Communication and networking

Structured Cabling System (SCS)

Definition

A structured cabling system (SCS) is a set of cabling and connectivity products that integrates the voice, data, video, and various management systems of a building (such as safety alarms, security access, energy systems, etc.).

Overview

An SCS consists of an open architecture, standardized media and layout, standard connection interfaces, adherence to national and international standards, and total system design and installation. Other than the structured cabling system, voice, data, video, and building management systems (BMS) have nothing in common except similar transmission characteristics (analog or digital data signals) and delivery methods (conduit, cable tray, raceway, etc.) that support and protect the cabling investment. This tutorial discusses the elements of a structured cabling system and the operational advantages such an approach may enable.

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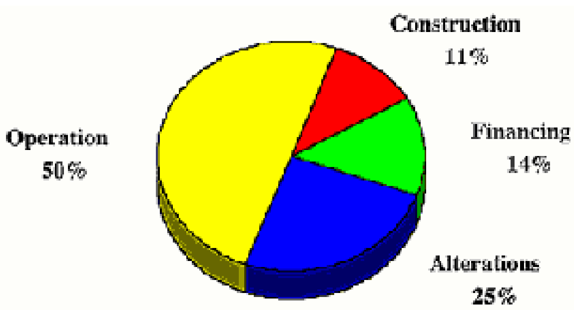
Glossary

1. Introduction

Providing an internationally standardized SCS and consolidating cable-delivery methods for all the systems can reduce initial construction costs for the cabling infrastructure of a modern intelligent building by up to 30 percent. The actual level of savings achieved depends upon the configuration and geographical pricing for material and labor. This also gives the structure an inherent ability to respond quickly and cost-effectively to the changing needs of tenants, which impacts the cost to occupy the space. In some cases, additional construction expenditures for the SCS or BMS, such as devices to optimize the use of power consumption, may be necessary to reduce the operational expenses. However, the costs for cabling-related changes can typically be reduced by 25 to 40 percent—with possible savings of up to 60 percent—for a new or renovated facility when using a total systems integration approach.



As Figure 1 indicates, typical costs for building operation and alterations over a 40-year life cycle far exceed the initial construction costs. Proper systems-integration planning to optimize the construction process can reduce these ongoing life cycle costs.

Figure 1. Typical Costs for a SCS

2. The Foundation for Systems Integration

For many years voice and data systems were cabled separately. Now it is standard practice to use a common SCS for both of these systems. Like the voice and data systems of the past, the traditional construction process separately installs each of the BMS disciplines under various divisions of a specification. The BMS typically consists of the following:

- fire, life, and safety (FLS) or fire alarm (FA)
- security and access control (SAC)

- energy management systems (EMS)
- heating, ventilation, and air conditioning (HVAC)

These BMS categories are typically cabled separately by the mech anical and electrical specifications. The voice and data cabling is rarely addressed during construction and is usually not part of the construction budget. Planning and installation are normally accomplished when the floor space is being prepared for occupancy. This means multiple cabling systems and cable delivery methods are installed during various stages of the construction.

With proper planning, the only limiting factor for complete systems integration of the voice, data, video, and BMS may be the FA system. In the United States, Article 760-54 (b) of the 1996 National Electrical Code (NEC) allows conductors of power-limited FA systems and signaling/communications circuits (Article 725/800) to share the same cable, enclosure, or raceway. In addition, Article 760-61 (d) of the NEC allows the use of the same type of cable for FAs that is typically used for the signaling/communications (voice and data) circuits. Some local codes however, especially codes in other countries, may invoke limitations or require special approvals for integrating the FA system. Yet, even if the FA cabling is installed separately, there are still substantial cost reductions and benefits that can be derived from integrating the remaining BMS.

In addition to the code requirements, there is also a need to evaluate the electrical characteristics of the systems. The voice and data systems primarily consist of analog and digital signals and have established guidelines for signal strength over distance. The BMS devices operate on current draw, circuit resistance (contact closure), or consist of analog or digital signals. Basically, each BMS terminal or device will operate over a particular cable type as long as it is located within a specified range from the equipment.

