on the budget and business model in place. Once several cabinets are deployed, a widespread switch upgrade in a ToR configuration obviously will impact many more switches than with structured cabling. An upgrade to a single ToR switch also improves connection speed to only the servers in that cabinet. With an EoR structured cabling configuration, a single switch upgrade can increase connection speeds to multiple servers across several cabinets in a row.

Application and cabling for the switch-to-server connections is also a consideration when it comes to scalability. For EoR configurations with structured cabling, standards-based category 6A twisted-pair cabling is typically the cable media of choice. Category 6A supports 10GBASE-T up to 100 m (328 ft) distances. The 10GBASE-T standard includes a short reach (i.e., low power) mode that requires category 6A and higher performing cabling up to 30 m (98 ft). Recent advancements in technology have also enabled 10GBASE-T switches to rapidly drop in price and power consumption, putting them on par with ToR switches.

For direct switch-to-server connections in a ToR configuration, many data center managers choose SFP+ twinaxial cable assemblies rather than category 6A modular patch cords. While these assemblies support low power and low latency, which can be ideal for supercomputing environments with high port counts, there are some disadvantages to consider.

Standards-based category 6A cabling supports autonegotiation, but SFP+ cable assemblies do not. Autonegotiation is the ability for a switch to automatically and seamlessly switch between different speeds on individual ports depending on the connected equipment, enabling partial switch or server upgrades on an as-needed basis. Without autonegotiation, a switch upgrade requires all the servers connected to that switch to also be upgraded, incurring full upgrade costs all at once.

For decades, data center managers have valued standards-based interoperability to leverage their existing cabling investment during upgrades regardless of which vendors' equipment is selected. Unlike category 6A cabling that works with all BASE-T switches, regardless of speed or vendor, higher cost proprietary SFP+ cable assemblies may be required by some equipment vendors for use with their ToR switches. While these requirements help ensure that vendor-approved cable assemblies are used with corresponding electronics, proprietary cabling assemblies are not interoperable and can require cable upgrades to happen simultaneously with equipment upgrades. In other words, the SFP+ assemblies will likely need to be swapped out if another vendor's switch is deployed.

Some ToR switches are even designed to check vendor security IDs on the cables connected to each port and either display errors or prevent ports from functioning when connected to an unsupported vendor ID. SFP+ cable assemblies are also typically more expensive than category 6A patch cords, causing additional expense during upgrades. In addition, many of the proprietary cable assemblies required by switch vendors come with an average 90-day warranty. Depending on the cable vendor, category 6A structured cabling typically carries a 15 to 25 year warranty.

Equipment, Maintenance and Energy Costs

In a ToR configuration with one switch in each cabinet, the total number of switch ports depends on the total number of cabinets, rather than on the actual number of switch ports needed to support the servers. For example, if you have 144 server cabinets, you will need 144 ToR switches (or 288 if using dual primary and secondary networks for redundancy). ToR configurations can therefore significantly increase the amount of switches required, compared to the use of structured cabling configurations that use patch panels to connect access switches to servers in multiple cabinets.

Having more switches also equates to increased annual maintenance fees and energy costs, which impacts TCO. This is especially a concern as power consumption is one of the top concerns among today's data center managers. As data centers consume more energy and energy costs continue to rise, green initiatives are taking center stage. Reducing the number of switches helps reduce energy costs while contributing to green initiatives like LEED, BREEAM or STEP.

Based on a low-density 144-cabinet data center using a fat-tree architecture, Table 1 compares the cost for installation, maintenance and annual power consumption for a ToR configuration using SFP+ cable assemblies to an EoR configuration using category 6A 10GBASE-T structured cabling. The ToR configuration ultimately costs 30% more than using an EoR configuration.

The example assumes an average 5 to 6kW of power per cabinet, which supports ~14 servers per cabinet. It also assumes primary and secondary switches for redundancy. Installation costs include all switches, uplinks, fiber line cards, fiber backbone cabling and copper switch-to-server cabling. Annual maintenance costs are based on an average 15% of active equipment costs. Annual power costs are based on the maximum power rating of each switch for 24x7 operation. The example excludes the cost of software, servers, cabinets and pathways.

Low-Density, 144 Server Cabinets, 14 Servers Per Cabinet		
Material, Power & Maintenance	ToR (SFP+)	EoR (10GBASE-T)
Material Cost	\$11,786,200	\$8,638,300
Annual Maintenance Cost	\$1,655,200	\$1,283,100
Annual Energy Cost	\$101,400	\$44,400
Total Cabling Cost (Included in Material Cost)	\$1,222,300	\$70,300
TOTAL COST OF OWNERSHIP	\$13,542,800	\$9,965,800

Table 1: Low Density ToR SFP+ vs. EoR Structured Cabling Cost Comparison (based on MSRP at time of print) for an actual 144-cabinet data center.

High-Density, 144 Server Cabinets, 40 Servers Per Cabinet		
Material, Power & Maintenance	ToR (SFP+)	EoR (10GBASE-T)
Material Cost	\$26,394,000	\$21,596,100
Annual Maintenance Cost	\$3,371,900	\$2,737,900
Annual Energy Cost	\$177,600	\$106,700
Total Cabling Cost (Included in Material Cost)	\$5,123,900	\$2,078,200
TOTAL COST OF OWNERSHIP	\$13,542,800	\$24,440,700

Table 2: High Density ToR SFP+ vs. EoR Structured Cabling Cost Comparison (based on MSRP at time of print) for an actual 144-cabinet data center.

