

# Modern Network Technology Infrastructure Guidelines for Campus Networks

Modern campus network technologies are replacing older, proprietary voice and data technologies with integrated, Internet-enabled technologies, leveraging Internet Protocol (IP). These can bring tremendous increases in performance and lower certain costs. The new standards are becoming so pervasive that architects, contractors, and owners can count on them as a reliable path to the future. You don't have to build multiple cable pathways for PBX, data, and video anymore. Now all can run on the same cable and use the same network equipment.

Using IP networks allows the designers and owners of a campus to solve a problem that has been an issue for over a decade—how to design a facility that supports future network evolution without delaying projects or hurting current communications. Understanding the requirements of modern networks is vital to the efficient design, building, and future planning of campuses.

An array of different technologies with distinct requirements and multiple service providers bringing dialtone and data to facilities have greatly added to the complexity of designing and building a campus network. With complexity comes the risk of time and budget overruns due to mistakes in the physical design and construction of the campus environment. While blueprints and floor plans for buildings and rooms follow established patterns, plans for network infrastructure are typically more difficult and may not be complete until buildings are already built. The result of this lack of standardization may be unnecessary delays, cost overruns, and compromises.

The following are guidelines for the physical infrastructure requirements necessary for a modern campus network. Key decisions and issues that architects, builders, and owners should ideally consider early in the process of designing a facility are highlighted. This document explores important questions to ask your client or vendor so that you can gain the best campus design at the lowest cost. Further suggestions for anticipating and therefore mitigating the cost, delay, and disruption of future campus growth are included.

A customer's information technology (IT) management may know exactly what kind of network they want to deploy, but future plans and anticipated growth are harder to grasp. Yet contingencies for future space, power, and other resource needs must be part of the physical plan of a campus.

Building a modern campus network environment also includes operational and safety components that also go beyond the IT department's responsibilities and expertise. All too often these factors and how they influence design are not fully understood and communicated until buildings are designed and built. Modern networks need to grow more robust in many ways beyond the network topology and devices themselves to meet the needs of today's networking environment. Outages due to air conditioning problems, accidental circuit pulls, and shortages of space and bandwidth all lead to reliability issues that now affect millions of users worldwide.

Public

Copyright © 2000 Cisco Systems, Inc. All Rights Reserved.

Page 1 of 15

Planning ahead makes it easier to get it right the first time and alleviates the need and high costs associated with making changes. Anticipating future needs and growth will hopefully mitigate the need to tear up walls and ceilings to make room for necessary space as the network grows and changes.

Cost overruns can be huge, if the physical infrastructure of a campus is not adequately defined and designed upfront. Pitfalls of improperly designed environments can include: wiring rooms that are placed beyond the regulation distances to network-enabled devices; water and drain pipes placed in close proximity to technology rooms; staircases and vaulted open foyers that block wire pathways to intended Intermediate Distribution Frame (IDF) rooms; and ceilings not sized to accommodate cable trays and fire sprinklers, heating and air conditioning ducts, and water pipes.

When designing and building a modern campus, mistakes and oversights can have huge cost, time, and business impacts. This paper draws its theme from the old adage “An ounce of prevention is worth a pound of cure.”

## **Campus Location and Layout**

A campus network from a physical perspective, can be envisioned as a complex distribution system of interconnecting conduit (pipes containing cables and wiring), redundant routes, cable trays, wall boxes, risers, and special equipment rooms. Devices include servers, switches, and routers on one end and PCs, phones, fax machines, and other user devices on the other end. Additionally, there are other systems in the buildings to provide security, air conditioning, lighting, power, redundancy, and fire suppression.

Needs and anticipated growth should dictate the location of the campus, number of buildings, and size and configuration of rooms. Access to services such as fire and police protection, alternative service providers, and power grids are important. Power and redundancy are key issues related to a high-availability “never down” network, and ideally the campus should be located near more than one power company’s grid or power plant, so that personnel can restore power quickly in case of failure, while emergency backup systems are engaged.

While scheduled network downtime for maintenance was common a few years ago, today downtime and loss of data are not options for companies in the burgeoning Internet economy. Campus environments must therefore be built with a high degree of “redundancy” so that systems, network connections, power, and environmental controls all have automatic backup features.

Depending upon what type of company the campus will house, plans may include a data center, server room, network operations center, call center, development and engineering labs. The size of these rooms will depend upon the equipment to be installed and the number of employees working in them. These factors should be determined at the outset.

The location of these technology infrastructure rooms is also very important. Avoid adjacencies to bathrooms and water pipes, since water and electronics don’t mix, should a leak occur. Another consideration is whether the campus buildings encompass one tenant or multiple tenants, whose environments may require their own technology rooms that will impact the campus network design and layout.

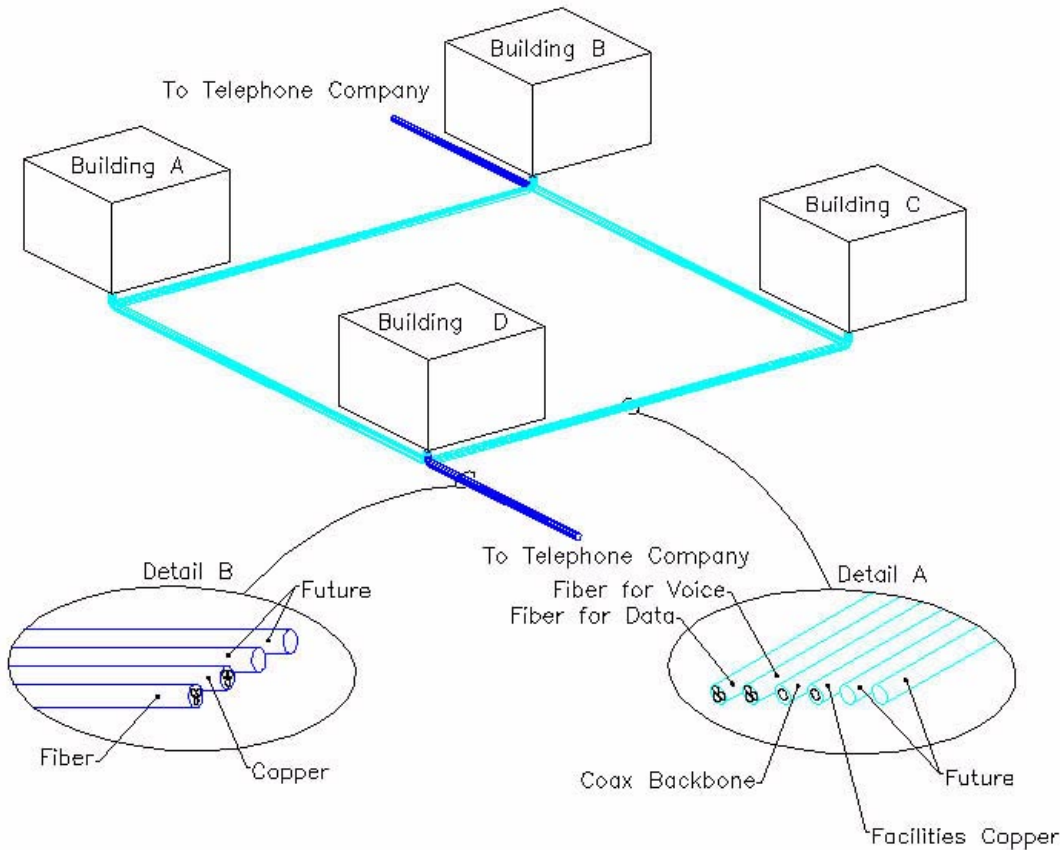
It’s safe to assume that at least 25 percent of the entire campus facility will be taken up by things other than computers, such as the power system, fire-suppression equipment, and air conditioning units. Is the facility going to be open to the public? If so, a space for controlled entrance to buildings housing sensitive information and equipment will be necessary.

