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Information and Communication Technology Systems Design and Implementation Best Practices for Educational Institutions and Facilities

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PREFACE

Revision History

April 13, 2009 First publication of this standard, titled ANSI/BICSI 001-2009, *Information Transport Systems Design Standard for K-12 Educational Institutions*

January 11, 2017 Complete revision of ANSI/BICSI 001-2009, retitled and published as ANSI/BICSI 001-2017, *Information and Communication Technology Systems Design and Implementation Best Practices for Educational Institutions and Facilities*

Document Format (Usability Features)

This standard is considered a complete revision. As such, additions, changes, and deletions to the previous text are not marked or indicated.

Translation Notice

This standard may have one or more translations available for the convenience of its readers. As translated text may contain inconsistencies when compared to the original text, if differences between the translation and the published English version exist, the English text shall be used as the official and authoritative version.

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1 Introduction

1.1 General

The telecommunications cabling, pathways and spaces infrastructure for educational facilities often requires a more diverse approach to design considerations than what is used in a commercial office building. Teachers and students may take advantage of a multitude of network resources that serve to aid in the students' educational experience. Educational facilities and campuses may contain commercial, industrial, data center, healthcare, and entertainment environments.

In addition to the needs of the cabling, pathways and spaces for an educational building, facility, or campus, consideration should be given to other facility demands such as:

- Electronic equipment electrical requirements
- Audio system clarity for outdoor, building-wide, and in-classroom systems
- Distance learning (e.g., cameras, audio)
- Video distribution, video display, and production
- Electronic safety and security
- Intelligent building management systems
- Administration and office staff

1.2 Categories of Criteria

Two categories of criteria are specified - mandatory and advisory.

- Mandatory criteria generally apply to protection, performance, administration, and compatibility; they specify the absolute minimum acceptable requirements.
- Advisory or desirable criteria are presented when their attainment will enhance the general performance of the ESS system infrastructure in all its contemplated applications.

Mandatory requirements are designated by the word *shall*; advisory recommendations are designated by the words *should*, *may*, or *desirable*, which are used interchangeably in this standard. When possible, recommendations and requirements were separated to aid in clarity.

2 Scope

This standard provides requirements, recommendations, and best practices for the design and implementation of information technology systems and their infrastructure for educational institutions and facilities. Educational facilities include, but are not limited to, public and private educational institutions and facilities serving primary, secondary, and post-secondary levels of education, as well as preschool facilities, vocational training institutions, and specialty training facilities (e.g., teaching hospitals, broadcasting schools).

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3 Required Standards and Documents

The following standards and documents contain provisions that constitute requirements listed within this standard. Unless otherwise indicated, all standards and documents listed are the latest published version prior to the initial publication of this standard. Parties to agreements based on this standard are encouraged to investigate the possibility of applying a more recent version, as applicable.

Where equivalent local codes and standards exist, requirements from these local specifications shall apply. Where reference is made to a requirement that exceeds minimum code requirements, the specification requirement shall take precedence over any apparent conflict with applicable codes.

BICSI

- ANSI/BICSI 002, *Data Center Design and Implementation Best Practices*
- ANSI/BICSI 003, *Building Information Modeling (BIM) Practices for Information Technology Systems*
- ANSI/BICSI 004, *Information Technology Systems Design and Implementation Best Practices for Healthcare Institutions and Facilities*
- ANSI/BICSI 005, *Electronic Safety and Security (ESS) System Design and Implementation Best Practices*
- ANSI/BICSI 006, *Distributed Antenna System (DAS) Design and Implementation Best Practices*

CENELEC

- EN 50173-1, *Information technology – Generic cabling systems – Part 1: General requirements*
- EN 50174-1, *Information technology. Cabling installation. Installation specification and quality assurance*
- EN 50174-2, *Information technology - Cabling installation - Part 2: Installation planning and practices inside buildings*
- EN 50174-3, *Installation technology. Cabling installation. Installation planning and practices outside buildings*
- EN 50310, *Application of equipotential bonding and earthing in buildings with information technology equipment*

Institute of Electrical and Electronics Engineers (IEEE)

