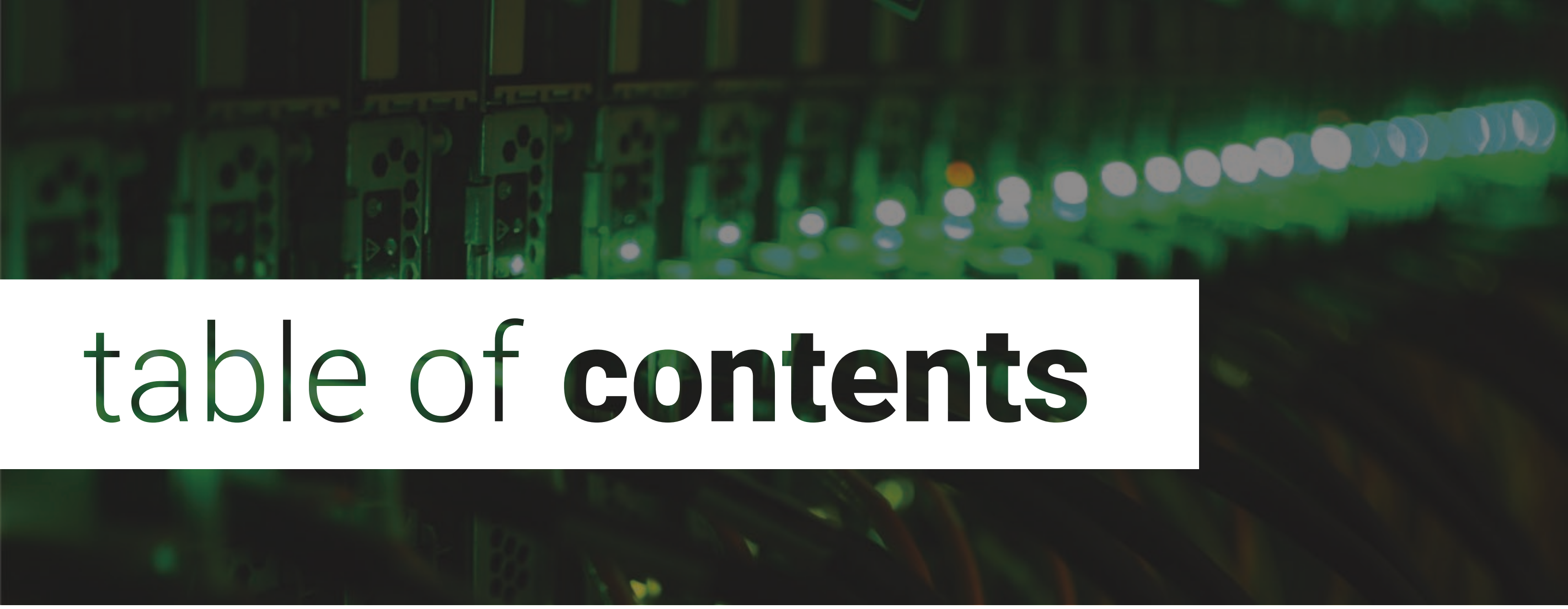
Structured Cabling

Design Considerations

Planning your structured cabling system

Planning
Topologies
Ethernet Standards



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This guide is intended to provide an overview of the design considerations that govern structured cabling systems. For expert advice on your new or upgraded structured cabling system, and for complete services ranging from design and products through installation and maintenance, call Black Box at 0118 965 6088 or go to bboxservices.com/en-gb.

Important Design Considerations

A structured cabling system is the wiring network that carries all your communications systems, including unified communications, VoIP, data, voice, multimedia, security, PoE, and even wireless, throughout your office, building, or campus. It's a critical component of your organization. Proper planning, design, installation, and maintenance of this infrastructure can have a positive impact on your company's day-to-day operations and can contribute to its success.