Table 2 compares a ToR configuration to an EoR configuration with the same assumptions but in a high-density environment that assumes an average of 15 to 20 kW of power per cabinet to support 40 servers per cabinet. In this scenario, the total cost of ownership for ToR is still 20% more than that of using an EoR configuration.

Figures 5 and 6 show the graphical representation of the ToR and EoR configurations used in the above cost examples.



Figure 5: 144-Cabinet EoR Configuration



Figure 6: 144-Cabinet ToR Configuration

Switch Port Utilization

Low utilization of switch ports also equates to higher total cost of ownership. In a low-density environment of 5 to 6 kW that can accommodate just 14 servers in a cabinet, server switch port demand will be lower than the 32 switch ports available on a ToR switch. As shown in Table 3, the same 144-cabinet example used in Table 1 equates to 5,184 unused ports with ToR versus just 576 unused ports with EoR. That equates to more than 162 unnecessary switch purchases and related maintenance and power. Using an EoR configuration with structured cabling allows virtually all active switch ports to be fully utilized because they are not confined to single cabinets. Via the patching area, the switch ports can be divided up, on demand, to any of the server ports across several cabinets in a row.

Low-Density, 144 Server Cabinets, 14 Servers Per Cabinet	ToR (SFP+)	EoR (10GBASE-T)
TOTAL UNUSED PORTS	5,184	576

Table 3: Low-density switch port utilization for ToR vs. EoR Structured Cabling for a 144-cabinet data center (assumes average 5 to 6kW per cabinet, dual network, 14 servers per cabinet).

Even when enough power and cooling can be supplied to a cabinet to support a full complement of servers, the number of unused ports can remain significantly higher with ToR than with EoR and structured cabling. As shown in Table 4, the same high-density 144-cabinet example used in Table 2 with 40 servers per cabinet equates to 6,912 unused ports with ToR versus just 224 unused ports with EoR. The reason for this is that two 32-port ToR switches are required in each cabinet to support the 40 servers, or four for a dual network using primary and secondary switches. That equates to 24 unused ports per cabinet, or 48 in a dual network. In a 144-cabinet data center, the number of unused ports quickly adds up.

High-Density, 144 Server Cabinets, 40 Servers Per Cabinet	ToR (SFP+)	EoR (10GBASE-T)
TOTAL UNUSED PORTS	6,912	224

Table 4: High-density switch port utilization for ToR vs. EoR Structured Cabling for a 144-cabinet data center (assumes average 15 to 20kW per cabinet, dual network, 40 servers per cabinet).

In reality, the only way to truly improve switch port utilization with ToR is to limit the number of servers to no more than the number of switch ports per cabinet. However, limiting the number of servers to the number of ToR switch ports is not always the most efficient use of power and space. For example, in a high-density environment that supports 40 servers per cabinet, limiting the number of servers per cabinet to 32 (to match the number of switch ports) results in 8 unused rack units per cabinet, or 1,152 unused rack units across the 144-cabinet data center. In addition, once the number of servers surpasses the number of available switch ports, the only option is to add another ToR switch (or two for dual networks). This significantly increases the number of unused ports.

Regardless of the configuration being considered, it's always best to consider port utilization when designing the data center and ensure that either empty rack spaces or unused ports can be effectively managed.

Conclusion

With several configurations available for fat-tree switch fabrics, data center professionals and IT managers need to examine the pros and cons of each based on their specific needs and total cost of ownership (TCO).

There is no single cabling configuration for every data center. A ToR configuration with access switches placed in each rack or cabinet and SFP+ cable assemblies used for switch-to-server connections is ideal for data center environments that demand extremely low-latency server connections and cabinet-level deployment and maintenance.

However, many data center environments can benefit from the manageability, cooling, scalability, lower cost and better port utilization provided by category 6A structured cabling and 10GBASE-T used in End or Row, Middle of Row or centralized configurations.

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TECH BRIEF

SFP+ Cables and Encryption

Cost-Effective Alternatives Overcome Vendor Locking

As 10Gb SFP+ cables and transceivers become more common in today's data centers, the question of vendor lock or encryption can become an issue for data center professionals. This paper addresses the mechanism that is used to implement the encryption, why it is employed and how to overcome it.

I2C INTERFACE

SFP+ cables and transceivers employ a 2-wire serial interface (called I2C) that allows the network equipment to poll a particular port and get information about the cable or transceiver that is plugged into that port.

This interface is also commonly referred to as the Digital Diagnostic Management Interface, Digital Diagnostic Monitoring Interface or DDMI.

The DDMI provides information about the cable or transceiver assembly such as vendor, serial number, part number, and date of manufacture that is stored on a memory chip or microprocessor within the cable assembly.

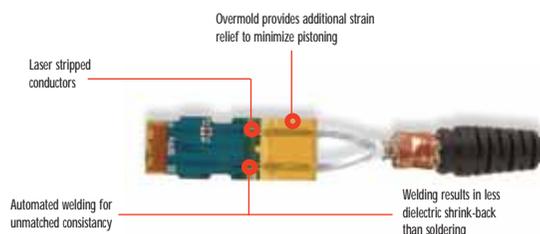
SFP+ passive copper cables contain EEPROMs within the connector back shell that have I2C ports. These cables may also be referred to as DAC or "direct attached copper" cables. An EEPROM is an "Electrically Erasable Programmable Read-Only Memory" chip that is programmed at the factory with specific information about the cable assembly.