- ANSI/IEEE C2, *National Electrical Safety Code (NESC)*

International Electrotechnical Commission (IEC)

- IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

International Organization for Standardization (ISO)

- ISO/IEC 11801, *Information technology – Generic cabling for customer premises*
- ISO/IEC 14763-2, *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation*
- ISO/IEC 15018, *Information technology – Generic cabling for homes*

National Electrical Contractors Association (NECA)

- ANSI/NECA/BICSI 568, *Standard for Installing Commercial Building Telecommunications Cabling*
- ANSI/NECA/BICSI 607, *Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings*

National Fire Protection Association (NFPA)

- NFPA 70®, *National Electrical Code® (NEC®)*
- NFPA 99, *Health Care Facilities Code*

Telecommunications Industry Association (TIA)

- ANSI/TIA-568.1-D, *Commercial Building Telecommunications Infrastructure Standard*
- ANSI/TIA-568-C.2, *Balanced Twisted-Pair Telecommunications Cabling and Components Standard*
- ANSI/TIA-568.3-D, *Optical Fiber Cabling and Components Standard*
- ANSI/TIA-568-C.4, *Broadband Coaxial Cabling and Components Standard*
- ANSI/TIA-569-D, *Telecommunications Pathways and Spaces*
- ANSI/TIA-570-C, *Residential Telecommunications Infrastructure Standard*
- ANSI/TIA-606-B, *Administration Standard for Telecommunications Infrastructure*
- ANSI/TIA-607-C, *Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises*
- ANSI/TIA-758-B, *Customer Owned Outside Plant Telecommunications Infrastructure Standard*
- ANSI/TIA-4966, *Telecommunications Infrastructure Standard for Educational Facilities*

4 Definitions, Acronyms, Abbreviations, and Units of Measurement

For the purpose of this standard, the following definitions, acronyms, abbreviations, and units of measurement apply.

4.1 Definitions

audio visual — Materials, such as films and sound or audio recordings, that present information in audible and pictorial form.

backbone cabling — Backbone cabling is the inter-building and intra-building cable connections in structured cabling between entrance facilities, equipment rooms and telecommunications closets. Backbone cabling consists of the transmission media, main and intermediate cross-connects and terminations at these locations.

balun — An impedance matching transformer used for coupling two electrical circuit elements, where one is balanced (balanced twisted-pair) and the other is unbalanced (coaxial cabling).

building automation system — Equipment and telecommunications infrastructure that supports monitoring, control, operation, and management of building services.

cabinet — A container with a hinged cover that may enclose telecommunications connection devices, terminations, apparatus, wiring, and equipment.

cable tray — A support mechanism used to route and support telecommunications and other cable. Cable trays may be equipped with side walls or barriers to constrain a cable's horizontal placement or movement.

connectivity — The patch panels, cabling, connectors, and cable management used to create and maintain electrical and optical circuits.

consolidation point — A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

cross-connect — A facility enabling the termination of cable elements and their interconnection.

cross-connection — A connection scheme between cabling runs, subsystems, and equipment using patch cords or jumpers that attach to connecting hardware on each end.

entrance facility (telecommunications) — (1) An entrance to a building for both public and private network service cables (including wireless), including the entrance point of the building and continuing to the entrance room or space. (2) A facility that provides all necessary mechanical and electrical services for the entry of telecommunications cables into a building and that complies with all relevant regulations.

equipment room (telecommunications) — An environmentally controlled centralized space for telecommunications and data processing equipment with supporting communications connectivity infrastructure.

horizontal cabling — (1) The cabling between and including the telecommunications outlet/connector and the horizontal cross-connect. (2) The cabling between and including the building automation system outlet or the first mechanical termination of the horizontal connection point and the horizontal cross-connect.

horizontal cross-connect — A cross-connect allowing horizontal cabling to be interconnected to backbone cabling. A horizontal cross-connect may also be known as a floor distributor.

hybrid cable — An assembly of two or more cables, of the same or differing types of media, categories designation, etc., covered by one overall sheath.