## **Network Topology**

Today, many types of businesses require mission-critical networks and therefore high-availability and redundancy. Call centers and companies that buy and sell over the Internet require network infrastructures that are never down. Even businesses such as law firms, ad agencies, and consulting firms may demand 7x24 networks as well.

Modern campus networks are built using two physically diverse connections to each building (i.e., two different trenches with fiber conduit coming in to different access points in each building) so if one point of connection fails, the other connection keeps devices attached. In a modern network, redundancy will encompass phones as well as PCs and peripherals. Redundancy will also take different forms and entail different costs for such elements as backup power, air conditioning, and fire suppression.

Figure 1 Multiple physical connections to each campus building enable a high degree of redundancy. Should one connection into a campus building go down, the second connection continues to supply the network connections.



In a campus network, redundant connections enable all of the buildings and the devices within them to be linked in various ways to the local area network's main switches in the network center. If there is one connection failure, each computer remains connected to the network through the building's other connection to the network core. Another advantage of such a redundant topology is that it can span larger distances than other types of networks, because each node regenerates messages as they pass through it. This is especially beneficial to larger campuses.

## Conduit

Conduits carry the voice and data cables into each campus building. Modern campus networks have multiple service providers bringing in various special communications services, so plan for as many conduits as necessary to bring in the current and anticipated services. Since conduit is placed underground and become part of each building's foundation, expanding it once the network of pipes is in place is extremely difficult, time-consuming, and costly. Plan for extra conduit, so that future service providers can simply feed their cables through the existing infrastructure.

Conduit to provide service provider connections come into the buildings through external, underground vault boxes. Service providers will accommodate modern campuses by building fiber vault boxes as close to the main point of entry into the network as possible. Telephone companies and ISPs are used to building separate vault boxes for their conduits. By planning ahead, however, the campus tenant can direct service providers to share vault boxes with conduit so that fewer but larger vault boxes can be built to accommodate multiple service providers and use external space more economically.

A modern campus network integrating multimedia over IP will probably utilize fiber or fiber optic cable instead of copper wire, which is limited in its use as a multimedia transport medium. An exterior infrastructure of conduit and vault boxes that will carry the cables to connect the campus buildings to each other, to the main switch, and to external service providers, must be designed.

Again, this infrastructure will go underground and often through the foundations of buildings. Once in place, it is difficult, costly, and entails major delays to replace, so take great care in first determining the number and type of vault boxes, conduit, and cables necessary both short and long-term.

### **Minimum Point of Entry (MPOE)**

In a modern campus network, the Minimum Point of Entry (MPOE) for telephony and data connections should be located in the basement or ground floor of the main building, for easier outside access. This is the first stop of services coming into the campus from the outside. Modern campus networks have fiber cable coming into the MPOE and include a device called a multiplexer or “fiber mux,” which enables the distribution of bandwidth (splitting of the main signal) throughout the building. This device requires air conditioning, so the modern MPOE should be an enclosed room, complete with appropriate power, lighting, and security.

Even though fiber and coaxial cables bring multimedia (voice, data, video) services via Internet Protocol, campuses may choose to have some traditional copper wires bringing traditional dial-tone services into the MPOE. It is not necessary to house dialtone in a separate MPOE. Integrating all of the outside services in each building’s MPOE is the most secure, cost-effective solution.

### **Main Distribution Frame (MDF)**

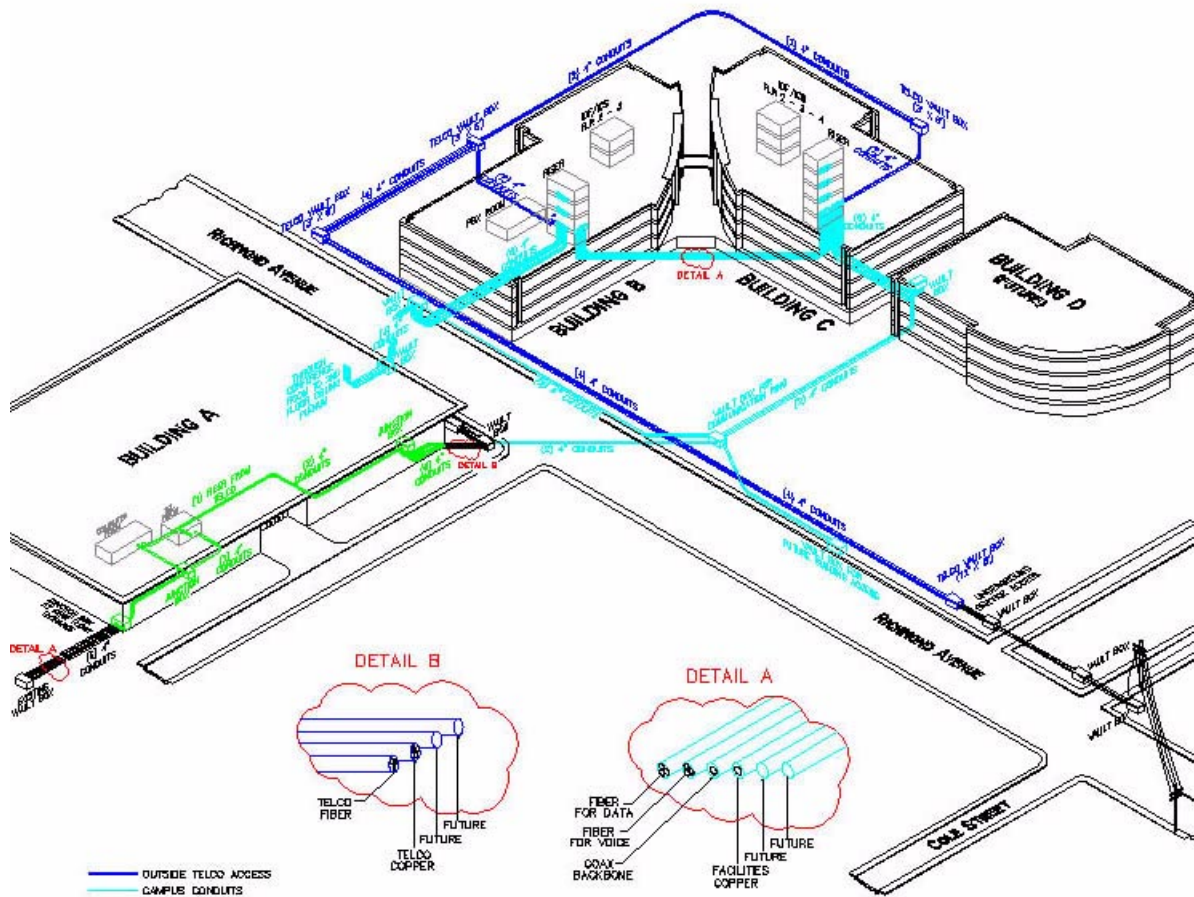
A few years ago, telephone infrastructure was the responsibility of building facilities staff. There were basic requirements for power, air conditioning, lighting, fire-suppression, and cabling. Now the phone system is part of the network and the network brings a growing list of vital services to employees, from telephony to data communications to Internet access.