BMS devices are utilized to monitor or control a specific function. This can be equated to an output from the equipment or an input from a device. As an example, there may be a temperature sensor that gathers information and sends a signal to the equipment panel (input) and, as a consequence, the equipment sends a signal to a device that closes a damper or vent (output). Devices are primarily power -limited or communicate using low-speed protocols. The signal distance supported by the devices is usually limited by the current draw and line voltage delivered by the power supply. Typically, 24–American wire gauge (AWG) unshielded twisted-pair (UTP) cable has the capacity to handle 1 Ampere (Amp) of current draw per conductor, with a maximum of 3.3 Amps per four-pair cable.

What does this mean? The current or signal from the equipment leaves at the specified voltage level. The device requires a certain voltage level to operate. As the signal travels through the cable, the voltage drops due to resistance. Cable pair resistance is measured by shorting one end of the cable and taking a resistance reading between the conductors at the other end. A typical 24–AWG UTP cable pair has 57.2 Ohms of resistance per one-thousand feet or .0572 Ohms per foot. Circuit resistance can be measured by dividing the voltage drop by the current draw.

If a 24 Volt (V) device requires .05 Amps of current to operate and the allowable voltage drop is ±10 percent, or 2.4V, the maximum circuit distance using 24–AWG UTP cable is 839 feet (256 meters). This can be easily calculated for any cable and circuit using the following two-step formula:

1. voltage drop (2.4 V)/current draw (.05 Amps) = circuit resistance (48 Ohms)
2. circuit resistance (48 Ohms)/1 foot cable resistance (.0572 Ohms) = maximum distance (839 feet/256 meters)

Some equipment vendors state that a lower-gauge cable, such as 18 AWG, is required for proper system operation. This is typically found to be unnecessary once the electrical characteristics of the system are analyzed.

3. Planning

Statements in previous modules of this tutorial have established that it is possible to use the same type of 24–AWG UTP cable and share a common cable delivery method for all power-limited services. The next step is to determine the best way to perform systems integration. The process starts with early planning and a decision by the building owner or management to select the cabling as the first system. Once the decision is made to use a common cabling infrastructure, it is very easy to select voice, data, video, and BMS equipment that is compatible with the cabling. In fact, the sooner the consolidation of cabling systems and delivery methods is considered, the greater the potential savings and flexibility.

The Electronic Industries Association/Telecommunications Industry Association (EIA/TIA) and International Standards Organization/International Electrotechnical Commission (ISO/IEC) have created industry standards for cabling voice and data systems. These standards address the cabling and cable-delivery methods (pathways and spaces) and are based on a structured subsystem architecture or cabling elements (see Figure 2). Prior to the standards, the subsystem concept was first used for voice systems. During the 1980s, it was also adopted for data systems. Like the BMS equipment of today, there were many different types of cables and wiring methods for data systems before the standards were established. Data networks were typically unmanageable, with little or no flexibility, and new cabling was often necessary when systems were changed or upgraded.

