Conflicts in Data Center Fiber Structured Cabling Standards

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Various telecommunications and data center (DC)-specific standards are commonly applied or referenced in requests for proposal (RFP) or planning documents. This white paper will discuss the latest trends in Layer One Fibre Channel and Ethernet communications equipment and how to design a flexible, standards-compliant infrastructure that is adaptable to these trends.

It will also cover the impact of documents such as ANSI/TIA-568.3-D, ANSI/TIA-942-B, BICSI 002 and others for infrastructure, as well as various IEEE documents for protocols. Using internationally recognized standards is an effective and rational course of action when designing data center cabling topologies as it is in the industry's best interest to flatten DC designs to a common denominator. Standardized DC designs ensure a continued path for growth and provide maximum system choice, optimal flexibility and simplified staff training. Therefore, it is imperative that design specifications and standards keep pace with technology and other industry drivers.

Recent technology advances such as virtualization, cloud computing, and movements toward mainframe-type and super-computing systems seriously tax current IT physical infrastructures and are driving copper cabling largely out of the DC. The cabling standards we have today leave gaps in physical infrastructure planning, specifically in using fiber optics to address the ever-growing need for bandwidth to support these new technologies.

Conflicts in Today's Standards

The existing crop of standards commonly referenced in RFP documents have both minor and sometimes serious conflicts that leave designs and designers in jeopardy. Application of these standards can put users at risk of poor fiber performance or, worse yet, intermittent downtime if not clarified to match the intended systems and protocols that are to be employed.

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For example, TIA-942-B is the overall DC design standard and includes exceptional design detail for many facets of the building and floor space. One key element is the layout of the communications cabling plant (Figure 1). This drawing lays out the overall cabling plan that should be modeled and scaled to match every DC design. It does not discriminate between copper and fiber cabling. All systems are intended to be assembled similarly.

Figure 1

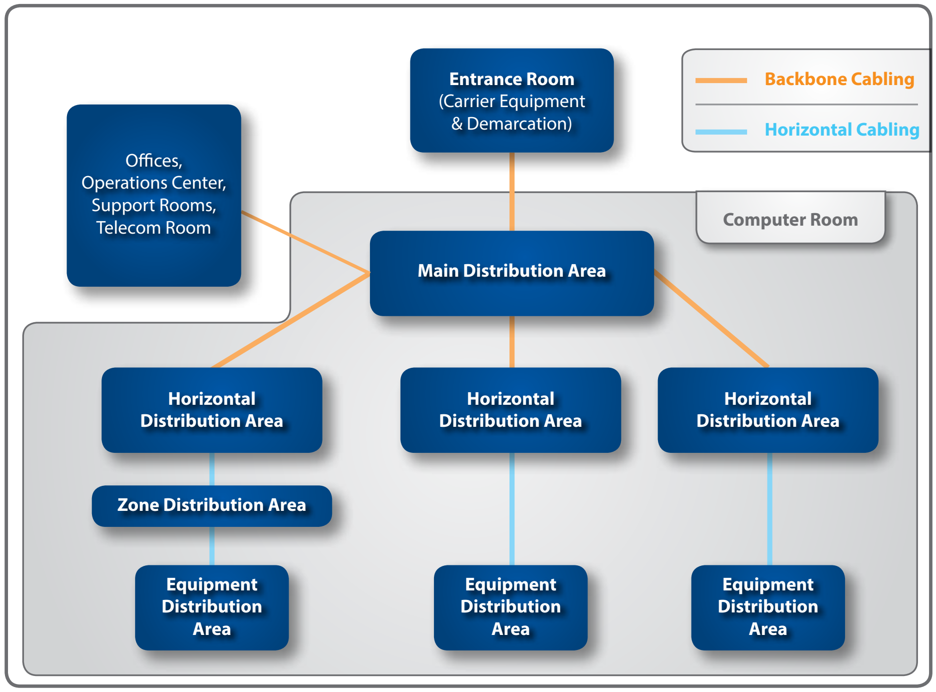

Figure 1 - TIA-942 Computer Room Infrastructure

For copper cabling, this design is well-known and documented with channel, permanent link and component specifications in supporting documents such as the TIA-568 series. However, problems arise when following this cross-connection plan with fiber optics. Here, the supporting TIA-568 series leaves room for interpretation, and potential for confusion or design flaws. These documents specify mated pair loss, with no mention of maximum length or number of allowable connections. Allowable loss budgets per IEEE standards are known at 2.6dB for 10G and 1.9dB (to as little as 1.5dB) for 40/100G (see Figure 2).