SFP+ active copper cables and optical transceivers contain microprocessors within the connector back shell. The microprocessor has memory that is accessible to the network through the 2-wire I2C interface. For active cables and transceivers, the interface allows real time access to device operating parameters and includes alarm and warning flags, which alert the equipment when particular operating parameters are outside of the factory settings.

Typically, these EEPROMs and microprocessors comply with the SFF or Small Form Factor standards, which define the I2C interface protocol and allocate certain information to specific memory locations.



PCB Termination



TECH BRIEF

ENCRYPTION OR VENDOR LOCK

Some vendors incorporate encryption or “vendor lock” into their equipment that will issue a warning message if a non-vendor approved cable assembly is plugged into a port. Theoretically, this ensures that equipment manufacturers won’t have to troubleshoot problems caused by sub-standard cables. In many cases, equipment vendors who use encryption charge more for their own cords because they lock out use of other cords. In reality, encryption is unnecessary as all reputable manufacturers of SFP+ cables and transceivers meet the standards that IEEE and SFF have established for SFP+ and interoperability is never a concern. Most network equipment vendors that employ encryption allow a work around as long as the user acknowledges the warning. For example, the user may have to acknowledge that he understands the warning and he can accept it before moving on.

SIEMON’S SFP+ CABLES

SFP+ passive copper cable assemblies from Siemon Interconnect Solutions (SIS) are a cost-effective and lower-power alternative to optical fiber cables for short reach links in high-speed interconnect applications such as high performance computing (HPC), enterprise networking, and network storage markets.

Siemon’s SFP+ connectors feature robust die cast housings and cable strain reliefs as well as gold plated contacts. They are SFF-8083, SFF-8431 and SFF-8432 compliant, which are the industry standards for this particular connector form factor.

SIEMON’S CISCO COMPATIBLE OFFERING

Siemon has offered industry standard SFP+ cables for several years which have been tested by the UNH Interoperability lab and proven to be compatible with Cisco and equipment from other major vendors. Siemon is now introducing Cisco Compatible SFP+ passive copper cables.

Siemon’s Cisco compatible SFP+ passive copper cables use proprietary encryption within the assembly’s EEPROM to circumvent the warning messages that Cisco equipment may produce when non-Cisco approved cables are plugged in. This allows data center designers to avoid unwarranted concern that may be associated with startups when the users see these warning messages. Siemon’s cables meet the industry standards for SFP+ cables and are offered in the same lengths and wire gauges as Cisco DAC assemblies, but at a significant cost reduction.

Ordering Information:

Cisco Part Number	Siemon Cisco Compatible Part Number	Length (Meters)	Gauge (AWG)
SFP-H10GB-CU1M	SFPH10GBCU1MS	1 (3.3 ft)	30
SFP-H10GB-CU1.5M	SFPH10GBCU1.5MS	1.5 (4.9 ft)	30
SFP-H10GB-CU2M	SFPH10GBCU2MS	2 (6.6 ft)	30
SFP-H10GB-CU2.5M	SFPH10GBCU2.5MS	2.5 (8.2 ft)	30
SFP-H10GB-CU3M	SFPH10GBCU3MS	3 (9.8 ft)	30
SFP-H10GB-CU5M	SFPH10GBCU5MS	5 (16.4 ft)	24

TECH BRIEF

SIEMON'S INDUSTRY STANDARD OFFERING

Siemon has one of the industry's most comprehensive SFP+ direct attached copper cable assembly offerings, with lengths of up to 7 meters. Please visit <http://www.siemon.com/sis/> to learn more.

Ordering Information:

Siemon Industry Standard Part Number	Length (Meters)	Gauge (AWG)
SFPP30-00.5	0.5 (1.6 ft)	30
SFPP30-01	1 (3.3 ft)	30
SFPP30-01.5	1.5 (4.9 ft)	30
SFPP30-02	2 (6.6 ft)	30
SFPP30-02.5	2.5 (8.2 ft)	30
SFPP30-03	3 (9.8 ft)	30
SFPP28-05	5 (16.4)	28
SFPP24-07	7 (23.0)	24

STANDARDS

SFF-8431, "Enhanced Small Form Factor Pluggable Module SFP+", Chapter 4, "SFP+ 2 Wire Interface"
 SFF-8472, "Digital Diagnostic Management Interface for Optical Transceivers"
 SFF-8636, "Common Management Interface"
 "InfiniBand™ Architecture Specification Volume 2, Release 1.3, PHYSICAL SPECIFICATIONS"

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Getting Smart, Getting Rugged Extending LANs into Harsher Environments

Virtually everything we do now on a daily basis touches the network—whether it's buying a snack, sending an email or taking a ride at an amusement park. The proliferation of digital information, wireless handheld devices and Ethernet into every facet of our lives means that connections to networks need to be in more places than ever before.

With manufacturing environments having rapidly migrated to Industrial Ethernet over the past decade as a means to deliver information for industrial automation and control systems and to integrate factory environments with the corporate LAN, it's no wonder that the industry is seeing a growing demand for network cables, patch cords and connectors capable of withstanding more severe conditions.

But what about environments that fall somewhere in between—not quite severe enough to be considered “industrial” but in need of something more ruggedized than what exists in everyday commercial office environments? Extending the network into these types of environments is becoming more common than one might think. As our world becomes more digital, these types of environments are popping up everywhere and demanding ruggedized network cables, patch cords and connectors that maintain long-term network reliability and prevent the need to replace components due to corrosion and damage from a variety of elements.