In the past, telephone companies installed dialtone and PBX equipment in the MPOE. With modern campus networks, while dialtone and data initially come into the MPOE, new Internet Protocol call manager technology, along with data servers and network switches, are housed in the Main Distribution Frame (MDF) room. Since the deregulation of the telephone and communications industry in the United States, multiple service providers now bring connections for voice and data into the same building, especially in a multi-tenant campus, and the MDF is where all of these external services converge.

The MDF must be much bigger than past telephone equipment rooms, and must have sufficient power, air conditioning, and electrical grounding.

A plan should be created that traces a path for the wiring from the MDF to other floors and other buildings. The vertical wiring feeds up through stacked “risers” or open spaces between building floors. Cables and wiring are distributed to other floors of a multi-story building in this way. In a campus network, the cables and wires that are fed through risers connect to the IDFs on each floor.

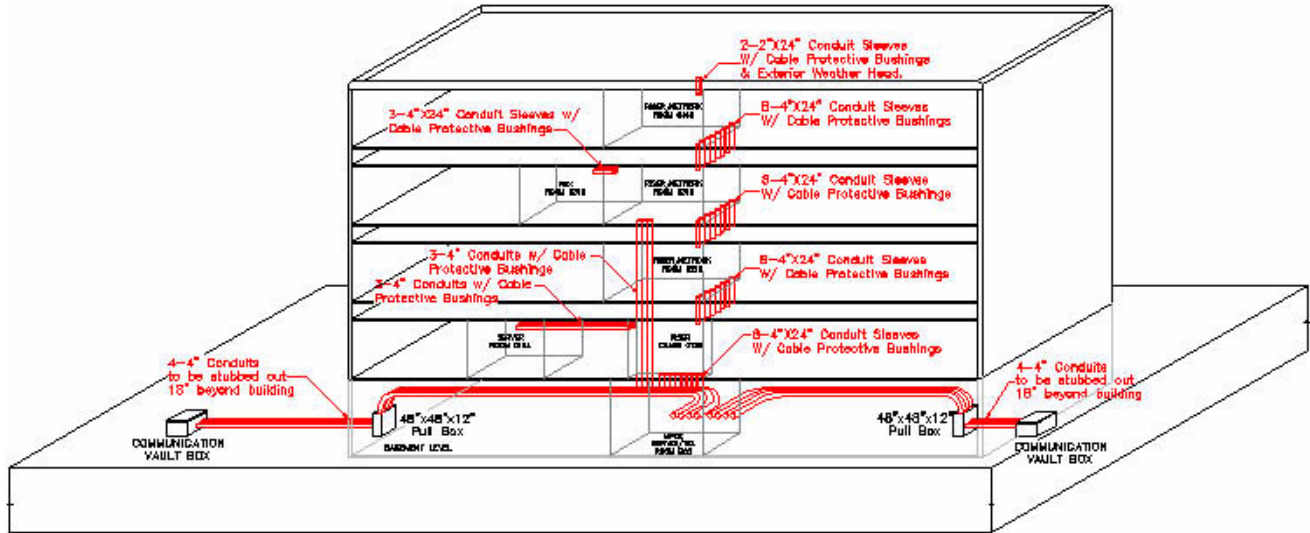
Figure 2 External conduit has become an important part of the planning of modern campus networks. Plan for large conduits to accommodate cabling from multiple service providers. Vault boxes should be built large enough to be shared by multiple providers. Conduit enters buildings at MPOE and then services go to MDFs and, through risers, to IDFs on different building floors. Multitenant buildings share MPOEs and have separate MDFs and IDFs.



Conduit Site Plan

The locations of the wiring rooms are essential for the wiring design to be both cost effective and to provide the highest cable integrity. Ideally, the riser system is designed in a straight vertical line from the basement MDF room up through the IDF wiring rooms on each floor, where horizontal wiring connects individual computers and devices and supplies telecommunications services.

Figure 3 Risers are used to distribute cable between floors in campus buildings.



Planning a riser cable system requires some significant planning decisions. Among these decisions are the total number of stations in each building, the number of stations planned for each floor, intended devices and services for each work area, and the location of IDFs and their distance from the stations. Additionally, in shared tenant buildings, the conduit in shared risers must be carefully separated, catalogued, and access to risers should be restricted so the network remains secure.

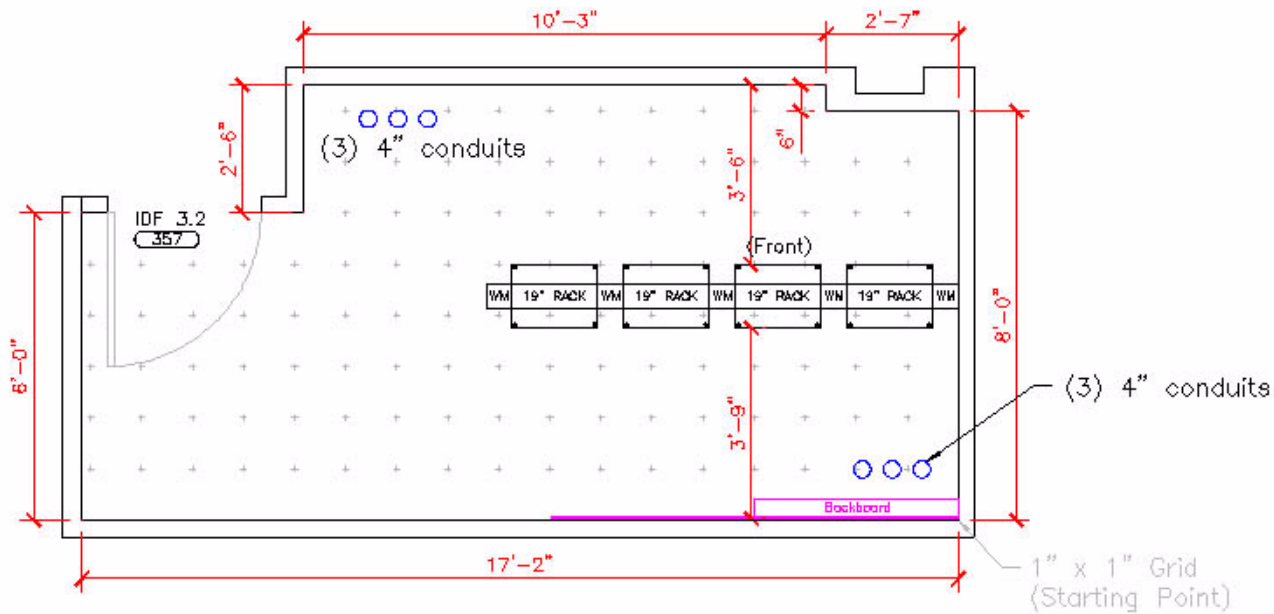
All of these factors will have an impact on the size and location of risers throughout each campus building.