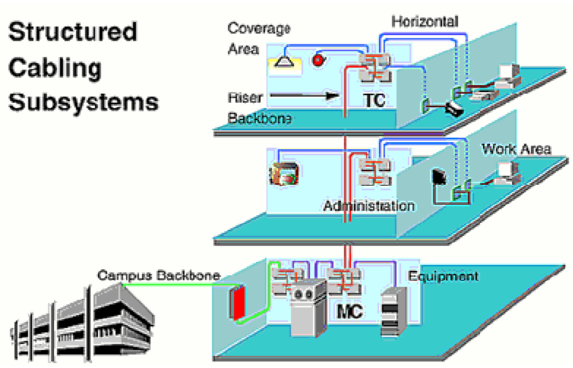


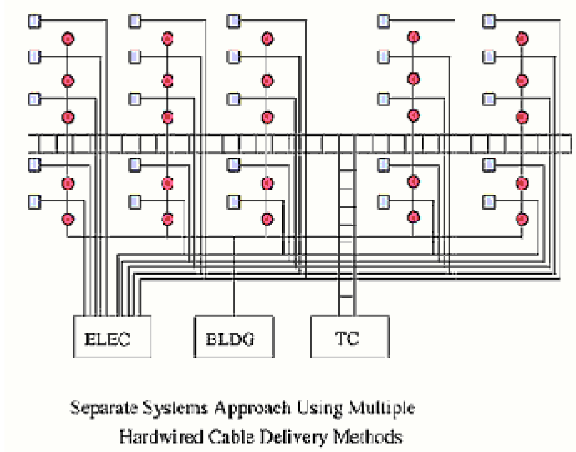
Figure 2. Subsystem Architecture

With some slight modifications (e.g., use of a coverage ar ea), the EIA/TIA and ISO/IEC documents can also be used to provide the same standardized cabling architecture for the BMS devices, systems, and applications. The cabling and cable-delivery methods can be designed for all the services with the telecommunications closet (TC) as the terminating point for horizontal cables. This is the key to the integration of cabling and delivery methods. The wallfields/distribution frames at the TC location can be combined for maximum flexibility, or individual termination fields can be established within the same TC. Therefore, a secure area for all cabling is created, thus reducing the multiple spaces required for traditional separate installations. Maintenance is also simplified since all systems are located in a common area.

Standardized cabling architecture allows a single delivery method to be designed for supporting the various horizontal cables in the work space. It can be taken a step further by incorporating the horizontal electrical services from the electrical panel into a modular partitioned raceway. This can be used instead of a traditional hardwired installation consisting of several conduit and cable-tray systems for the voice, data, video, BMS, and electrical services. Case studies show that an integrated approach can provide up to a 30-percent construction savings for cabling and delivery methods when a single high/low voltage cabling infrastructure is implemented. The majority of savings is attributed to the reduction in the amount of labor hours. By reducing labor hours, the space can typically be occupied at an earlier date. This means saving money by vacating other leased spaces sooner or collecting additional revenue from tenants that will occupy the new space.

Even if an integr ated high/low voltage raceway system is not utilized, the methods of delivery may be consolidated by using one cable-tray system for all of the power-limited services. Conduit can also be provided from the cable tray to protect critical services. With either choice, with early planning comes the ability to evaluate all the services and consolidate individual voice, data, video, and BMS using a single cable type and delivery method instead of multiple cable types and delivery methods.

Figure 3. Separate Systems Approach Using Multiple Hardwired Cable-Delivery Methods



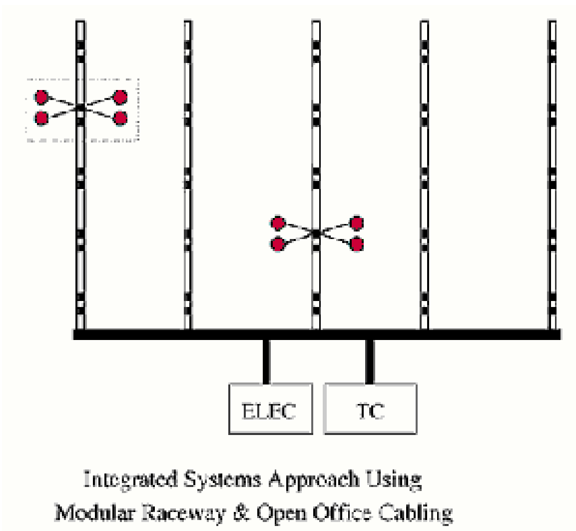


Figure 4. Integrated Systems Approach Using Modular Raceway and Open Office Cabling

The building's tenants can also realize significant savings. A traditional facility with leased space may not provide horizontal cabling for any services. This makes the setup time for tenants longer. In addition, the tenant usually pays for the voice and data cabling, along with the cost of occupying the space during setup. The cost and setup time for the tenant can be dramatically reduced by installing an open office horizontal cabling grid during the construction phase. Open-office cabling, which is actually another term for prewired zone cabling, provides a building with a marketable advantage that could mean the difference between empty space and occupied space. One month of full occupancy could pay for the entire cabling system.

With open-office cabling fast becoming the preferred method of cabling for both new construction and renovations, it is possible to provide a cabling design without knowing where any of the devices will be located. The entire design for the cabling can be based on the maximum usage of the size and type of space. As an example, a typical voice and data work area for an office can be located every 100 square feet (9 square meters), and the BMS devices can be calculated based on every 250 square feet (23 square meters). Even if an open-office cabling approach is not utilized, costs can still be reduced by consolidating the cable-delivery methods for the voice, data, video, and BMS services.