A structured cabling system that's smartly designed takes careful planning, even for the most seasoned professional. It's much more than just pulling cable through the ceiling. It's a complex undertaking that involves integrating different technologies and cabling types, projecting future capacity requirements, and making sure the whole system operates smoothly and reliably. The more complex your network is now, the more important it is to successfully plan for growth. No matter if your network consists of a two-room office or a multi-building campus, decisions you make now will impact your business's or organization's success for many years to come. The system you plan today should support new and different applications, including migrating to 40-/100-GbE, even 1-TB systems.

The question is, how do you plan for the future? The first step in designing and implementing a new or upgraded network infrastructure is to step back and assess your needs.

Plan on using the best cable, hardware, and components your budget can afford. The latest technologies you install today will be old hat by the time you're ready to replace your cabling system. And, most importantly, plan for more capacity and space than you think you'll need. Consider these factors during your planning.

Lifespan. Consider how long you want your structured cabling system to serve your facilities.

Plan on a life span of 10–20 years, with 10 years being the minimum, and 15 years being typical. While the cabling itself represents only about 5% of the total network budget, it is also the most difficult and expensive part of the network to replace, requiring extensive labor and major workplace disruption. Your cabling system should have the longest life cycle of any component in your network. You can expect to replace network electronics at least two to three times over the lifespan of your cabling infrastructure. Electronics have an average lifespan of five years.

Bandwidth. The demand for it just keeps growing. The more the better. Consider how much capacity and speed you need now, and how much you are going to need in the future. Remember, recabling is a very expensive proposition. Or in some instances, you may have to plan on shorter cabling runs to achieve higher speeds.

BYOD/wireless. Plan for complete coverage with as much bandwidth as possible. Gartner estimates that tablet sales will reach 369 million by 2016. Forrester Research Inc. estimates that about 25% of computers used for work globally are tablets and smartphones, not PCs.

Media. What media will you use? Fiber, copper, or both? The types and mixtures of cable you choose will depend on the applications, architecture, environment, and more. Carefully consider any trade-offs of price for performance. The lowest-cost cable may not be the most economical long-term choice, particularly as you migrate to 40-/100-Gbps in the future. Labor is the most expensive part of installing new cable, so choose the best grade cable you can that will serve you for years to come as your organization grows.

Location and number of users. How many users do you have now and how many do you anticipate adding over the next 10 years. Where are users and how far are they from the network switches? Will a collapsed backbone work better? Centralized cabling? Zone cabling? Your architecture may also affect your cabling choices.

Usage. Consider how your network is to be used. A network in educational buildings has far different requirements than a network in healthcare facilities. Other factors that can affect network planning include peak load periods, number of ports, particular usage patterns, security, even outlet density.

Unified Communications/VoIP. The question isn't if, it's when. Plan on using the best cable you can to carry your voice, data, and multimedia transmissions.

Standards. ANSI/TIA. State and local building codes. NEC codes. They exist for a reason and will make your life easier in the long run when it comes to performance, maintenance, upgrades, etc. If you follow the standards for distance limitations, installation, and best practices, you should get good performance and conform to all safety regulations. Don't forget cable management, documentation, and testing requirements. Also, if you are in healthcare, education, or another specialized vertical, be aware of specific standards that apply to you, such as TIA 1179 for healthcare facilities.

Other Factors To Consider

Documentation. Don't forget proper documentation, diagrams, labeling, color coding, and other administrative duties. Doing it right in the beginning will make your life so much easier in the future.

Power over Ethernet (PoE). Consider where you may need to run power over your data lines. Also consider where you want to locate networking devices, especially if it's in an area where there is no power or would be difficult to install power. PoE devices, such as security cameras, alarms, and locks, solve the problem of no power availability.

Physical plant. Consider available space for data centers, equipment, telecommunications rooms, and cable runs. Also consider any unusual physical constraints, such as power lines, EMI influences, seismic activity, or industrial activity. Make sure to factor in plenum runs, additional air ducts, suspended ceilings, etc.

Security. Plan on current and emerging data, network, and physical security systems, including PoE and wireless applications.

Redundancy. Do you need to run duplicate pathways? Pay particular attention to this if you are in healthcare, finance, industry, or education.

Warranties/manufacturer support. Be aware of product warranties. What is the length of the warranty? What components does it cover? How long will the manufacturers will support the cabling?