### Intermediate Distribution Frame (IDF)

Each IDF room is filled with networking equipment used to distribute the backbone's capacity to individual jacks. IDF rooms must be no farther than 90 meters (295 ft.) in actual cable length from the farthest wall jack on each floor to the IDF patch panel. Degradation of IP data and voice carried over Ethernet occurs beyond that distance, which is not an option. If users are to be located more than 290 feet from an IDF, another IDF or smaller satellite distribution frame (SDF) located closer to them is necessary.

IDF dimensions will vary, depending upon how many users are to be served and what equipment will be installed. The IDFs also have major power, air conditioning, and electrical grounding requirements, based on what devices and how many cables are inside. IDFs may also serve more than one floor, with vertical cable paths running between them through risers. Uninterruptible power supply units are often desired for IDFs which house such devices as print servers and network routers that, if down, would cut off access to workstations.

Figure 4 The IDF may be used to connect network devices in a campus building, where distance is an issue.



Many different types of cable can be used to connect IDF rooms to each workstation jack location. At either end of the cables, patch panels are installed in the IDF to facilitate rapid changes to the network. In offices and cubicles, the patch point is typically a wall jack faceplate or surface-mount jack box. Between the IDFs and the MDF, fiber optic, coaxial, and other high-performance cables are used because, unlike copper cable, fiber can be run across distances greater than 90 meters and carry higher bandwidth.

### Multi-Tenant Campuses

Even the largest companies in the world plan their campuses with the flexibility to potentially include tenants. Just as tenants in an office building share common areas such as entrances, foyers, hallways, and elevators, campus networks should be designed to contain both common and separate areas for technology.

The campus MPOE is shared, normally managed by the primary campus tenant. From the MPOE, plan for two sets of risers, one shared, and the other company-specific. The shared riser system brings the main network services and power into each company's domain in each building. Within each domain are tenant risers accessible only within each company's area. These risers should provide conduit to each company's separate MDF room and IDF rooms.

### Special Rooms

Data centers, server rooms, development labs, network operations centers, and other special technology rooms have special requirements for air conditioning, security, space, and wall, ceiling, and floor materials. Some of these rooms may be more "public" than others, necessitating a more discrete placement of cabling and other exposed parts of network infrastructure as well as higher security and more extensive redundancy.

Rooms like network operations centers and laboratories may not require windows. All mission-critical rooms will require backup power, fire suppression, and air conditioning.

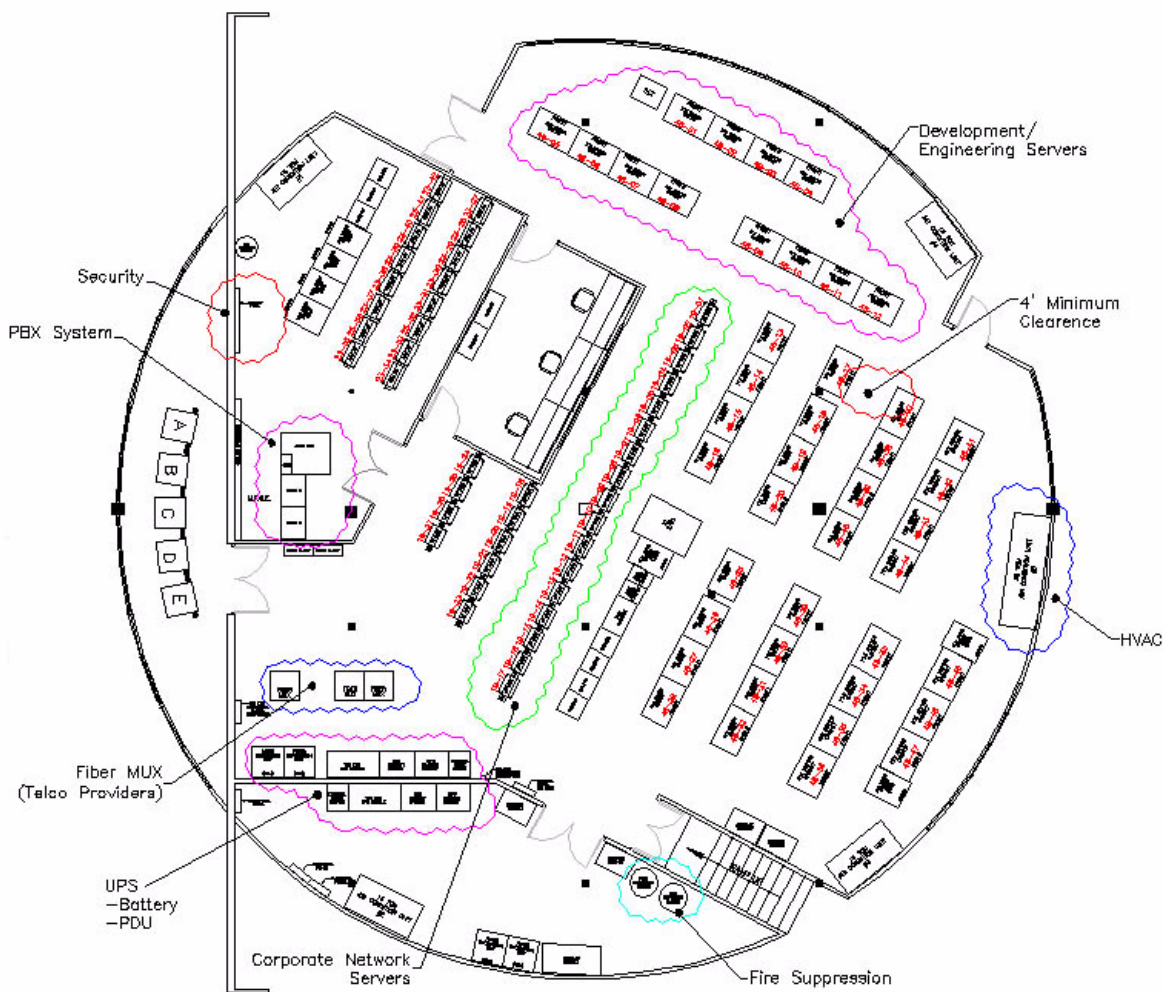
Often overlooked are secure storage area requirements for rooms housing expensive technology, as well as work spaces for fixing and reconfiguring computers and network devices. Consider how much incoming equipment must be stored and for how long. If storage and build areas are not planned correctly, rooms can end up being overcrowded and inefficient.

Separate rooms for building and storage may be considered, preferably adjacent to data centers or labs. These may not require raised flooring, fire suppression, air conditioning, or as much security, so could be built and maintained more cost-effectively.