Figure 2

Operating Distances Over Fiber Types

Speed	Fiber type	Number of fibers	Maximum Operating Distance (meters)	Loss Budget Maximum (dB)
10G Ethernet	OM3	2	300	2.6
40G Ethernet (SR4)	OM3	8	100	1.9
40G Ethernet (SR4)	OM4	8	150	1.5
100G Ethernet (SR10)	OM3	20	100	1.9
100G Ethernet (SR10)	OM4	20	150	1.5
100G Ethernet (SR4)	OM3	8	70	1.8
100G Ethernet (SR4)	OM4	8	100	1.9

Figure 2 - Allowable distances and channel losses per IEEE standards

A design example following these standards and allowable losses is shown in Figure 3. This represents a TIA-942-compliant cabling infrastructure plant, including a Main Distribution Area (MDA) cross-connect and a typical end-of-row Horizontal Distribution Area (HDA) patch panel. Following allowable mated pair losses per TIA-568 (0.5dB per mated LC pair and 0.75dB per mated MTP®/MPO pair) yields a cable channel with loss higher than acceptable. In this case, the system design utilizes a new, high-density core switch running both 10G and 40G connections.

Figure 3

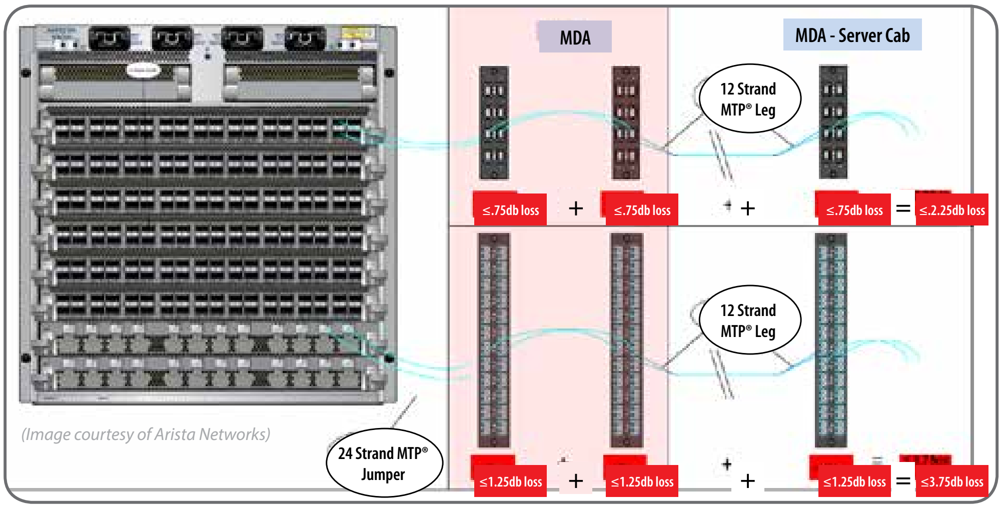

Figure 3 - Channel map of TIA-942-compliant fiber path

The scenario illustrated in Figure 3 is common in today's DC designs. Changes in design or component selection are mandatory in order to support current and future network speeds. Since the overall TIA-942 infrastructure plan is proven and widely installed in copper plants, care in selecting fiber components can yield a compliant design that meets network needs. Documentation of component and channel loss budget requirements in RFP documents will ensure that a DC fiber plant will perform as intended. Figure 4 lists basic recommendations for minimum component and channel performance. Demanding that these specifications are met via testing and verification is essential for a successful operation.

Figure 4

OM4 Fiber Maximum Loss Budgets	Mated Pair Loss	Channel Loss
Duplex connectivity	≤ 0.15dB	≤ 2.6dB
12-strand multi-pair (MPO/MTP®) connectivity	≤ 0.2 dB	≤ 1.5dB
24-strand multi-pair (MPO/MTP®) connectivity	≤ 0.35dB	≤1.5dB

Figure 4 - DC fiber infrastructure loss budgets

Given the expanding use of high-density computing, and storage area network (SAN) and switching systems in modern data centers, changes to plant design to support these systems are critical. Copper cabling has had a great deal of focus on design and implementation, but the trend toward an all fiber optic data center is rolling ahead and picking up steam. With proper planning and more detailed design specifications, DC operators and constructors can be assured that their systems will perform properly, efficiently and reliably.