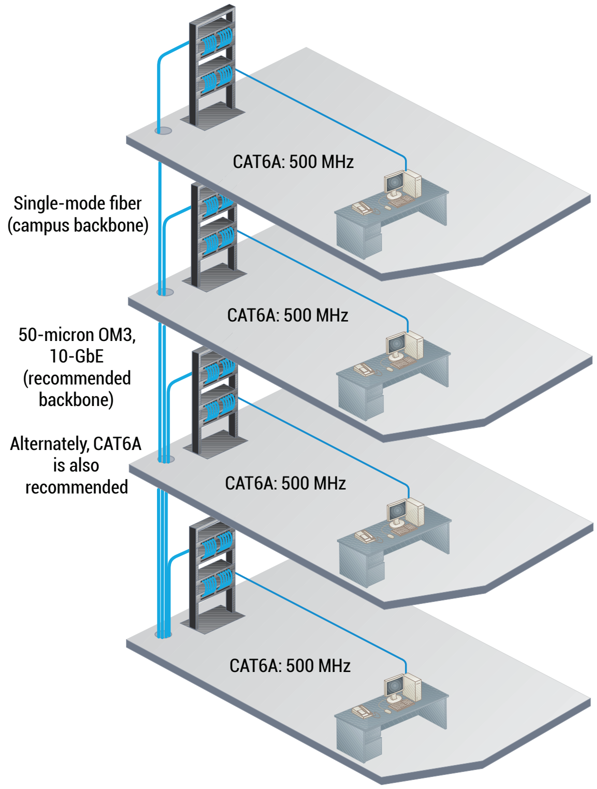
Total Cost Of Ownership

This can be tricky. The lowest initial installation cost is not always the least expensive or most economical solution. You have to factor in the cost of upgrades and recurring costs over the lifetime of the system. One of the greatest initial expenses is the labor to pull the cable. Carefully consider what media you're going to use. What may initially seem to be a bargain may end up costing you much more in the long run if you have to tear out and replace cable. You may be better off spending more now on the highest category cable you can afford, as it will serve you longer and better as you migrate to higher bandwidth applications.

The greatest expenses after your original investment will be MACs and equipment upgrades. Plan on replacing your electronic equipment two to three times over the life of the cabling system. When all totaled, these ongoing costs can actually equal or exceed the cost of your original investment.

You also have to consider the quality of the installation. The lowest bid may not necessarily be the best. A well-planned and documented installation will more than pay for itself by lowering long-term maintenance, eliminating problems from poor workmanship, reducing downtime, and most importantly, giving you peace of mind.

Structured cabling system with mixed media



Physical Network Topologies

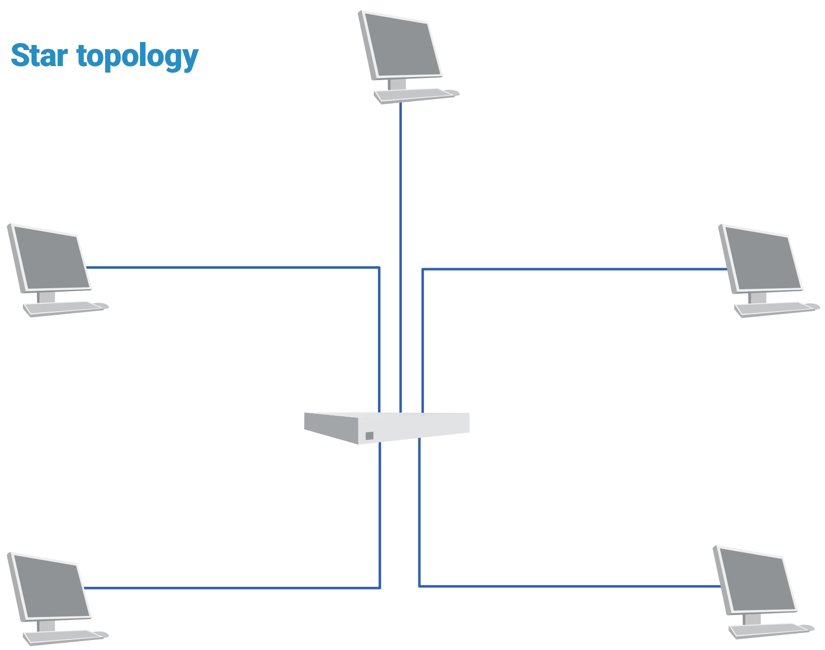
A physical network topology describes how the devices in a network are physically connected and how the network is physically laid out. Physical topologies include star, bus, ring, mesh, hybrid, and point-to-point. There are advantages and disadvantages to each.