Historically, voice and data horizontal cabling has not been installed during the construction phase. Installing cabling during the construction phase is easier, minimizes damage to finished surfaces, and is reusable for the life of the structure when designed properly. New cabling does not have to be installed every time the tenants move, or when systems are changed or upgraded. This helps to eliminate cluttered floor and ceiling spaces. In addition, constant rewiring within a structure tends to cause modifications that may affect the physical structure of the building and the integrity of the technology deployed in the structure. As seen in Figure 5, systems will change many times during the life of a structure. With proper planning, it is not necessary to provide new cabling every time systems are changed or upgraded.

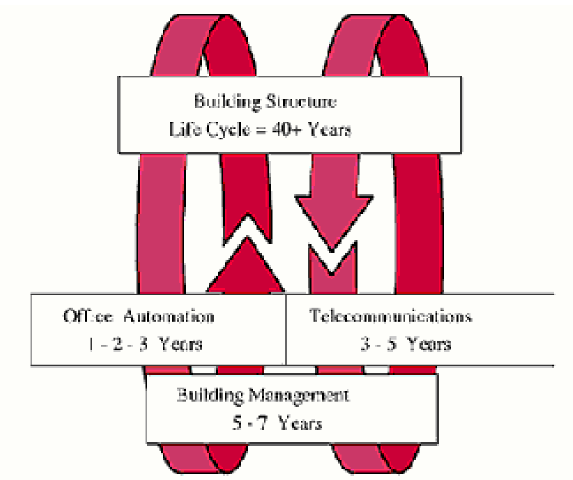


Figure 5. Life-Cycle Diagram

4. Structured Cabling for the BMSs

The SCS can provide up to a 15-percent construction savings for just the BMS installation. A traditional installation uses a heavier gauge cable which, per foot, is typically more expensive. An SCS approach provides additional components, such as administration (cross connects), equipment cabling, and a multipair riser. These SCS components, which are part of the SCS subsystem architecture, can make it possible to reduce the number of equipment panels required for the BMS configuration. In addition, since a riser backbone is required for the voice and data, it is very cost-effective to increase the riser cable size for the BMS services.

The SCS subsystem cabling approach allows the BMS equipment to be centralized, thus fully utilizing all of the available equipment ports. Any power required to operate devices, such as FA strobes or variable volume air boxes, can be distributed from the TC locations or provided locally. This may necessitate additional BMS hardware for the SCS approach since 24–AWG cable will typically power less devices per cable. However, this situation could be alleviated if BMS power supplies were manufactured with more power taps that supplied less current per tap. The power taps could even be modular with multiple appearances on a jack, which would also simplify the installation.

On the other hand, a traditional BMS installation typically distributes the equipment panels. This leaves many unused ports scattered around a facility and usually requires more equipment panels than a centralized approach. Since the traditional installation has no administration subsystem, it is neither practical nor cost-effective to run the device cables to a central equipment location.

Centralization of the BMS equipment, which can be used for most structures, is possible because of the SCS subsystem architecture. This solution can be equated to a typical private branch exchange (PBX) installation, which uses a centralized approach for providing service. A distributed PBX architecture (remote PBX cabinets) will not be used unless the distance limitations are exceeded.

Using a distributed equipment approach is typically not cost-effective for most types of equipment or systems. Sometimes the system limitations for data transmission or power require a distributed topology, but this is usually not the case for the typical low-speed and power-limited BMS equipment. Using a centralized SCS solution can reduce the combined cabling and equipment costs as well as reduce the multiple spaces typically required to house the equipment.

