Fiber Design for 1 Gigabit and 10 Gigabit Campus Backbone Applications

CORNING

Author:
David Kozischek
Marketing Manager, Data Center Applications
Corning Optical Communications

Systems engineers at Corning are routinely asked these two questions:

1. How do I determine the type of fiber needed for my campus backbone?
2. How do I determine the number of fibers needed for my campus backbone?

Both of these questions require some analysis to help the network designer make the best decision. This article provides design guidance to help put analysis behind the decision-making process. This paper discusses the following:

- Fiber types used in the campus backbone
- Designing the cabling infrastructure
- Determining the fiber type and fiber mix for 10 Gigabit Ethernet
- Determining the total fiber counts
- Conclusion

Fiber Types Used in the Campus Backbone

There are many factors that go into the determination of which fiber type to use in a campus backbone. Two of the main factors are the type of media that is needed along with the distance of the cable run. A single fiber type may not be satisfactory for all applications and multiple fiber types may be needed.

Before Gigabit Ethernet, determining fiber types for the campus backbone was an easy decision. Standard 62.5/125-micron multimode fiber was generally used for any application up to 2000 meters, and single-mode fiber was used for anything else. With the introduction of 10 Gigabit Ethernet, these rules have changed for multimode fiber. Laser-optimized 50-micron multimode fiber was introduced to offer increased performance for 10 Gigabit Ethernet, and the fiber performance was included in TIA/EIA-568revB. Section C.3 - Table 6 of the TIA-568.0-D Standard shows the maximum supportable distances for multimode optical fiber applications and Table 7 has the maximum supportable distances for single-mode applications.

Designing the Cabling Infrastructure

Before attempting to determine the fiber types, we need to determine the cabling topology for the campus. To do this, let us create a campus backbone model using our campus illustrated in Figure 1.

Let us assume the following:

1. All buildings contain multiple floors with a minimum of one telecommunications room (TR) acting as a horizontal cross-connect/distributor A.
2. All distances are in meters. This includes the length from the entrance facility (EF) at each building back to the main cross-connect (MC)/distributor C.
3. All network analysis is based on a Gigabit Ethernet building-to-building fiber optic backbone and a 10G Ethernet fiber backbone.

The design of the cabling topology can be separated into five smaller steps to help the network designer make the best choice:

1. Consult the TIA-758-B and 568.0-D for design topologies.
2. Determine the location of the main cross-connect (MC)/distributor C, entrance facilities intermediate cross-connects (IC)/distributor B, and horizontal cross-connects/distributor A.
3. Determine the fiber distances needed for each fiber optic cable run.
4. Consult TIA-568.0-D for the maximum supportable distances for single-mode and multimode fiber applications to determine the appropriate fiber type.
5. Determine fiber counts needed.

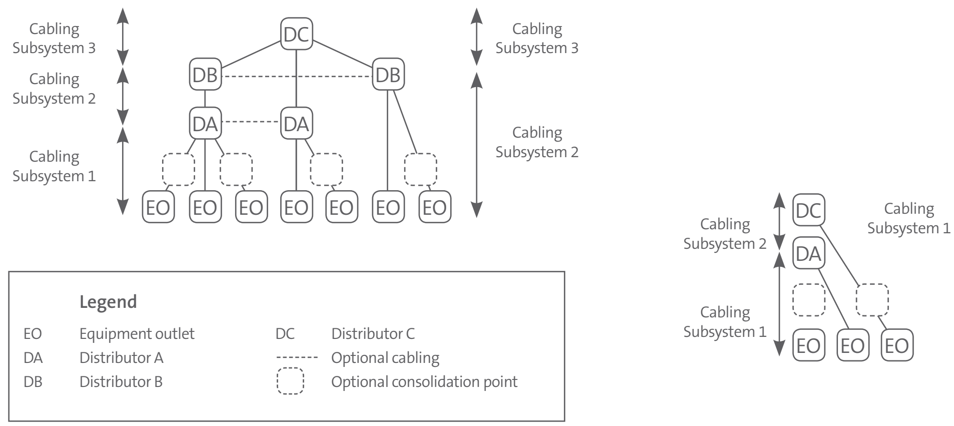
Let's look at each of these steps.