Knowing the Standards – From MICE to NEMA

While standards for industrial environments are certainly applicable to factory floors, manufacturing plants and processing facilities, the same standards can be used to determine the type of ruggedized cable and connectivity required for those in-between environments that are not as clearly identified as either commercial or industrial.

The international standard ISO/IEC 24702 provides application-independent requirements for both balanced copper and fiber optic cable systems that support Ethernet-based data communications in industrial environments. The standard provides implementation options and requirements for cable and connectivity that reflect the operating environments within industrial premises. ISO/IEC 24702, along with its comparable U.S. TIA-1005 and European EN 50173-3 standards, incorporate the MICE method of classifying parameters for the materials needed to build an industrial network.

MICE stands for Mechanical, Ingress, Climatic and Electromagnetic and includes three levels of environmental harshness—level 1 for everyday commercial office environments, level 2 for light industrial and level 3 for industrial. For example, M3I3C3E3 environments require network infrastructure components that are able to withstand the highest levels of vibration, shock, tensile force, impact and bending (see Table 1).

INCREASING SEVERITY 			
Mechanical (shock, vibration, crush, impact)	M ₁	M ₂	M ₃
Ingress (particulates and liquid)	I ₁	I ₂	I ₃
Climatic (temperature, humidity, contaminants, radiation)	C ₁	C ₂	C ₃
Electromagnetic (ESD, RFI, transients, magnetic fields)	E ₁	E ₂	E ₃

Table 1: MICE Parameters

While the MICE method is used to determine the harshness level of commercial, light industrial and industrial, rarely is an environment exclusive to one MICE classification. Furthermore, one run of cabling from point A to point B can traverse through various MICE classifications along the route. Designers planning cabling systems in harsh environments therefore need to have a good understanding of the environment and what constitutes levels 1, 2 and 3 for each parameter. In some cases, measuring the environment can require specialized equipment, especially when it comes to measuring vibration and electromagnetic interference. The standards include MICE tables to help determine which levels exist within the targeted environment (see Table 2).

The trick to using MICE levels to determine components is to always consider the worst case scenario and worst case level parameter, regardless of the other parameters. For example, an environment exposed to liquid may be classified as M1I3C1E1. If only ruggedized components meeting M3I3C3E3 are available, they may need to be used regardless of whether that level of protection is required for all parameters.

Mechanical	M ₁	M ₂	M ₃
Shock			
Peak acceleration	40 ms ⁻²	100 ms ⁻²	250 ms ⁻²
Vibration			
Displacement amplitude (2-9Hz)	1.5 mm	7.0 mm	15,0 mm
Acceleration amplitude (9 -5000Hz)	5 ms ⁻²	20 ms ⁻²	50 ms ⁻²
Tensile Force			
Installation specific			
Crush	45 N	1100 N	2200 N
Impact	1 J	10 J	30 J
Bending, Flexing and Torsion			
Installation specific			
Ingress	I ₁	I ₂	I ₃
Particulate maximum diameter	12.5 microns	50 microns	50 microns
Immersion	None	Intermittent jet ≤12.5 l/min ≥6.3 mm jet >2.5 m distance	Intermittent jet ≤12.5 l/min ≥6.3 mm jet >2.5 m distance Immersion ≤ 1 for ≤30 min
Climatic Chemicals	C ₁	C ₂	C ₃
Ambient temperature	-10 °C to 60 °C	-25 °C to 70 °C	-40 °C to 70 °C
Rate of temperature change	.1 °C per minute	1.0 °C per minute	3.0 °C per minute
Humidity	5% to 85% (non-condensing)	5% to 95% (condensing)	5% to 95% (condensing)
Solar radiation	700 Wm ⁻²	1120 Wm ⁻²	1120 Wm ⁻²
Liquid Pollutants			
Sodium chloride (sea water)	0 ppm	<0.3 ppm	<0.3 ppm
Oil (dry-air concentration)	0 ppm	5.0 ppm	<500 ppm
Sodium Stearate (soap)	None	5% aqueous non-gelling	>5% aqueous gelling
Detergent	None	ffs	ffs
Conductive materials in solution	None	Temporary	Present
Gaseous Pollution Contaminants			
	Mean/Peak (concentration X 10 ⁻⁶)	Mean/Peak (concentration X 10 ⁻⁶)	Mean/Peak (concentration X 10 ⁻⁶)
Hydrogen sulphide	<0.003/<0.01	<0.05/<0.5	<10/<50
Sulphur dioxide	<0.01/<0.03	<0.1/<0.3	<5/<15
Sulphur trioxide (ffs)	<0.01/<0.03	<0.1/<0.3	<5/<15
Chlorine wet (>50% humidity)	<0.0005/<0.001	<0.005/<0.03	<0.0051/<0.03
Chlorine dry (>50% humidity)	<0.002/<0.01	<0.02/<0.1	<0.2/<1.0
Hydrogen chloride	-/0.06	<0.06/<0.3	<0.06/<0.3
Hydrogen Fluoride	<0.001/<0.005	<0.01/<0.05	<0.1/<1.0
Ammonia	<1/<5	<10/<50	<50/<250
Oxides of Nitrogen	<0.05/<0.1	<0.5/<1	<5/<10
Ozone	<0.002/<0.005	<0.025/<0.05	<0.1/<1
Electromagnetic	E ₁	E ₂	E ₃
Electrostatic discharge – contact (.667 μC)	4 kV		
Electrostatic discharge – Air (.132 μC)	8kV		
Radiated RF – AM	3 V/m @ 80-1000 MHz 3 V/m # 1400-2000 MHz 1 V/m@2000-2700 MHz		
Conducted RF	3 V @150 KHz-80 MHz		10 V@150 kHz-80 MHz
EFT/B	500 V		1000 V
Surge (transient ground potential difference)	500 V		1000 V
Magnetic Field (50/60 Hz)	1 AM ⁻¹	3 AM ⁻¹	30 AM ⁻¹
Magnetic Field 60-200000 Hz	ffs		