master station	An input and output point within a communications system, which is connected to one or more remote stations and may be connected to other master stations.
multiuser telecommunications outlet assembly	A grouping in one location of several telecommunications outlets/connectors. A multiuser telecommunications outlet assembly may also be known as a *MUTOA*, *multi user telecommunications outlet*, or *MUTO*
network	An interconnected system of computers, peripherals, and other equipment (e.g., servers, controllers) that transmits, receives, and shares commands, files, and messages.
post-secondary school	A facility that supports the education of children and adults that have completed secondary school (or can demonstrate an equivalent of experience). A post-secondary school is known by many terms, including *college*, *vocational school*, *trade school*, and *university*.
primary school	A facility that supports the education of children, usually between the ages of 5-11 yrs of age. A primary school may also be known as a grade school, elementary school.
rack	An open structure for mounting electrical and electronic equipment.
secondary school	A facility that supports the education of children, usually between the ages of 11-16 yrs of age. A secondary school may also be known as a *high school* or *senior school*.
telecommunications enclosure	A box or cabinet used to house telecommunications equipment. Enclosures are often wall-mounted, but may be mounted in other locations, such as the floor or ceiling.
telecommunications room	A telecommunications space that differs from equipment rooms and entrance facilities in that this space is generally considered a floor-serving or tenant-serving (as opposed to building- or campus-serving) space that provides a connection point between backbone and horizontal cabling.
university	See *post-secondary school*

4.2 Acronyms and Abbreviations

Abbreviations and acronyms, other than in common usage, are defined below.

24/7	twenty-four hours a day, seven days a week
AFF	above finished floor
AHJ	authority having jurisdiction
ATM	automated teller machine
AV	audio/video
AWG	American Wire Gauge
BAS	building automation system
BYOD	bring your own device
CATV	community antenna television system
CCTV	closed-circuit television
COAM	customer owned and maintained
CP	consolidation point
DVD	digital versatile disk
DVR	digital video recorder
EF	entrance facility
EMI	electromagnetic interference
ER	equipment room
ESS	electronic safety and security
GPS	global positioning system
HVAC	heating, ventilating, and air conditioning
ICT	information and communication technology
IPTV	Internet protocol television
IR	infared
IT	information technology
LAN	local area network
MIDI	musical instrument digital interfaces
MUTOA	multiuser telecommunications outlet assembly
OSP	outside plant
PA	public address
PC	personal computer
PIN	personal identification number
PoE	power over Ethernet
PON	passive optical network
POS	point of sale
PTZ	pan/tilt/zoom
RF	radio frequency
SNR	signal-to-noise ratio
TE	telecommunications enclosure
TR	telecommunications room
TO	telecommunications outlet
USB	universal serial bus
VCR	video cassette recorder
WLAN	wireless local area network

4.3 Units of Measurement

The units of measurement used in this standard are metric. Approximate conversions from metric to U.S. customary units are provided in parentheses; e.g., 100 millimeters (4 inches).

Units of measurement used in this standard are defined below:

°C	degree Celsius
°F	degree Fahrenheit
dB	decibel
dBm	decibel milliwatt
ft	foot
Gb/s	gigabit per second
in	inch
m	meter
mm	millimeter
V	volt

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5 Telecommunications Infrastructure

5.1 Introduction

While an educational facility is commonly associated with the classroom and its immediate supporting spaces, an educational facility may incorporate more functions than just the classroom. This section provides the common requirements and recommendations for the telecommunication infrastructure with additional information provided for specific functions and systems in the following sections.

5.2 Topology

5.2.1 Star Topology

5.2.1.1 Requirements

The topology for horizontal and backbone cabling shall be configured as a star (horizontal) or hierarchical star (backbone). See Figure 5-1 for an example of a hierarchical star topology.

5.2.1.2 Recommendations

Horizontal cabling topology should be planned to incorporate the deployment of other services such as electronic safety and security (ESS) (e.g., security cameras, access control devices), audio visual, and other specialty applications that may reside on the information and communication technology (ICT) network along with voice and data services.