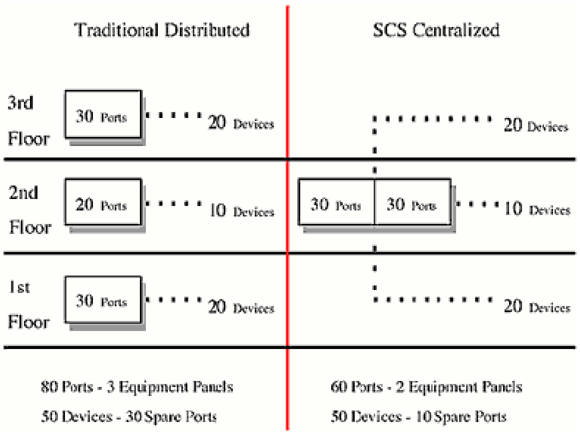


Figure 6. Traditional Distributed Approach versus SCS Centralized Approach

Installation, testing, and the electrical costs for the panels can also be reduced with a centralized equipment approach. Additionally, if an equipment panel fails, the ports can be easily reconnected to another equipment panel and retranslated. In a traditional installation, the panel—or components within the panel—would have to be replaced in order to restore service. Some vendors state that the panels must be placed in close proximity to the mechanical equipment for troubleshooting, but an RJ45-type outlet can provide plug-in capabilities for a remote hand-held tester. Centralization also allows ports from the same equipment panel to be dynamically alternated throughout a structure, which alleviates complete failures on any given floor or area if an equipment panel fails. The subsystem cabling approach also makes upgrades for the BMS equipment faster and more cost-effective. In a traditional installation, devices are wired straight from the equipment panel to the device. When the panel needs to be upgraded, the cables have to be reterminated in the new panel. This is not always easy or practical, and sometimes the device cables may not be reusable. With the subsystem cabling approach, at worst, a new equipment subsystem is provided and the devices are reconfigured at the cross connect location. The SCS approach assures economical upgrades to the equipment with minimal service outages. Data-transmission speed is rising as technology advances and more information is processed. As the BMS equipment becomes more advanced, its associated data-transmission speeds will also increase. Currently, some of the traditional BMS cabling will only support limited data rates and applications. If the right cabling is not incorporated into the structure during construction, it may require new cabling in the future.

5. Bid Specifications

Systems integration can easily be accomplished with the proper bid specifications and a decision by the building owner, developer, or executive management to select the cabling system first. Each individual equipment specification should provide, or refer to, an overview of the systems-integration concept and define the scope of work responsibilities by SCS subsystem for the equipment vendor and cabling contractor. The electrical characteristics of the cabling sh ould also be included in the specification to assure systems performance.

Once this has been provided, a bid specification for the cabling and delivery methods can be defined to integrate all the systems. By using this systems-integration approach, it is possible to reduce each equipment vendor's bid by 20 to 30 percent since cabling, delivery methods, and cable-path engineering will be provided by an integrated cabling specification.

6. Integrated SCS Cost Comparison:

Overview

This cost model compares a traditional separate systems installation to a singly designed and installed SCS. The approach can be applied to any new or renovated building project. In this case, the traditional approach uses multiple cable types and delivery methods. The SCS method uses the same cable type for all the voice, data, video, and BMS services with a common delivery method for all horizontal low-voltage and high-voltage services. The SCS open-office cabling approach also provides for additional horizontal coverage with 599 spare outlets.

Table 1. Integrated SCS Cost Comparison

Premises Configuration	**Traditional**	**SCS**
floors	5	5
square feet	100,000	100,000
square meters	9,294	9,294
horizontal cabling	homerun	open office
cable delivery	conduit/tray	raceway
work a rea s	850	850
voice/data outlets	1,700	1,700
spare outlets	0	599
BMS devices	400	400
electrical circuits	257	257

The following three modules contain the construction, labor, and operational comparisons based upon this configuration. Please note that the actual level of savings achieved depends on the configuration and the actual prices for material and labor. Also note that the spare-outlet capacity can be adjusted to meet customer needs, but 25 to 35 percent of the total voice, data, video, and BMS outlets is recommended. All cabling and delivery methods are installed in an access ceiling for this example.

7. Integrated SCS Cost Comparison:

Construction Costs

Using the configuration from the previous module, the construction-cost comparison uses typical pricing from the United States for labor, material, and engineering. Although the pricing for these items may vary, particularly outside of the United States, the concept can be applied to projects anywhere. The SCS savings is basically achieved by designing and installing a single integrated cabling system versus multiple cabling systems and delivery methods. In addition, by centralizing the BMS equipment using the SCS subsystem approach, there is also a savings associated with reducing the quantity of HVAC/EMS equipment panels.