Star

In the star topology, all the network devices (individual workstations or peripherals) are connected to a central device, such as a switch, in a point-to-point fashion. The star topology is one of the most commonly used today. ANSI/TIA 568-C.0, the Generic Telecommunications Cabling for Customer Premises standard, recommends the star network. It specifies that there be no more than two hierarchical levels of cross-connects between the main cross-connect and the equipment outlet. This is called a hierarchical star topology.

Advantages of the star topology include its simplicity in installation. You can centrally manage the star network and will find it easier to troubleshoot than other topologies. If one node/device goes down, it doesn't bring the entire network down. You can also add and remove network nodes without disrupting the entire network. In addition, a star topology is easier to troubleshoot.

Its major disadvantage is its single point of failure. If the central device goes down, the network goes down. To provide redundancy and resiliency, star networks are often deployed in an "extended" star, in which multiple stars are attached to the central star. Think of this network as a snowflake pattern. The star topology can be more expensive than other topologies because of the need for more network switches. When planning for future growth and flexibility, plan on using a star topology for your campus network. You can always add redundancy with a secondary bus or ring network. This is called a hybrid network.

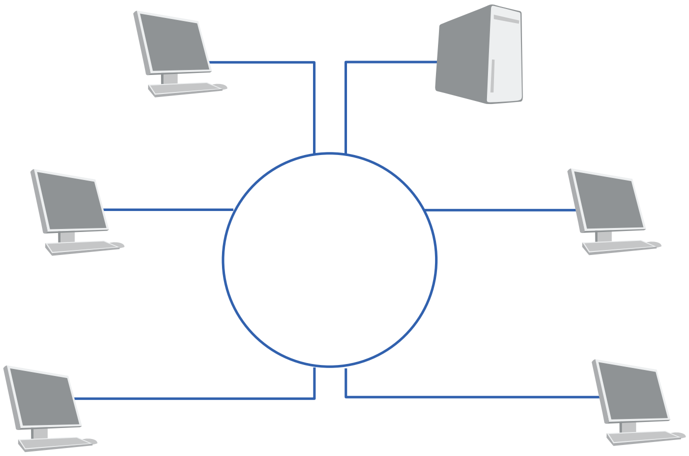


Ring

A physical ring topology links a series of devices in a continuous loop, and the network sends the signals around the ring. One of the main disadvantages of a ring network is if the main cable or a single device goes down, so does the entire network. To counteract this, often a second, counterrotating ring is added for resiliency and redundancy. A counter-rotating ring will continue to operate even if a node fails or a cable is cut. This is seen in Fiber Distributed Data Interface (FDDI) networks.

The ring topology is mostly remembered as being used in legacy Token Ring networks. If you're concerned about reliability, consider installing a counter-rotating campus backbone ring to be used as a hybrid topology with your star networks.

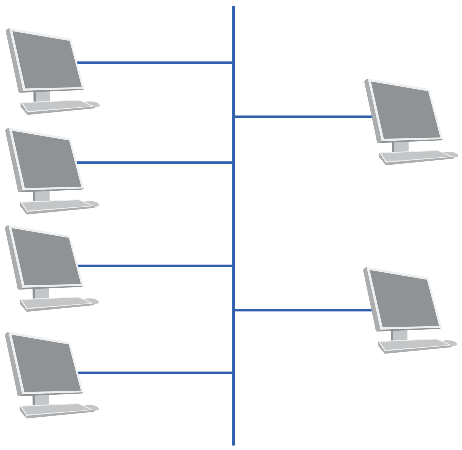
Ring topology



Bus

The physical bus topology consists of one continuous, linear backbone cable with devices connected it. All the devices are linked to each other and the line is terminated at each end. In the bus, when data is transmitted, it is received by all nodes in the network. The bus topology is the oldest and was the original Ethernet topology because it was easy and inexpensive to set up. It is now out of date in favor of a star topology. The bus has some disadvantages such as a limited cable length and nodes, a single point of failure if there is a cable problem, low security, and inefficient transmissions.