Implementation Example

Ethernet networking has been dominated by copper cabling for many years, while fiber optics were used primarily in low strand-count backbone applications. Copper cabling infrastructure, unlike fiber, has had very detailed component, permanent link and channel models embedded in the standards for designers to follow. TIA-568 copper specifications not only cover the expected performance of individual connections (via component specifications), but also clearly model all of the components in a permanent link including cabling, patch panels, cross-connects and distances. There is also a channel specification that includes the permanent link along with patch cords to create a complete port-to-port path, or channel.

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TIA-568 adequately covers fiber optic component performance requirements, but does not provide any details on building a complete channel. The good news is that when transitioning from copper to fiber optic systems, an increasingly common occurrence in today's DC environments, networking staff and designers already have an understood set of parameters and language with which to work. What the standard lacks is a recognized fiber optic permanent link and channel map to design and specify for new fiber installations.

A typical scenario often occurs in the daily operations of many mid- to large-sized data centers. For example, an organization operates a 100-rack DC in-house and is refreshing part of its SAN and network cores. The organization's technicians plan to replace their SAN directors with current models that support 16G Fibre Channel, but will run with 8G optics for now. They are also planning to replace their network core switching on the virtualized portion of the DC to support new blade servers that require additional bandwidth.

The SAN is already cabled with point-to-point fiber optic jumpers - they are orange and a little bulky, but the prevailing opinion in the organization is that "fiber is fiber." The racks containing the existing directors are very full, but since the fabrics are redundant the technicians decide to take one director off-line while the other carries the load. With the old director out, there is very limited time to rack the new chassis, install the cards and optics, and reconnect all those jumpers.

After the chassis is wrestled in place and cabled up, testing reveals that the new chassis is

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running slower than the director it replaced. Calling the manufacturer starts a process that ultimately ends in the realization that the old jumpers are too long and have too much loss. Now the decision is made to run new jumpers wherever the line speed is below par. However, this is complicated by the fact that the current jumpers run all over the DC and are tangled beyond resolution with the other fabric and everything else under the floor.

The network core refresh goes a little differently. The network team has been dealing with structured cabling for years. Their plant consists primarily of copper cabling and is set up with an MDA cross-connect and patch panels with CAT6 to every row. Because the new cores deliver 10G to the blade servers the team decides to run a new 10G/40G fiber backbone to end-of-row cabinets and place aggregate switches there. Small form-factor pluggable (SFP) cables are routed down the row to the new aggregate switch. The team feels everything should be fine. The network engineer puts out an RFP for the structured cabling - requiring the installation of a factory-terminated, plug-and-play fiber optic cabling plant that meets all TIA specifications, referencing 942 and 568 specifically. The lowest bid wins the project and the new system looks very tidy.

Upon inspection, it is discovered that while the fiber cassettes and MTP®/MPO did meet TIA-568 loss specifications, the total channel has 3.75dB of loss on the 10G links and 2.25dB of loss on the 40G links. Both of these links meet TIA-568 and 942 standards, but will not support IEEE-mandated loss budgets, meaning they do not work. The organization does a workaround with long jumpers to bypass half of the MDA cross-connect and get the system up and running, but their tidy installation has become a mess now.

This scenario happens far too often. The problem lies in the way copper systems are specified and installed, as opposed to legacy fiber optic systems.

Conclusion: Get Full Understanding of Both Copper and Fiber Specifications

Understanding the disconnection between existing copper and fiber standards is critical to the success of a new DC build, whether via RFP or design. Judging the performance specifications from various contractors and vendors must be done with a channel model in mind for both copper and fiber optic systems. The TIA-942 standard does a great job in flattening cabling infrastructure into a structured and easy-to-follow system. For copper systems, it covers everything. For fiber, however, there are lurking problems to address.

TIA-942 refers the reader to TIA-568 for details on individual system performance specifications. Fiber optic specifications within 568 are given only at the "component" level (ie. mated pair). In order to truly follow TIA-942 standards, a channel will have several mated pairs. At least four are required to complete an MDA and HDA arrangement. Following this standard, a compliant TIA-942-based fiber optic system will show at least 2dB of loss in an LC arrangement and 3dB in an MTP®/MPO channel. The problem becomes clear when you consider loss budgets from IEEE in the 1.5dB to 2.6dB range.

Keys to achieving a proper fiber optic RFP specification in the current market:

- Fiber optic system channel performance must be specified:
  - <2.6dB total loss for duplex channel based systems (LC, SC, etc.)
  - <1.5dB total loss for parallel optics based systems (MTP®/MPO 12- or 24-strand)
  - <0.15dB per LC/SC and <0.2dB per MTP®/MPO maximum mated pair insertion loss
- Specify total channel measurements and testing including jumper/patch cords
- Demand worst case total channel loss budgets for all tendered designs

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