Table 2: MICE Classifications

Another standards-based rating to consider for harsh environments is the ingress protection (IP) ratings developed by the European Committee for Electro Technical Standardization (CENELEC). Sometimes referred to as an IP code, the IP rating consists of the letters IP followed by two digits—the first digit classifying protection against solids (i.e., dust) and the second classifying protection against liquids (i.e., water). For example, as shown in Table 3, an IP rating of IP22 would indicate protection against finger-size objects and vertically dripping water.

Table 3: IP Code Ratings

Protection Against Solids		
0	No special protection	
1	>50 mm	Protected against objects greater than 50 mm (e.g., accidental touch by surface of human hands)
2	>12.5 mm	Protected against solid objects greater than 12 mm (i.e., human finger size)
3	>2.5 mm	Protected against solid objects greater than 2.5 mm (e.g., tools, thick wires)
4	>1 mm	Protected against solid objects greater than 1 mm (e.g., most wires, screws, paperclips)
5	Dust Protected	Protected against limited dust ingress (e.g., protection against contact but no harmful deposit of dust)
6	Dust Tight	Totally protected against dust
Protection Against Liquids		
0	No special protection	
1	Dripping water	Vertically falling drops have no harmful effect
2	Dripping water with 15-degree tilt	Vertically falling drops have no harmful effect if enclosure tilted up 15 degrees
3	Spraying water	Water falling as spray at any angle up to 60 degrees from the vertical has no harmful effect
4	Splashing water	Water splashing from any direction has no harmful effect
5	Water jetting	Water projected (12.5 mm nozzle) from any direction has no harmful effect
6	Immersion up to 1 m	Immersion in water under defined conditions of pressure and time (up to 1 m) has no harmful effect
7	Immersion above 1 m	Continuous immersion as specified by manufacturer has no harmful effect. Typically hermetically sealed.



NEMA 4X Enclosures provide protection against dust, water and corrosion in rugged environments.

One of the common IP ratings seen for ruggedized connectivity in our industry is IP66/IP67, which offers total protection against dust ingress and water ingress. While the IP rating is especially useful for determining the level of protection needed when dealing with wet, dusty environments, it's important to remember the remaining MICE parameters such as ability to withstand higher temperature and humidity ranges or to maintain performance amidst higher levels of electrostatic discharge (ESD) or radio frequency interference (RFI).

NEMA Rating	NEMA Definition	IP Equivalent
1	Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection against falling dirt	IP10
3R	Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, and snow; and that will be undamaged by external formation of ice on the enclosure	IP14
4	Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water; and that will be undamaged by the external formation of ice on the enclosure	IP66
4X	All of the same capabilities of NEMA 4 but with the added benefit of resistance to corrosion	IP66
12	Enclosures constructed (without knockouts) for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against circulating dust, lint, fibers, and flying; and against dripping and light splashing of liquids	IP52

Table 4: NEMA Enclosure Ratings and IP Equivalents

There is yet another standard to consider related to enclosures, which can include cabinets, surface mount boxes, floor and ceiling boxes, junction boxes and even network equipment housing. The National Electric Manufacturer Association (NEMA) uses a standard rating system for enclosures that defines the types of environments where they can be used. NEMA ratings for enclosures also have IP code equivalents, as shown in Table 4 that highlights the most common NEMA enclosures.

Identifying the Key Components – From Cables to Connectors

When it comes to selecting ruggedized cable and connectivity, both copper and fiber solutions may need to be considered—especially as more fiber is extending out of the commercial data center and telecommunications room environment to bring higher bandwidth closer to the work area outlet or to deal with longer distance requirements.

While not all MICE parameters will relate to both copper and fiber, especially with fiber being immune to electromagnetic interference, the IP66/IP67 rating on connectivity can easily apply to both as can other mechanical, climatic and chemical parameters. In general, ruggedized cable and connectivity solutions for harsher environments should feature components and characteristics such as the following:

- **Chemical-resistant thermoplastic housing on connectivity** — Plugs and outlets should use materials that provide the widest range of protection from most solvents and common industrial chemicals.
- **Dust caps for outlets** — Ruggedized dust caps can protect unused outlets and seal outlets during wash downs.
- **IP67-rated copper and fiber connectivity** — Ruggedized outlets and modular patch cords with an IP66/IP67-rated seal protect plugs and outlet contacts from dust and moisture.
- **Shielded twisted-pair cabling for copper** — Shielded copper cabling such as F/UTP cables and S/FTP cables will provide much higher resistance to EMI/RFI.
- **More durable cable jacket materials** — Jacket materials such as polyurethane and thermoplastic elastomers can provide better tensile strength and lower temperature flexibility and brittle points, as well as better tear, abrasion, chemical and moisture resistance.
- **IP44-rated faceplates** — Stainless steel faceplates with rear sealing gaskets provide a protective seal from moisture and debris.
- **NEMA 4X enclosures** — Enclosures and surface mount boxes with a NEMA rating will protect the termination points of ruggedized outlets.