Networking equipment, and increasingly servers, switches, power management units, and monitors are mounted on 19-inch racks. This has helped eliminate the spaghetti-like chaos of past networking installations. It also enables pre-planning of equipment-dense rooms, once the network equipment required is identified.

Computer-aided design programs let you see exactly how the racks will look filled with the equipment to be installed. Often the cable racks or trays are installed weeks or months before technology rooms and cubicles or furniture are installed. Planning ahead is therefore crucial to validating space requirements before multiple contractors arrive at different times to install infrastructure.

Figure 5 Failure to anticipate space requirements in special technology rooms is the leading cause of delays, cost overruns, and future reconstruction. Plan for space, power, environmental, lighting, security, and fire suppression in special technology rooms by calling on specialists to create detailed drawings of all elements to thereby plan for these requirements.



Determine how many racks you need. Leave necessary space in front of, in back of, and between the racks. Leave sufficient space between the rows of racks. The space should accommodate cable ducts next to each rack and aisles.

Figure 6 Plan for rooms containing multiple devices by using an equipment matrix to calculate space, power, and air conditioning requirements.

Quantity	Manufacturer	Model	Description	Dimension HxWxD	Weight	Temp	Humidity	Volts	Amps	Service Type	BTU
1	Compaq	20"	Monitor	16.8"x15.9"x17.7"	44lbs	50 - 95 F	40 - 80%	110	2		1,122
1	Compaq	5100	System Unit	5"x19.9"x17.5"	35lbs	50 - 93 F	20 - 80%	110	4		2,244
1	Sun	Ultra 10	System Unit	15.8"x6.9"x17.1"	44lbs	50 - 95 F	40 - 80%	110	4		1,496
1	Sun	Ultra 10	System Unit	15.8"x6.9"x17.1"	44lbs	50 - 95 F	40 - 80%	110	4		1,496
1	Sun	Ultra 10	System Unit	15.8"x6.9"x17.1"	44lbs	50 - 95 F	40 - 80%	110	4		1,496
1	Sun	Ultra 10	System Unit	15.8"x6.9"x17.1"	44lbs	50 - 95 F	40 - 80%	110	4		1,496
1	Sun	Ultra 10	System Unit	15.8"x6.9"x17.1"	44lbs	50 - 95 F	40 - 80%	110	4		1,496
1	Sun	Ultra 10	System Unit	15.8"x6.9"x17.1"	44lbs	50 - 95 F	40 - 80%	110	4		1,496
1	Sun	Ultra 10	System Unit	15.8"x6.9"x17.1"	44lbs	50 - 95 F	40 - 80%	110	4		1,496
1	Sun	Ultra 10	System Unit	15.8"x6.9"x17.1"	44lbs	50 - 95 F	40 - 80%	110	4		1,496
1	Sun	21"	Monitor	21"x19"x22"	47lbs	50 - 95 F	40 - 80%	110	3		
1	Sun	21"	Monitor	21"x19"x22"	47lbs	50 - 95 F	40 - 80%	110	3		
1	Sun	21"	Monitor	21"x19"x22"	47lbs	50 - 95 F	40 - 80%	110	3		
1	Cisco	Catalyst 5500	Switch	25"x17"x22"	150lbs	41 - 104 F	20 - 80%	110	18		5,984
1	Cisco	Catalyst 5500	Switch	25"x17"x22"	150lbs	41 - 104 F	20 - 80%	110	18		5,984
1	Cisco	Cisco 7000	Router	10.5"x17.5"x17"	70lbs.	41 - 104 F	20 - 80%	110	9		2,440
1	Cisco	Cisco 7000	Router	10.5"x17.5"x17"	70lbs.	41 - 104 F	20 - 80%	110	9		2,440
1	Misc	Data Com.	CSU/Modems						10		3,740

Projected Total BTU Load			43,010
Projected Total Electrical Load KVA			12650
Room @ approx. 40 watts psf			
Room spec. @ 75 watts psf			
Growth Factor 50%			

All of the equipment going into special technology rooms with network connections can be documented in a matrix that includes equipment types, quantities, dimensions, weight, temperature and humidity requirements, electrical draw, required electrical plugs, and British thermal units (BTUs). These in turn dictate necessary power and HVAC requirements. Once those requirements are known, the devices that enable power and HVAC can also be factored into the space requirements of the total campus environment.

### Structured Cabling System

A structured cabling system<sup>1</sup> should be part of the campus networking strategy. Cabling should encompass all communications services, including voice, video, and data. Cabling can run under the floor or on overhead ladder racks.

Modern networks with integrated voice, data, and video will contain fewer twisted pair cables. Call management systems now run on the data network using the data cables. This means there is a reduction in cabling and savings in space, power, and air conditioning requirements for former PBX equipment that is no longer necessary.

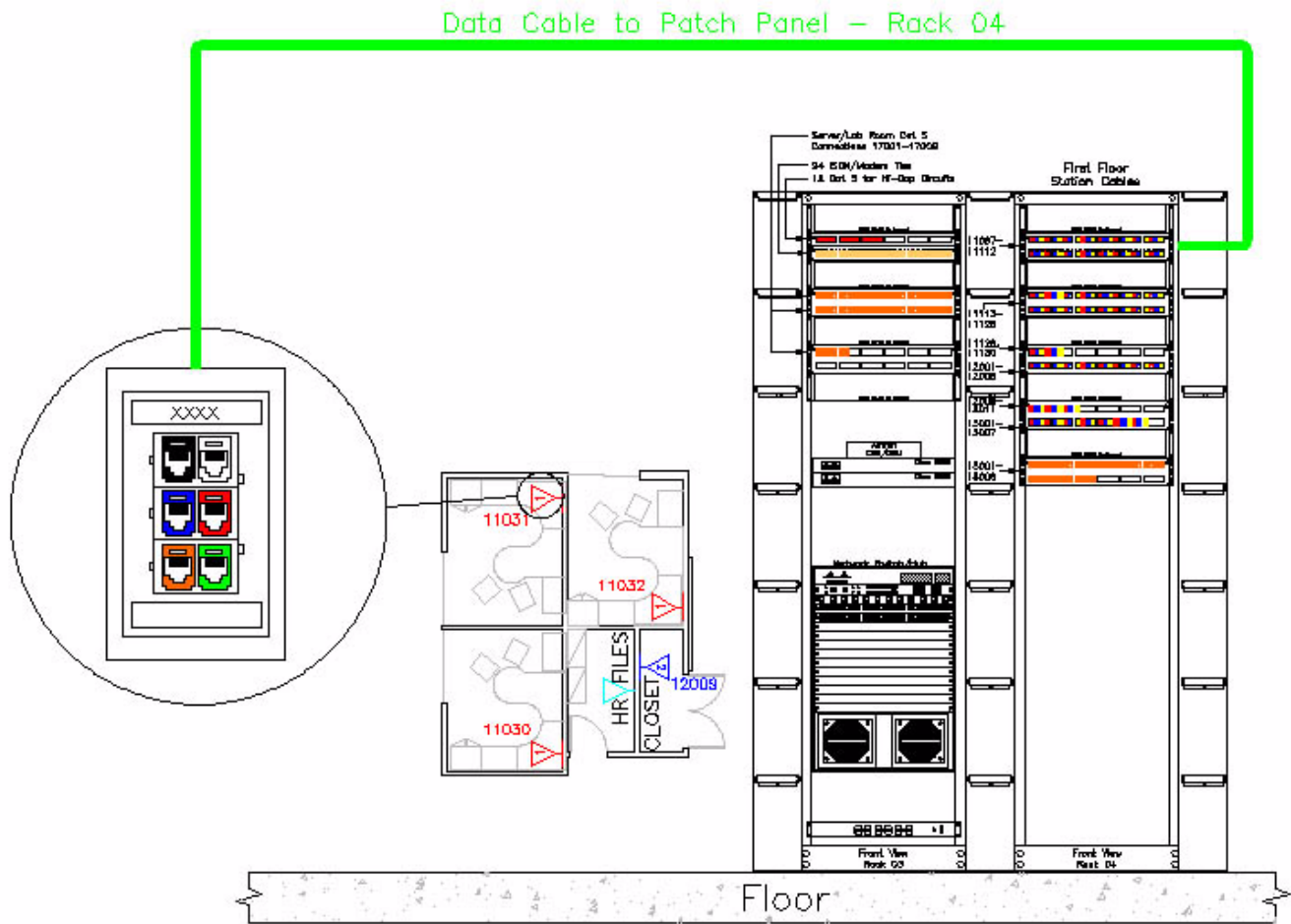
Cabling characteristics will be determined by the type and quantity of equipment in each area of each building and the number of users. Options for cabling include raised floor and ceiling racks. With a raised floor, the flow of air conditioning can be better controlled. Cabling can be fed through racks mounted on top of server cabinets in a server room.