Table 2. Constructions Costs—SCS versus Traditional

Construction Cost	Traditional	SCS
material—distribution cabling	$117,588	$173,224
labor—distribution cabling	$102,527	$102,360
material—conduit/tray versus raceway	$60,217	$85,871
labor—conduit/tray versus raceway	$86,301	$31,160
material—electrical (horizontal)	$35,083	$95,137
labor—electrical (horizontal)	$85,277	$57,160
additional HVAC/EMS equipment panels	$48,000	empty
engineering and consultation	$79,295	$78,076
project management	$61,600	$44,520
total project cost	$775,888	$667,508
SCS construction savings (14 percent)		$108,380

8. Integrated SCS Cost Comparison: Labor Hours

The integrated approach, in this example, dramatically reduces the labor hours and actually takes about half the time to implement when compared to the traditional methods. The primary labor savings comes from consolidating the horizontal-cable delivery methods and providing modular electrical services. The hours for the distribution cabling are relatively close, but the SCS approach has 599 additional outlets. More cables can be installed for about the same amount of labor because the open-office cabling approach consolidates the number of cables pulled together. In addition, all voice, data, video, and BMS cables are installed concurrently. By reducing the labor hours, the space can typically be occupied at an earlier date.

Table 3. Labor Hours—SCS versus Traditional

Labor Hours for Construction	**Traditional Hours**	**SCS Hours**
labor—distribution cabling	2,563	2,559
labor—conduit/tray versus raceway	4,658	779
labor—electrical (horizontal)	2,132	1,429
total labor	9,353	4,767
SCS labor savings (49 percent)		4,586

9. Integrated SCS Cost Comparison: Operational Costs

It is also important to evaluate the operational costs associated with moving, changing, and rearranging the voice, data, and electrical services. The costs depicted in this example are based on typical United States labor rates for the actual work to be accomplished and do not include visit charges. The comparison assumes that 15 percent of the work areas will be new and that the remaining 85 percent will be rearranged or reused. One work area consists of a voice, data, and dual electrical outlet.

If 40 percent of the work areas experience these changes (churn) over a one-year period, the SCS operational savings amount to 34 per cent. When projected over a five-year period, the savings are not only substantial but allow the building owner or manager to quickly respond to changes requested by occupants.

Table 4. Operational Costs—SCS versus Traditional

Operational Costs per Work Area	Traditional	SCS	Savings
cost per new work area (15 percent)	$202	$132	$70
cost per rearrangement (60 percent)	$88	$44	$44
cost per reuse (25 percent)	$20	$20	
40 percent churn of work areas five-year operational costs	$184,224	$121,459	$62,765
SCS operational savings	34 percent		

10. Summary

Construction costs for the cabling of the voice, data, and BMS can be reduced by up to 30 percent when integrating the cabling and delivery methods. One project team can engineer, install, and project manage the installation for all the cabling. Trade contention is reduced, scheduling is easier, and ultimately the project runs more efficiently. If something goes wrong, the customer only has to deal with one team for systems integration. The length of the overall project for engineering and installation can also be reduced by consolidating the cabling installation.

The key to this is early planning. If the systems (voice, data, fire, security, HVAC, etc.) are bid and designed separately, costs for delivering the cable will increase and flexibility will decrease. Costs can be minimized and flexibility can be increased if delivery methods are shared for the various services. How the cabling is delivered to the work areas and devices will ultimately determine the cost of changes and rearrangements. One integrated cabling system and cable-delivery method can be implemented, versus five or six individual cabling systems and delivery methods.

Moves, changes, rearrangements, and upgrades can be performed more cost-effectively, with a potential savings of 25 to 40 percent for material and labor when using an open-of fice cabling approach. There is less disruption to the work environment, which also affects the cost and performance of doing business. In addition, with only one cabling system to administer, the response time to end-user cabling requests is reduced. This also reduces the time required to maintain the cabling system. How the building is built today will ultimately determine how much it costs to live there tomorrow.