The need for ruggedized connectivity can also relate to fiber outlets in a variety of environments.



Stainless steel faceplates with rear sealing gaskets and dustcaps for unused connections are ideal for protecting critical network connections in harsh environments.

Making the Best Choice – From Home Plates to Seafood Platters

With the proliferation of digital information, handheld devices and Ethernet, consumers and employees everywhere demand network and Internet access at all times and digital applications that make their lives and jobs easier. Consequently, enterprise businesses are required to expand their networks into places that in the past would have gone without network connections and wireless service. With many of the environments that now need access being outside of the realm of standard commercial environments, enterprise businesses are partnering with manufacturers that offer ruggedized cable and connectivity in addition to commercial-grade components.

In a \$150 million upgrade at Dodger Stadium, the 52-year old home of the Los Angeles Dodgers and the third oldest park in Major League Baseball, plenty of enhancements were made to deliver a state-of-the-art experience to fans, including a new high-performance copper and optical fiber cable system to support stadium-wide WiFi, digital displays, IP-based security, box offices, kiosks and point-of-sale locations.



Dodger Stadium



Siemon Ruggedized Z-MAX Category 6A shielded IP66/IP67-rated outlets and cords were deployed at Dodger Stadium's outdoor concession stands and kiosks

As part of the upgrade, two new plazas were added at the left field and right field stadium entrances. While concession stands are located throughout the stadium, the new Bullpen Overlook Bars, the Think Blue Bar-B-Que and Tommy Lasorda's Italian Trattoria concession stands in the new plazas have drawn the most pre- and post-game attention.

During the design stages of the network, Ralph Esquibel, the Dodgers' vice president of IT, worked with Siemon to determine which products would best ensure reliability for LAN connectivity at the outside food and beverage locations. Due to the potential for harmful environmental factors that could adversely impact commercial-grade components, Siemon Ruggedized Z-MAX category 6A shielded IP66/IP67-rated outlets and modular cords were selected for use at these locations.

The Ruggedized Z-MAX connectors offer total protection against dust ingress and short-term protection against water ingress, as well as the ability to withstand higher temperature and humidity ranges. They feature a durable, chemical resistant, industrial-grade thermoplastic and patented bayonet style quarter-turn mating design for superior protection. Siemon shielded F/UTP cabling was also selected to provide the performance and noise immunity required throughout the stadium.

"We don't know when we'll be able to make this type of investment again," says Esquibel. "We have a lot of technology here, and we need to make sure we are protecting it."

Trident Seafoods

The largest seafood company in the U.S., Seattle-based Trident Seafoods is a vertically integrated seafood company of fishing vessels and processing plants that produce fresh, frozen, canned, smoked and ready-to-eat seafood products under a variety of brand names, including Trident, Louis Kemp and Rubenstein's. When the company wanted to extend network access throughout its three factory trawlers, they turned to Siemon's ruggedized connectivity.

Starting with the 276-foot Kodiak Enterprise, Trident sought to upgrade the entire on-board network to not only improve existing wheel house communications, but also to provide whole-ship Wi-Fi for the more than 125-person crew that lives on the ship for extended periods of time during peak fishing season. During the short month of dry-dock time, Cabling & Technology Services (CTS), a full service integrator of network infrastructure systems, removed and replaced the ship's entire cabling infrastructure.

"It's very challenging to deploy cabling on a ship due to tight spaces, corrosive sea water and other environmental elements," says James Gannon, service project manager for CTS. "We needed to deploy connections throughout for Wi-Fi access and to connect to computerized packaging systems in the fish processing area, which is often wet from floor to ceiling and undergoes wash downs as part of the company's sanitation process."

Throughout the ship, Siemon Ruggedized MAX IP66/IP67-rated category 6 outlets and modular cords were once again



Trident Seafoods' 276-foot Kodiak Enterprise is just one of the company's trawlers that uses Siemon Ruggedized MAX IP66/IP67-rated outlets.

deployed to offer protection against water ingress, as well as the ability to withstand the corrosive nature of sea water that can typically cause non-ruggedized components to fail.

"Trident wanted something that could handle the wet, and Siemon had the product," says Gannon. "While I've used Siemon products for many projects in the past, I had not used their ruggedized connectivity before. We're also using it in the two other factory trawlers—the Island Enterprise and the Seattle Enterprise—both of which will be completed this year."

Choosing the Right Partner – From Experience to Breadth of Product

With an increase in the number of harsh environments that are an extension of the corporate LAN, designers and installers who are experienced in commercial environments may not necessarily understand industrial standards, how to use MICE parameters or which product features to look for. Furthermore, standards-based methods and parameters for determining the level of harshness and the components required are not always cut and dry.

While industry standards can be used for determining components based on environment, they often refer to in-between environments as "light industrial." This term can be confusing when the environment is clearly not one that is industrial but is simply an extension of the commercial LAN into a harsher environment. Consequently, "industrial" standards are not always followed during the planning stages of these environments, often resulting in the use of inadequate components and network failures.

Experience goes a long way in designing for these environments. For example, designers experienced with deploying networks in industrial and harsh environments will likely know that induction heating within about 10 feet of a component can require an E3 classification while fluorescent lighting located a few feet away will have little impact and require only an E1 classification.