1. Many standards for the physical infrastructure of internetworked environments are found in the Electronic Industry Association/Telecommunications Industry Standard (EIA/TIA) 568 and 569 standards. The standards detail cable types and performance, connector standards, pin outs, general structured cabling architecture, distance limits, and link performance.

In a typical environment with cubicles, overhead cabling comes down to jacks through power poles or is run under the floor and comes up via a floor monument. Large cable trays can be run through hallway ceilings. Always run data and power perpendicular to each other or otherwise separated to prevent electromagnetic fields from power feeds from affecting data cables.

A good strategy is to create a diagram showing all of the different work areas on each floor and the devices to be supplied with network connections. After understanding what kind of users there are and where they will be situated, cabling and jack requirements and layout can be defined.

Figure 7 Consider the connections, power, and space requirements for each network-connected devices—including PCs, printers, and fax machines—on each floor.

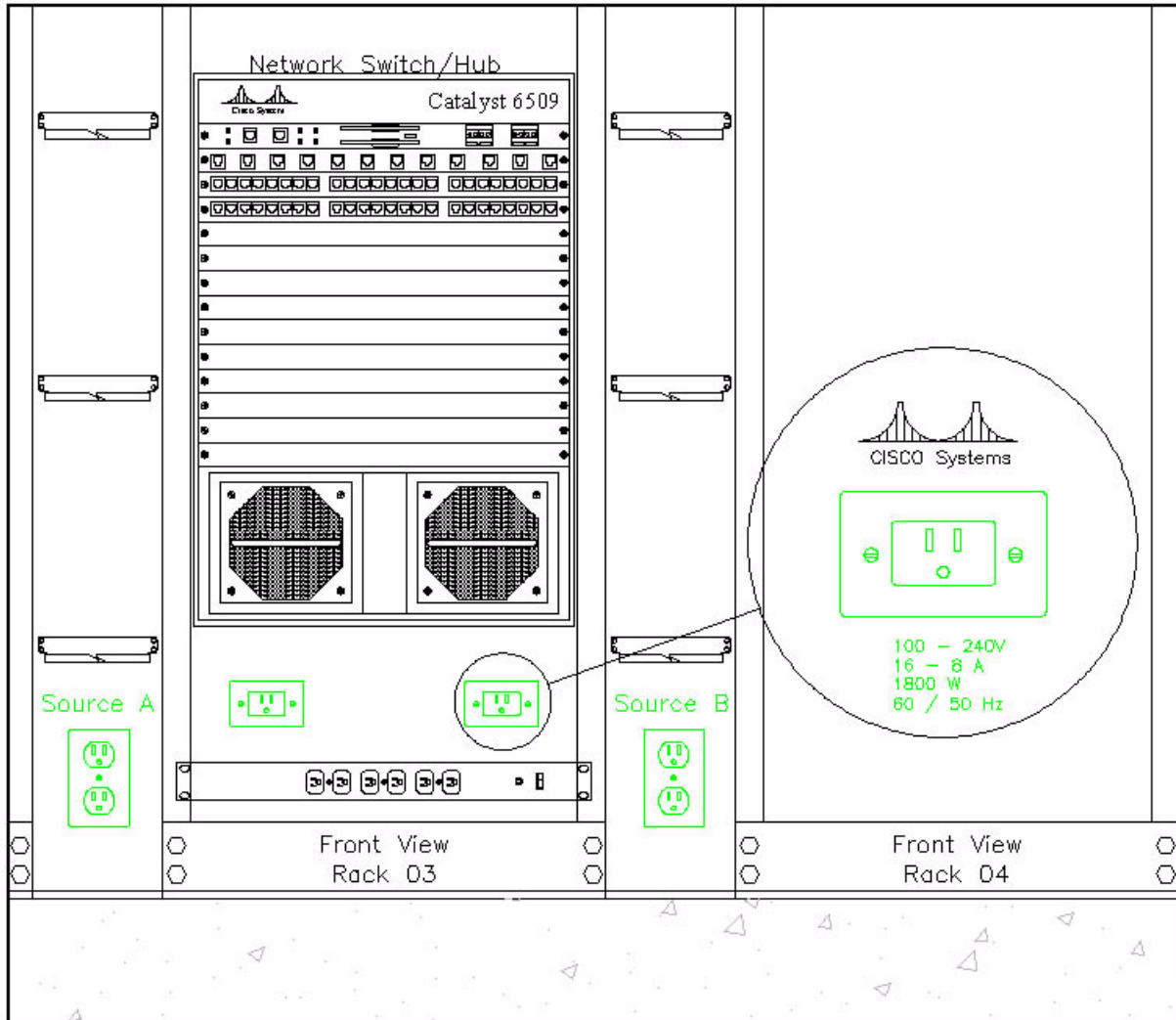


The goal is to standardize as much as possible so that different types of users (i.e., engineers, administrators, managers) can move to different parts of the buildings, if necessary. But there are always exceptions and special needs that may affect cabling changes. A company may standardize, only to discover later that more users than anticipated require multiple network services. For this reason, it is also a good idea to create a numbering scheme for each workspace. It can be utilized by many different vendors and support personnel to make changes to network connections. The consistent use of color, labeling, and numbering when preparing and maintaining records of wire and cabling also helps invaluable as the environment changes.

## Power and Electrical Requirements

Communications equipment has a variety of different power requirements, based on the type of unit. Electrical supply systems in critical facilities always include multiple services, uninterruptible power supplies (UPS), and backup generators.