1. Consult the TIA/EIA-758-B and TIA-568.0-D standards

The TIA-758-B standard gives design rules for cabling a customer-owned outside plant telecommunications infrastructure, and TIA-568.0-D for generic telecommunications cable for customer premises.

This includes:

- It is recommended that the backbone cable be designed in a star topology. This is the most advantageous backbone design because it provides flexibility and the opportunity for centralized administration and management. In a star topology, there shall be no more than two levels of cross-connects in the backbone cabling.
- Connections between any two horizontal cross-connects (HC)/distributor A shall pass through three or fewer cross-connects.
- Large campuses should be designed using a hierarchical star configuration. This allows selected ICs/DBs to serve a number of buildings rather than having all of the buildings connecting directly to the MC/DC.
- Redundancy/diversity should be provided for continuity of service and security.
- Sometimes a star topology is not always feasible as the distances between buildings may exceed the allowable cable lengths.



Source: ANSI/TIA-568

2. Determine the location of the MC/DC, IC/DB, and HC/DA

Before determining the location of the MC/DC, ICs/DBs, and HCs/DAs, let's define the function of each. The MC/DC is the central connection facility in a star topology. The IC/DB is an optional intermediate cross-connection between first level (subsystem 3) and second level backbone (subsystem 2) cabling. The HC/DA is the optional cross-connect that is cabled between the equipment outlet (EO) and distributor B or distributor C.

In the campus model, assume each TR will act as the HC/DA and connects to the building IC/DB. Next, the ICs/DBs connect back to the MC/DC in a physical star topology. The key decision is how to determine the location of the MC/DC. The location of the MC/DC can be dictated by where most of the servers, switches, and routers are housed. If a certain building is already chosen based on these criteria, then all length calculations would be from that point. If any of the buildings can act as the MC/DC, then you need to determine which building is centrally located to minimize cable lengths. In our sample campus design, selecting the admin financial building as the MC/DC, yields a practical solution since it is centrally located on the campus. In our example, there is only one path between the MC/DB and each building entrance. If pathway redundancy is needed, multiple divergent routes and entrances facility diversity for each building will be needed. The cable routes and distances are shown in Figure 1.

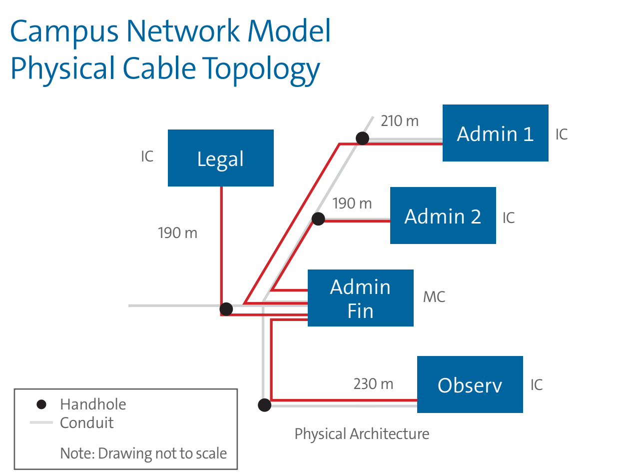


Figure 1

3. Determine the fiber lengths

Though the cable is deployed as a physical star, other logical topologies can be considered such as ring and mesh network. These logical topologies can be achieved through the use of cross-connects in the MC/DC. In our scenario, we want to create a logical mesh network on a physical star. In a logical mesh architecture, all switches will be connected together to create logical redundancy. See Figure 2.