Another consideration when selecting ruggedized cable and connectivity is a breadth of copper and fiber types in a variety of performance levels. Most manufacturers of industrial/ruggedized components provide category 6 at best for copper, with many offering only category 5e. Furthermore, few offer the latest fiber cable and connectivity in ruggedized versions. This could very well be due to the fact that many industrial systems don't require the higher bandwidth associated with category 6A and fiber. However, as more LANs extend into harsher environments, designers are looking to maintain the same performance level as the rest of the corporate LAN. Selecting a manufacturer with ruggedized copper and fiber cable connectivity available in the same copper and fiber performance as the rest of the LAN will prevent connections in more demanding environments from having to compromise on bandwidth and performance.

Commercial designers with limited experience in planning for cable and connectivity that extends into harsh environments would be wise to work closely with cable and connectivity manufacturers who understand the standards and specifications, offer the latest copper and fiber ruggedized components and have experience in determining the type of cable and connectivity required based on a variety of environmental factors.

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LA Dodgers Hit Home Run in Major League Upgrade

While the rest of us were busy watching football, hockey and basketball, something big was happening at Dodger Stadium. The 52-year old home of the Los Angeles Dodgers and the third oldest park in Major League Baseball has spent the past two off-seasons undergoing more than \$150 million of stadium upgrades.

Many of the enhancements were obvious to fans on opening day of the LA Dodgers' 2014 season in early April, including expanded entries, new seating and lounges, additional food services, new retail stores, memorabilia displays, improved access, beautified landscaping and a fenced walkway for navigating the stadium's entire circumference.

Many of the enhancements were obvious to fans on opening day of the LA Dodgers' 2014 season in early April, including expanded entries, new seating and lounges, additional food services, new retail stores, memorabilia displays, improved access, beautified landscaping and a fenced walkway for navigating the stadium's entire circumference.

Plenty of new technology was also a key component of the upgrade and one that was carefully considered to enhance the experience of longtime fans. Not only will fans have access to state-of-the-art wireless throughout the stadium, but season and mini-plan ticket holders will enjoy the new Dodgers Pride Rewards program that allows them to use their smartphones to gain entrance at all gates, make purchases, order food and beverages, and check earned rewards. In turn, the program will allow the stadium to keep tabs on fan preferences and provide a more tailored game experience. Enhanced technology will be improving performance of the players on the field by supporting data analytics and video replays from the past eight years of plays.

What won't be obvious to the fans and players is the high-performance copper and optical fiber cable systems installed throughout the stadium that make all of this exciting technology possible.

Forming a Dedicated Team



Ralph Esquibel, the Dodgers' vice president of IT.

One of the first upgrades at Dodger Stadium that was a critical foundation for all other enhancements was the electrical service. "We had electrical systems in place that were 40 and 20 years old, and these systems typically have a life expectancy of 15 to 20 years," said Ralph Esquibel, the Dodgers' vice president of IT.

"Those systems were at the end of their life and we couldn't do much of anything innovative like implement larger video boards or other technologies that needed more power."

During the first phase of the expansion during the 2013 off-season, the stadium deployed new equipment and substations in coordination with the Los Angeles Department of Water and Power. With an updated electrical infrastructure in place, the Dodgers' IT department was able to turn their focus to the network cabling infrastructure.

During the design stages of the network, Esquibel conducted some research and encountered expertise and products from Siemon (www.siemon.com). After reaching out to Siemon for more information, a new dedicated team was formed.

"When I started meeting the people at Siemon, I realized that they were smart people who knew what they were talking about. Valerie Maguire, Siemon's director of standards and technology, came and met with us several times and made quite an impression on me," said Esquibel. "Since the beginning, Siemon has been invested in the LA Dodgers and our success. While we may have a big name, we are actually a small company with only about 300 employees. That's why I look for true partnerships in my vendors and require that they act almost as extensions of my team. We looked at other companies, but it was Siemon that gave us that level of comfort."

Ed Havlik, Siemon's Sales Manager for the project, assembled a team of technical and product resources who were ready to lend expert support when needed. For example, when discussions arose related to the pros and cons of various wireless technologies, Havlik made sure that Esquibel and Maguire connected.

"It was clear from our first meeting that Ralph had a vision of providing guests at Dodger Stadium with the highest level of electronic technology," said Maguire. "Ralph wanted to hear our thoughts on the entire gamut of IT technologies—from which products would best support fans at outside kiosks and entry points, to ensuring congestion-free support of IEEE 802.11ac wireless and which media would be most mechanically and electrically suited to support Type 2 PoE. He even sought our recommendation on how to best save space in the data center."

Building a Reliable Backbone

Once the decision was made to deploy Siemon cabling systems for the upgrade, the project went out for bid. Due to the sheer size of the installation, several entities were involved in the installation, which included upgraded core switches in two main equipment rooms, new telecommunications rooms (TRs) and faster transmission speed via plenty of Siemon fiber and copper cabling.

“With all of the technology we wanted to add, we knew we had to introduce a 10 gigabit per second edge network and deploy new core switches, firewalls and redundancy,” said Esquibel. “In 1963 when the Dodgers first started playing here, there were no telecommunications rooms. As part of the upgrade, we built out 18 proper rooms that tie back to the two updated cores via 24 strands of singlemode optical fiber.”