Figure 8 Power requirements for each electrical device are typically found on the machine. Add this data to the matrix to calculate overall power and backup requirements. If power requirements are not listed, call the manufacturer.



When considering equipment power requirements, consider redundancy. Today, doing business on the Web means that your network must be available all the time. Redundancy translates to more space, more power, and a higher budget.

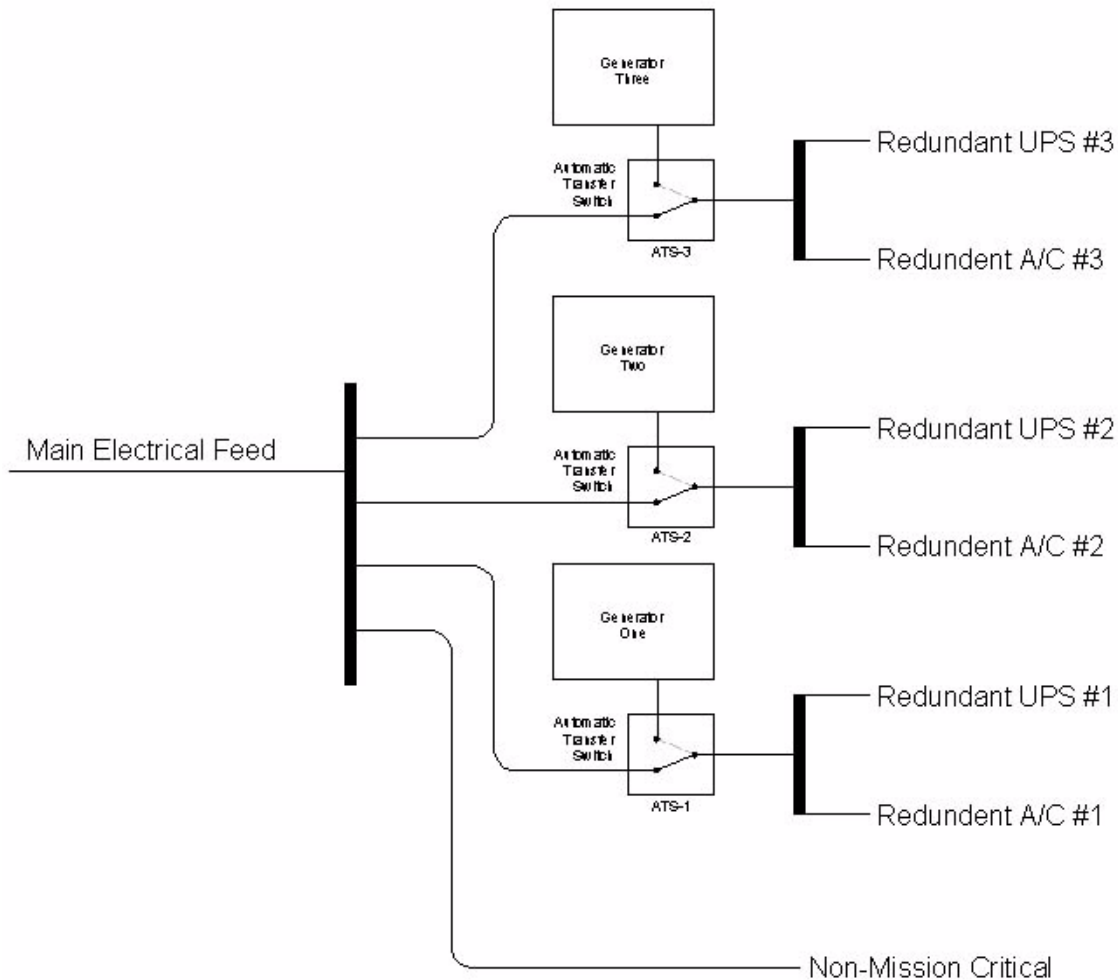
Automated Emergency Power Off (EPO) circuits should be integrated into the fire detection control panel to shut down electrical power to all computer equipment and the environmental system, and to automatically close vents and drains in the event of an emergency. Electrical power isolation equipment should be installed to eliminate power transients.

All areas with computer and networking equipment must be grounded to counter the effects of electrostatic discharge (ESD). Some environments, such as a microchip clean room, have higher ESD requirements than do others.

## Backup Power

Generators should be installed in computer facilities where 7 x 24 network availability is critical to business operations. In planning for deployment of generators, consider how close the campus is to residential units or other commercial buildings, due to the noise produced when generators are on. Also, plan for storage of fuel for generators.

Figure 9 Companies with stringent mission critical requirements build campuses that allow for 7x24x2 availability. In this example, power requirements met by two generators are supplemented by a third generator, which is used for redundancy while one of the other generators is being serviced.



Battery systems are necessary to automatically take over in the event of a power failure and allow the seconds necessary to transition to power from the backup generator systems. There are two basic types of large facility batteries: sealed and wet. Sealed batteries last about five years and are designed to power the network servers for a matter of minutes in the event of a power outage. They are the most prevalent batteries used for campus networks. Lead/acid or “wet” batteries can last up to 20 years and can provide power for network servers for a short period of time, but these batteries require separate rooms with special insulation and ventilation. The longer the requirements for running the facility, the larger the room for either variety of battery.



## Security Considerations

Security and fire suppression entail many specialized solutions, but our concern in the physical layer of the campus is on space impacts.

How secure should the perimeter of the campus and entrances and exits to the main building and other buildings be? Plan for sufficient security<sup>2</sup> spaces for environments within the campus with confidential company data, E-commerce applications, classified research and development projects, and other mission-critical functions. All wiring and cabling, power, HVAC, fire suppression, and other safety systems should all be secured within the controlled perimeter of each building. The IDFs and MDF should also be secure from unauthorized access.

Fire suppression for technology rooms can include an array of solutions, including air sampling systems, sprinkler systems, preaction, and gaseous fire retardant systems. Each system has different space and power requirements. Another approach impacting building design is to shield rooms with computer equipment from fires originating in nearby spaces by using noncombustible materials, such as gypsum board, that do not aid in combustion or add heat to an ambient fire.

Both security and fire suppression require workstations for monitoring and operation of these specialized systems. These must also be factored into design and overall space requirements.

## Heating, Ventilation, and Air Conditioning (HVAC)

Campus networks can have large air conditioning requirements, based on the equipment to be installed. The more redundant the network must be, the more air conditioning units necessary.

Air conditioning is directly related to power and space requirements. The large chillers are housed outside of campus buildings, while air conditioning units are in the rooms, either on the floor or mounted on the ceiling.

With long lead times for installation of air conditioning units and their significant space requirements, sizing air conditioning needs and translating these into a design should be done long before groundbreaking for a campus.

Modern campuses can be highly effective environments for businesses, where maximum benefits from internetworking and the Internet can be realized. As data and voice technologies continue to advance, and more and more companies work to become fully Internet-enabled, the physical requirements for a campus are becoming greater. Mission-critical modern networks require more space, more power, potentially at a higher price tag. Other important physical layer issues to be dealt with in a campus design are the size and layout of technology rooms, risers, and conduit between and within buildings. Solutions to these and other design challenges vary in single- and multi-tenant campuses.