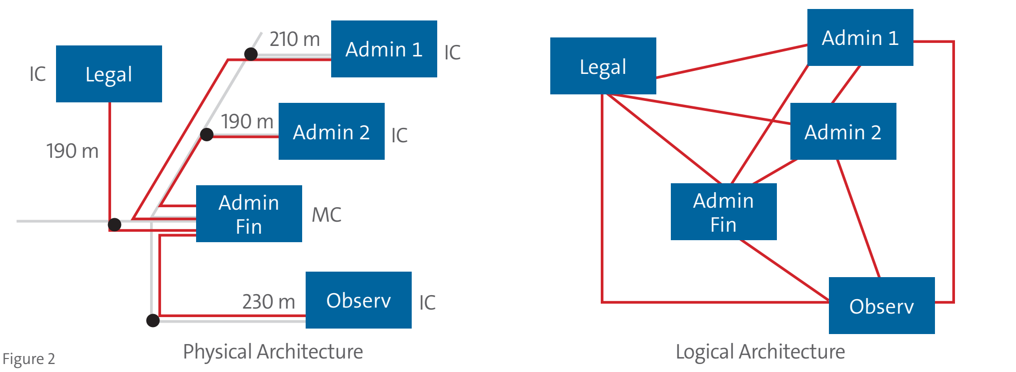


Figure 2

To get a better understanding of the fiber distances, it is a good idea to construct a matrix that defines the fiber distance between any two buildings in the backbone. Remember that the admin financial building is the MC/DC for our campus, so all network connections flow through the MC/DC. Table 2 illustrates this concept for our campus model. In Table 1, all of the lengths highlighted in green are the lengths from our MC/DC in admin financial to each of the buildings that we want to network. The lengths that are highlighted in white are the lengths for each building that we want to mesh via a cross-connect in the MC/DC.

CH LENGTH CALCULATOR (METERS)

To: \ From:	Admin Fin	Admin 1	Admin 2	Legal	Observ
Admin Fin		210	190	190	230
Admin 1	210		400	400	440
Admin 2	190	400		380	420
Legal	190	400	380		420
Observ	230	440	420	420	

Table 1: Fiber Distance Matrix

4. Choose the fiber type

Based on the cable routes chosen for our campus model, the next step is to determine the fiber types based off of the maximum supportable distances for the media dependent protocol that we want to use. Since we are concentrating on the campus backbone (building-to-building links) and 1 Gigabit and 10 Gigabit Ethernet technologies, we need to look at length restrictions based on fiber type. These maximum supportable distances can be found in TIA 568.0-D. In our example, we are going to be looking at a 10GBASE-S application. This comparison is shown in Table 2. By knowing the maximum supportable distances and the maximum channel lengths of our campus, we can choose the correct fiber type.

Fiber Type Versus Distances (Meters)

	OM1	OM2	OM3	OM4
1 G	300	600	1,100	1,100
10 G	33	82	300	400

Table 2: 1G and 10G Ethernet Distances

The 1 Gigabit and 10 Gigabit Ethernet distances shown in Table 2 are a function of the fiber core size and the associated effective modal bandwidth (EMB). Looking at Table 3, there are some questions that you can ask yourself. Though 62.5-micron fiber has been used in the past in campus backbones, is it worth switching over to 50 micron? Also, what should the fiber mix of multimode to single-mode be? To answer these questions, we need to apply our logical mesh networking scenario to the physical star topology.

To analyze this network you need to look at how many fibers and what type of fibers (multimode and single-mode) are needed in operating the network at 1G and 10G. This will vary based on the type of fiber used and the total distance required to support the logical mesh topology. This is shown in Table 3.

Based on Table 2, any links over 400 meters will need to have single-mode fiber to support the 10 GigE backbone. Though all the point-to-point links are under 400 meters, some of the cross-connected links are greater than 400 meters.

Note that the fiber mix (multimode vs. single-mode) changes based on the type of fiber we choose. In this example, the recommended fiber mix would be OM4+SM. The reason for this is to maximize the number of links we can operate over lower cost multimode electronics.

5. Determine fiber counts

In our campus model, an electronic redundant point-to-point logical mesh topology is implemented. This architecture uses redundant electronics in all buildings to reduce single points of failure. In this example, the campus backbone is sized for 1 Gigabit and 10 Gigabit Ethernet. Based on the results shown in Table 3, a mix of OM4+SM was determined to be the best choice. But how was the fiber count calculated?

This is accomplished by referring back to Table 1 for the building-to-building link lengths and comparing the fiber type to the length restrictions for 1 GigE and 10 GigE in Table 2.