According to Esquibel, the LA Dodgers also have a redundant data center at their spring training center in Arizona that is capable of running 90% of the stadium business in the event of downtime, which is something Esquibel doesn't foresee. “We have the redundancy and reliability in place that I don't foresee our network ever going down completely and having to rely on backup from Arizona,” he says.

In each of the main equipment rooms, switches and networking equipment are housed in Siemon's VersaPOD cabinets that feature Zero-U cable management and vertical patching capabilities to support high density while saving space and providing excellent thermal efficiency through improved airflow in and around the equipment. Within the VersaPOD cabinets, Siemon's intelligent power distribution units (PDUs) provide even more energy savings while reliably delivering power to the critical IT equipment. The PDUs can provide real-time power information and connect to environmental sensors for troubleshooting and optimizing energy efficiency.

Within the main equipment rooms and TRs, the singlemode fiber is terminated at Siemon's Quick-Pack adapter plates and housed in RIC3 enclosures that provide superior protection of the fiber and enhanced accessibility with front and rear door locks and a fully removable fiber management tray. Depending on size and configuration, a combination of Siemon's VersaPOD cabinets, V600 cabinets and four-post racks were deployed in the TRs to support active equipment and passive connectivity.



Siemon's VersaPOD cabinets provide space savings and thermal efficiency in the main equipment rooms.

Meeting the Latest Expectations

From each of the telecommunications rooms, Siemon's Z-MAX category 6A shielded (F/UTP) end-to-end cabling system support a wide range of devices throughout the stadium to bring technology to the fans and the field. The category 6A F/UTP cable is terminated on Z-MAX patch panels in each of the TRs and at Z-MAX 6A outlets for voice and data access in offices, wireless access points (WAPs) throughout the stadium, point of sale (POS) locations, box offices, kiosks, scanners and at several locations for eventually connecting digital displays, IPTVs and IP-based surveillance cameras.

While Dodger Stadium hasn't yet switched over video displays and cameras to IP-based systems using the Siemon cabling, Esquibel knew it made sense to install cabling to all of these locations while the walls were open. The stadium was however able to roll out digital scanning locations for the Dodger Pride Rewards program and the largest Wi-Fi network ever in Major League Baseball.

“Wireless is now like a utility. People show up at a venue to enjoy themselves and expect Wi-Fi access in the same way they expect to be able to turn on the water in a bathroom,” says Esquibel. “We have successfully architected our Wi-Fi infrastructure to support 50 percent of our 56,000 fans at any given moment.”

Unlike traditional overhead placement of WAPs, Dodger Stadium used a heterogeneous approach and placed the approximate 1,000 WAPs in unique locations that provide much better coverage. “If you only place the access points overhead, people in the prime front-row seating end up with poor service,” explains Esquibel. “To provide the best coverage, we're using a combination of overhead and underseat placement. We even have some access points placed within hand rails.”

Protecting the Investment

Siemon's Z-MAX 6A shielded solution that supports all the WAPs and other technology throughout the stadium represents the cutting edge of category 6A cabling. The Z-MAX 6A shielded system provides the highest margins on all TIA and ISO performance requirements for category 6A/class EA, including critical alien crosstalk parameters. Dodger Stadium also deployed Siemon's Ruggedized Z-MAX IP67-rated outlets in harsher areas such as concession stands and kiosks to protect against dust and water ingress.

"This has been a huge undertaking, and I don't know when we'll be able to make this type of investment again. We decided to go with shielded cabling to protect the harmonics of the cable and provide better performance for future technologies," says Esquibel. "For example, when next generation 802.11ac wireless devices hit the market we can easily swap out access points because we have the cabling in place to support the bandwidth and power over Ethernet requirements."

Due to the stringent timeline and the need to finalize the cabling infrastructure in time for opening day of the 2014 season, superior logistics and just-in-time delivery were also vital to the project's success. Siemon partnered with Accu-Tech Los Angeles to ensure proper warehousing and staging of the cabling components in conjunction with the installation schedule.

"This was a huge project with many reels of cable. We had to work behind the scenes to make sure we could consistently stage and release product as it was needed. Our dedicated driver was familiar with the stadium and knew where and when to deliver the material," says John Ittu, branch manager for Accu-Tech Los Angeles. "It was a great experience and exciting for us to be a part of something like this and actually go into that stadium and see where all of the cabling we supplied was being installed."



The Dodgers IT team, including Esquibel (3rd from left), Hisayo....

Winning On and Off the Field

After their 92-win campaign and trip to the National League Championship Series in 2013, the LA Dodgers embarked on the 2014 season with their upgraded stadium and new high-performance cabling infrastructure that will satisfy the technology demands of the fans and hopefully improve their own performance on the field.

"We're not done implementing technology, but we'll get there because we have a great IT team that is dedicated to this baseball team and the organization. Throughout this technology upgrade, we've always asked ourselves how we are going to give our fans a better experience. The ability for our fans to interact with the team through the Dodger Pride Rewards program is the direction that any consumer-facing industry should be moving in," says Esquibel. "Not only will we be able to tailor their game experience with exclusive offers, but fans appreciate the convenience of being able to order food right from their smartphones and avoid lines."

According to Esquibel, the technology upgrade at Dodger Stadium will also deliver a better game and help better prepare the players. "We have eight years of video on every player and every play that has ever transpired here. If we have a matchup of a specific player and a pitcher, the players can view past videos and review how they performed in the past," says Esquibel. "With our new cabling infrastructure, the players will have the ability to quickly and easily access the videos we need—they won't accept lag time."

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