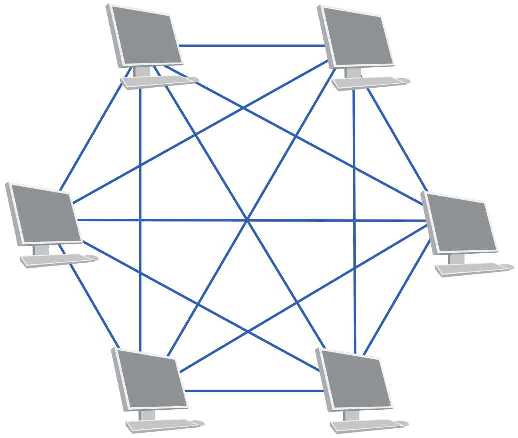
Bus Topology



Mesh

In a physical mesh topology, every node/device is connected to every other node or device. The main advantage of this topology is its high reliability. It is one of the most redundant topologies available. If one node goes down, the network doesn't go down. Mesh networks are mostly used in wide area networks where high availability is required. The major disadvantage of a mesh network is that it requires much more cable and is difficult to implement, manage, and troubleshoot. To add a node, you have to connect the new node to every other existing node. Partial mesh networks, ones in which not all nodes are connected, are a trade-off between redundancy and administrative management.

Mesh topology



Logical Network Topologies

The logical topology (also referred to as signal topology) describes how data flows through the network without regard to the physical network configuration or topology. The logical topology refers to the data transmission path, which may or may not be the same as the physical topology. Logical topologies are governed by network protocols, such as Ethernet, rather than by the physical configuration of the network devices. The protocols also describe the media access method used by the network. The two primary ones are shared media and ring (token based). You can have one physical topology and a different logical topology.

Logical topologies include bus, ring, star, and point-to-point.

Bus

This is the most common topology and is used by Ethernet and defined under IEEE 802.3. Ethernet is configured with a logical bus topology that operates over a physical star topology.
Under a bus topology, a node broadcasts simultaneously to the entire network and each receiving node checks to see if it the data is intended for them. Collision detection software directs traffic so network stations do not try to send and receive simultaneously. Ethernet uses a protocol called Carrier Sense Multiple Access/Collision Detection (CSMA/CD).

Ring

In this topology, a node gains access to the network by grabbing a token that attaches itself to the data packets (frame) being sent around the ring. Each node receives the signal and repeats it forward until it reaches the intended node. An acknowledgement is added to the frame, which continues around the ring to the originating node. One advantage of a ring is that if a node is down, the frame bypasses that station and continues. Only one node can send data at a time to avoid collisions.
Token based networks typically have latency problems and are usually configured in a physical ring topology.
In a counter-rotating ring, signals travel in one direction on one path and in the opposite direction on another path.
Token Ring networks are slow and are rarely used. FDDI is like a Token Ring network, but for fiber.

Star

In the star topology, all components are connected to a central switch that distributes traffic back out.

Point-to-point

This is literally a simple connection between one point and another, although it can connect multiple devices, such as in a Fibre Channel network.