The purpose of this document is to look at the decisions that an architect, builder, and owner will face now and in the future in designing a facility that will support future integrated networks. It provides questions to ask your client or yourself so that you can gain the best design at the lowest cost. We hope this paper conveys the need to plan for the physical requirements very early in the development of a campus. The goal is to reduce and eliminate delays that might otherwise creep into a campus project, and to do so without compromising the future network capabilities of these optimized workplaces.

## General Checklist

- Is the campus located near power grids, fire, and police services?
- What is the external vault box and conduit design connecting each building?
- Where are external generators to be housed?
- Where is the Minimum Point of Entry for service providers located?
- Where are the network communications rooms (IDFs and MDF)?
- What is the cable distribution system between the MDFs, IDFs, and the rooms?
- Does the riser system need to accommodate multiple tenants in the various campus buildings?

2. An excellent reference on facilities access control is "Critical Foundations — Protecting America's Infrastructures," available at <http://www.pccip.gov>. This report was released in 1997 by the President's Commission on Critical Infrastructure Protection and examines the vulnerabilities and threats to critical infrastructures, including telecommunications and electric power.

- How does each wire get from each IDF to each wall jack location?
- Have you ensured that every wire will be within 90 meters of the IDF on each floor, including both horizontal and vertical distances?
- Do the MDFs and IDFs all have power, grounding bars, and equipment racks?
- What fire rating does your cabling need?
- Does the distribution system have spare capacity after installation for future additions?
- Is the distribution system fully accessible after construction for future changes?

## Additional Resources

- **Cisco Systems, Inc.** See white paper “Gigabit Campus Network Design—Principles and Architecture” for a discussion of multilayer campus network design [http://www.cisco.com/warp/public/cc/sol/mkt/ent/cmpps/gcnd\\_wp.htm](http://www.cisco.com/warp/public/cc/sol/mkt/ent/cmpps/gcnd_wp.htm)
- **Teladata, Inc.** Independent technology infrastructure consulting firm since 1987; for a description of services for level 1 of campus design, <http://www.teladata.com>
- **Building Industry Cable Standard Institute (BICSI)** <http://www.biscsi.org/resource.htm> *Defines standards for the number of data ports for an office building for example (TIA568).*
- **Telecommunications Industry Association (TIA)** <http://www.tiaonline.org>  
Standards & Technology <http://www.tiaonline.org/standards/>  
Acronym resource <http://www.tiaonline.org/resources/acronym.cfm>
- **IEEE Color Book Series** <http://standards.ieee.org/catalog/industrial.html> *This series provides the most comprehensive set of guidelines used throughout the power engineering industry today. With these 12 volumes, you have immediate access to the most up to date, reliable data on implementing electric power systems in commercial and industrial environments.*
- **Network Equipment Building Standards (NEBS)** [http://www.gdc.com/home/nebs/nebs\\_detail.html](http://www.gdc.com/home/nebs/nebs_detail.html)  
*Contains criteria for personal safety, personnel property, and operational continuity.*

## Glossary

<b>Backbone</b>	A physical focal point within the campus network to which all MDF and IDF devices are attached.
<b>Conduit</b>	Heavy-duty casing used to enclose and conceal wire and provide additional protection for wires. Conduits should be sized to accommodate cables for all current and potential voice and data communications needs envisioned for a campus.
<b>Distribution Media</b>	The types of wire used to link network equipment such as phone, PC, routers, and servers to the main LAN. Media can include <i>copper wire</i> —traditional wire used for telephone systems; <i>coaxial cable</i> —two-conductor cable with a copper wire center conductor and another tubular conductor of braided wire or copper tubing, used for Ethernet communications; <i>fiber optic cable</i> —thin glass filaments that transmit signals as very high frequency light pulses; <i>twisted pair</i> —two insulated copper wires twisted together with a 4-pair total, sharing a common outer insulation. Category 5 twisted pair is standard for data communications.
<b>Intermediate Distribution Frame</b>	The IDF rooms are on each floor of campus buildings. They are connected to the network through fiber optic cables from the network backbone in the MDF via building risers. The IDFs are the source of connection for all network nodes on each floor.
<b>Main Distribution Frame</b>	The MDF room contains the network servers and switches necessary for connecting the campus LAN to external WANs and the Internet.

<b>Backbone</b>	A physical focal point within the campus network to which all MDF and IDF devices are attached.
<b>Minimum Point of Entry</b>	The MPOE is where dial tone and data services are first brought into the building. In modern campus network environments, it usually contains a fiber multiplexer for distribution of data services, so the room must be secured and air conditioned.
<b>Patch Panel</b>	Often in the IDF room, the patch panel is a high-density panel that includes a jack for every outlet fed from that room. In offices and cubicles, the patch point is typically a wall-jack faceplate or surface-mount jack box.
<b>Risers</b>	Spaces through which cables and wiring are distributed among floors of a multi-story building. In a campus network, the cables and wires that are fed through risers connect to the IDFs on each floor.



**Corporate Headquarters**  
 Cisco Systems, Inc.  
 170 West Tasman Drive  
 San Jose, CA 95134-1706  
 USA  
<http://www.cisco.com>  
 Tel: 408 526-4000  
 800 553-NETS (6387)  
 Fax: 408 526-4100

**European Headquarters**  
 Cisco Systems Europe  
 11, Rue Camille Desmoulins  
 92782 Issy Les Moulineaux  
 Cedex 9  
 France  
<http://www-europe.cisco.com>  
 Tel: 33 1 58 04 60 00  
 Fax: 33 1 58 04 61 00

**Americas  
 Headquarters**  
 Cisco Systems, Inc.  
 170 West Tasman Drive  
 San Jose, CA 95134-1706  
 USA  
<http://www.cisco.com>  
 Tel: 408 526-7660  
 Fax: 408 527-0883

**Asia Headquarters**  
 Nihon Cisco Systems K.K.  
 Fuji Building, 9th Floor  
 3-2-3 Marunouchi  
 Chiyoda-ku, Tokyo 100  
 Japan  
<http://www.cisco.com>  
 Tel: 81 3 5219 6250  
 Fax: 81 3 5219 6001

**Cisco Systems has more than 200 offices in the following countries. Addresses, phone numbers, and fax numbers are listed on the Cisco Connection Online Web site at <http://www.cisco.com/go/offices>.**

Argentina • Australia • Austria • Belgium • Brazil • Canada • Chile • China • Colombia • Costa Rica • Croatia • Czech Republic • Denmark • Dubai, UAE  
 Finland • France • Germany • Greece • Hong Kong • Hungary • India • Indonesia • Ireland • Israel • Italy • Japan • Korea • Luxembourg • Malaysia  
 Mexico • The Netherlands • New Zealand • Norway • Peru • Philippines • Poland • Portugal • Puerto Rico • Romania • Russia • Saudi Arabia • Singapore  
 Slovakia • Slovenia • South Africa • Spain • Sweden • Switzerland • Taiwan • Thailand • Turkey • Ukraine • United Kingdom • United States • Venezuela