Self-Test

1. The construction costs can far exceed the operational life-cycle costs associated with a new or renovated building.
    a. true

b. false

2. An integrated systems approach does not allow management to quickly and cost-effectively respond to the changing needs of the tenants.
   a. true
   b. false
3. The 1996 NEC allows FA and communications signals to be mixed in the same cable, enclosure, or raceway.
   a. true
   b. false
4. It is possible to design a cabling infrastructure without knowing where the communications and building control devices are located.
   a. true
   b. false
5. Construction costs are increased when integrating multiple systems with a common cabling infrastructure and delivery system.
   a. true
   b. false
6. Systems integration can easily be accomplished with the proper bid specifications and a decision by the building owner, developer, or executive management to select the cabling system first.
   a. true
   b. false
7. The SCS subsystem cabling approach allows the BMS equipment to be centralized, thus fully utilizing all of the available equipment ports.
   a. true
   b. false

8. Open-office cabling, which is actually another term for prewired zone cabling, requires new cabling to be installed every time tenants move, or when systems are changed or upgraded.
    a. true
    b. false
9. Construction costs for the cabling of the voice, data, and BMS can be reduced by up to 30 percent when integrating the cabling and delivery methods.
    a. true
    b. false
10. The integrated cabling approach can dramatically reduce labor hours and usually takes about half the time to implement when compared to the separate traditional installation methods. The primary labor savings comes from consolidating the horizontal-cable delivery methods and providing modular electrical services.
    a. true
    b. false
11. With proper planning the only limiting factor for complete systems integration of voice, data, video, and BMS may be the:
    a. FA system
    b. security system
    c. HVAC system
    d. EMS
    e. all of the above
12. Typically, 24–AWG UTP cable has the capacity to handle ______ of current draw per conductor, with a maximum of 3.3 Amps per four-pair cable.
    a. 1 Amp
    b. 1 volt
    c. 2 Amps
    d. all of the above

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Correct Answers

1. The construction costs can far exceed the operational life-cycle costs associated with a new or renovated building.
   a. true
   b. false
   See Topic 7.
2. An integrated systems approach does not allow management to quickly and cost-effectively respond to the changing needs of the tenants.
   a. true
   b. false
   See Topic 3.
3. The 1996 NEC allows FA and communications signals to be mixed in the same cable, enclosure, or raceway.
   a. true
   b. false
   See Topic 2.
4. It is possible to design a cabling infrastructure without knowing where the communications and building control devices are located.
   a. true
   b. false
   See Topic 5.
5. Construction costs are increased when integrating multiple systems with a common cabling infrastructure and delivery system.
   a. true
   b. false
   See Topic 7.

6. Systems integration can easily be accomplished with the proper bid specifications and a decision by the building owner, developer, or executive management to select the cabling system first.
    a. true
    b. false
    See Topic 5.
7. The SCS subsystem cabling approach allows the BMS equipment to be centralized, thus fully utilizing all of the available equipment ports.
    a. true
    b. false
    See Topic 2.
8. Open-office cabling, which is actually another term for prewired zone cabling, requires new cabling to be installed every time tenants move, or when systems are changed or upgraded.
    a. true
    b. false
    See Topic 3.
9. Construction costs for the cabling of the voice, data, and BMS can be reduced by up to 30 percent when integrating the cabling and delivery methods.
    a. true
    b. false
    See Topic 7.
10. The integrated cabling approach can dramatically reduce labor hours and usually takes about half the time to implement when compared to the separate traditional installation methods. The primary labor savings comes from consolidating the horizontal-cable delivery methods and providing modular electrical services.
    a. true
    b. false

See Topic 8.

11. With proper planning the only limiting factor for complete systems integration of voice, data, video, and BMS may be the:
    a. FA system
    b. security system
    c. HVAC system
    d. EMS
    e. all of the above
    See Topic 2.
12. Typically, 24–AWG UTP cable has the capacity to handle ______ of current draw per conductor, with a maximum of 3.3 Amps per four-pair cable.
    a. 1 Amp
    b. 1 volt
    c. 2 Amps
    d. all of the above
    See Topic 2.

Glossary

AWG
American wire gauge
BMS
building management system
EIA
Electronic Industries Association
EMS
energy management systems
FA
fire alarm

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FLS
fire, life, and safety
HVAC
heating, ventilation, and air conditioning
IEC
International Electrotechnical Commission
ISO
International Standards Organization
NEC
national electrical code
PBX
private branch exch ange
SAC
security and access control
SCS
structured cabling system
TC
telecommunications closet
TIA
Telecommunications Industry Association
UTP
unshielded twisted-pair