Ethernet Standards

Network	Standard	IEEE	Media	Speed	Distance
Ethernet	10BASE5, 2	802.3	Coaxial	10 Mbps	500 m/185 m
	10BASE-T	802.3i	CAT3	10 Mbps	100 m
	10BASE-F, -FB, FL, FP	802.3	Fiber	10 Mbps	2000 m/500 m
Fast Ethernet	100BASE-TX, T4	802.3u	CAT5	100 Mbps	100 m
	100BASE-FX	802.3u	MM Fiber	100 Mbps	400 m half-duplex, 2 km full-duplex
Gigabit Ethernet	1000BASE-T, TX	802.3ab	CAT5e/6	1000 Mbps	100 m
	1000BASE-LX	802.3z	MM, SM Fiber	1000 Mbps	550 m/2 km
	1000BASE-LX-10	802.3z	SM Fiber	1000 Mbps	10 km
	1000BASE-SX	802.3z	MM Fiber	1000 Mbps	Up to 550 m
10-Gigabit Ethernet	10GBASE-SR, -LR, LX, -ER, -SW, -LW, -EW 10GBASE-CX4	802.3ae	CAT6, MM, SM Fiber	10 Gbps	65 m to 40 km
	10GBASE-T	802.3an	CAT6 plus	10 Gbps	100 m
	10GBASE-CX4	802.3ak	(4) lanes (8 twinax pairs)	4 x 2.5 Gbps	15 m
	10-BGASE-LX4	802.3ae	MM, SM Fiber	10 Gbps	300 m/10 km
	10GBASE-LR	802.3ae	SM Fiber	10 Gbps	10 km
	10GBASE-ER	802.3ae	SM Fiber	10 Gbps	40 km
	10GBASE-SR	802.3ae	OM3 MMF	10 Gbps	26–82 m
	10GBASE-KRN	802.3aq	500-MHz MMF	10 Gbps	220 m
40-Gigabit Ethernet	40GBASE-KR	802.b1	(4) lanes backplane	40 Gbps	1 m over a backplane
	40GBASE-CR4	802.ba	(4) lanes (8 twinax pairs)	40 Gbps	7 m
	40GBASE-SR4	802.bm	MMF	40 Gbps	100 m
	40GBASE-SR4		(8) OM3 lanes	40 Gbps	125 m
			SM Fiber	40 Gbps	10 km
	40GBASE-FR		SM Fiber	40 Gbps	2 km
	40GBASE-LR4		SMF	40 Gbps	10 km
	40GBASE-FR		SMF	40 Gbps	2 km
100-Gigabit Ethernet	100GBASE-CR10		(10) Twinax lanes (20 pairs)	100 Gbps	7 m
	100GBASE-SR10		(10) OM3 MM pairs	100 Gbps	100 m
			(10) OM4 MM pairs	100 Gbps	150 m
	100GBASE-LR4		(4) SMF lanes	100 Gbps	10 km
	100GBASE-ER4		(4) SMF lanes	100 Gbps	40 km
1-Terabit Ethernet		Expected by 2015		400 Gbps to 1 Tbps	

Ethernet Nomenclature

Ethernet nomenclature is fairly easy to follow, although the standards do not spell out the meaning of all the letters. Informal terms have been adopted by the industry, but they don't always coincide with the original intent. (This information is based on a presentation by the Ethernet Alliance in 2012.)

Ethernet nomenclature: ATYPE-BCM1

ATYPE-BCM1 = Data rate
10 = 10-Mbps
100 = 100-Mbps
1000 = 1000-Mbps (1-Gbps)
10G = 10-Gbps
40G = 40-Gbps
100G = 100-Gbps

ATYPE -BCM1

BASE = Baseband modulation

ATYPE-BCM1

B = media type or wavelength
C = Twinaxial copper
E = Extra-long wavelength (1550 nm)/ extended reach
F = Fiber
K = Backplane
L = Long wavelength (1310 nm)/Long reach
S = Short wavelength (850 nm)/Short reach
T = Twisted pair

ATYPE-BCM1

C = Reach or PCS encoding
R = ScRambled coding
X = EXternal sourced coding
e = Energy Efficient Ethernet

ATYPE-BCM1

M = Multimode

ATYPE-BCM1

1 = 1 pair or lane
4 = 4 pairs or lanes
10 = 10 pairs or lanes, or 10 km

Example of Ethernet nomenclature for 100GBASE-LR4

Data Rate	Modulation type	Other distinctions
100G (100-Gbps)	BASE (Baseband)	-LR4 (Long Range, 4 pairs)