As stated above, any links over 400 meters will need to have single-mode fiber to support the 10 GigE backbone and anything below 400 meters can be supported by OM4.

Fiber Backbone Optimizer for 1 GigE and 10 GigE
Fiber Count Comparison (Topology and Fiber Type)

	Total Fiber Counts		Campus Backbone-Distributed	
	IC	MC	Rec. Fiber Count	
Fiber Type	From	To	MM	MM
62.5 µm Core OM1	Admin 1	Admin Fin	12	48
	Admin 2	Admin Fin	12	48
	Legal	Admin Fin	12	48
	Observ	Admin Fin	12	48
	From	To	MM	MM
50 µm Core OM2	Admin 1	Admin Fin	24	24
	Admin 2	Admin Fin	24	24
	Legal	Admin Fin	24	24
	Observ	Admin Fin	24	24
	From	To	MM	MM
50 µm Core OM3	Admin 1	Admin Fin	36	24
	Admin 2	Admin Fin	36	24
	Legal	Admin Fin	36	24
	Observ	Admin Fin	36	24
	From	To	MM	MM
50 µm Core OM4	Admin 1	Admin Fin	48	12
	Admin 2	Admin Fin	48	12
	Legal	Admin Fin	48	12
	Observ	Admin Fin	36	24
	From	To	MM	MM
SM	Admin 1	Admin Fin	0	48
	Admin 2	Admin Fin	0	48
	Legal	Admin Fin	0	48
	Observ	Admin Fin	0	48

Table 3: 1G and 10G Ethernet Distances

The last step is to determine the final fiber counts for each cable. Table 4 gave us the minimum fiber counts to migrate the backbone 10 GigE, but what about other applications that might run across the network? Applications such as security video, card readers, video conferencing, and control systems are applications that require additional fibers. Unless all applications are going to operate over an IP network, you will also need to add spare fibers in the cables. Spare fiber can run anywhere from 25 percent to up to 100 percent in a campus design. In this campus model, a 50 percent spare rule is used. The overall breakdown is shown in Table 4.

Campus Backbone-Distributed
Total Fiber Counts

IC	MC	GigE Fiber Count		Additional Fibers		10 GigE Fibers		Spare Fibers		Total Fibers		Recommended Count	
From	To	OM4	SM	MM	SM	MM	SM	MM	SM	MM	SM	MM	SM
Admin 1	Admin Fin	16	0	0	0	12	4	14	2	42	6	48	12
Admin 2	Admin Fin	16	0	0	0	12	4	14	2	42	6	48	12
Legal	Admin Fin	16	0	0	0	12	4	14	2	42	6	48	12
Observ	Admin Fin	16	0	0	0	4	12	10	6	30	18	36	24

Table 4

With this in mind, the following fiber counts were recommended:

- Minimum: 16 multimode OM4 for 1 GigE
- Minimum: 12 multimode OM4 + 4 single-mode for three 10G links and 4 OM4 + 12 single-mode for one 10G link
- Minimum + spare %: 42 multimode OM4 and 6 single-mode fibers for three links and 30 multimode and 18 single-mode for one link
- Cable to order based on common stocked: (3) 48 multimode OM4 and 12 single-mode cables and (1) 36 multimode and 24 single-mode cable

Conclusion

In summary, a few key points can be drawn from this analysis to help make the best decision when determining fiber types and fiber counts for a campus network.

1. Use the standards. They were created to protect the end user.
2. Do some analysis. Understand the network applications and possible traffic growth.
3. Understand the physical topology and the logical topology.
4. Examine where you can save money: MC selection, electronics choice, cable routing.
5. For distances less than 400 meters, a laser-optimized (OM4) multimode fiber is the best solution.
6. For distances greater than 400 meters, single-mode fiber is the best solution.

Are You Corning Connected?

www.corning.com/wireless-networks

CORNING

Corning Optical Communications LLC • PO Box 489 • Hickory, NC 28603-0489 USA
800-743-2675 • FAX: 828-325-5060 • International: +1-828-901-5000 • www.corning.com/opcomm