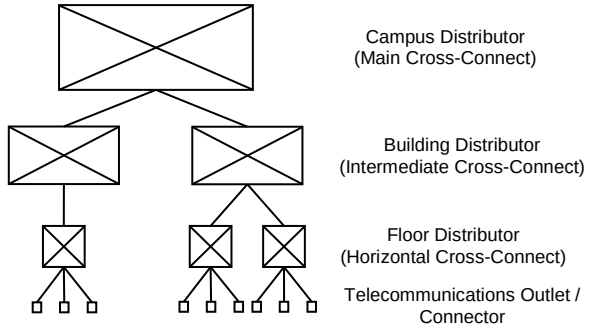

Figure 5-1
Hierarchical Star Topology

5.2.2 Non-Star Topologies

The required star topology for the structured cabling system may be supplemented (but not replaced) with cabling installed in a non-star configuration to accommodate other ICT services and associated cabling infrastructure. For example, backbone cabling may be installed between floor distributors to accommodate a ring topology. Additionally, some applications such as broadband coaxial cabling used for broadcast services or closed circuit television (CCTV) services is typically installed using a bus or tree topology. Examples of non-star topologies that are commonly used are shown in Figure 5-2.

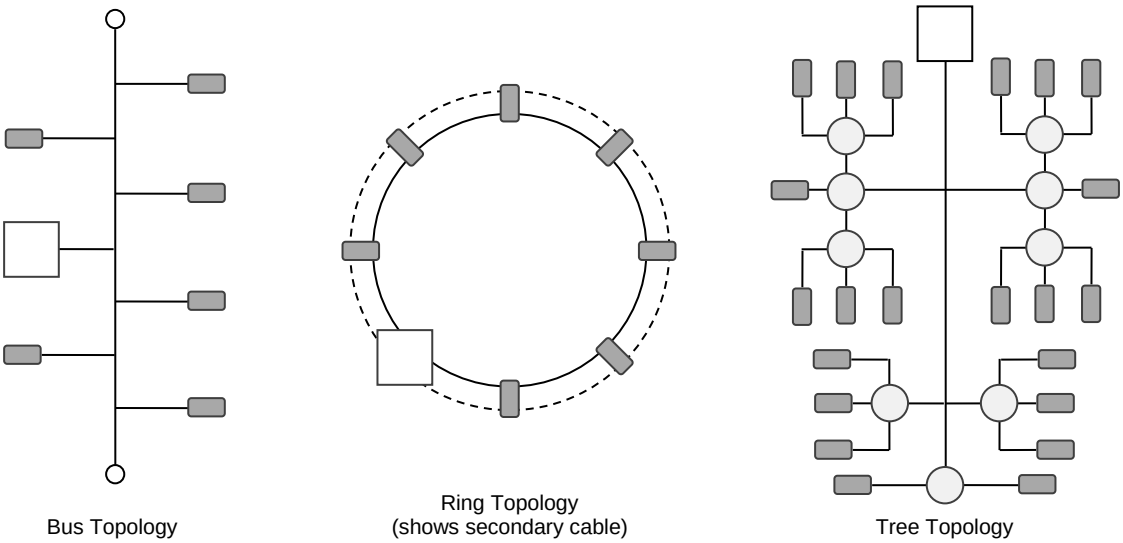

Figure 5-2
Examples of Non-Star Topologies

6 Special Systems

6.1 Community Antenna Television (CATV) System

6.1.1 Introduction

Television is an important tool for schools. It can be used in the following ways in the classrooms and on campus:

- A channel produced on campus for making announcements
- A channel produced on campus for enabling teaching by one teacher to multiple classrooms or remote buildings
- A channel produced on campus for the campus or community to train in multimedia production or show student projects or air extra-curricular activities
- To show live news events as they are happening
- To show education shows for discussion or reinforcement of class content (to accomplish this objective campus or teacher DVRs may be needed to show programs aired at different times than scheduled class time)
- To show sports channels in athletic areas
- For teacher entertainment after school hours when doing room decoration or preparation for the next day

On a campus, there are three types of television distribution:

- Analog
- Digital
- IP

These systems may also be used to broadcast signals not only from the community source but also from an onsite studio or room to room by sub-band carrier, which is re-modulated at the local headend system.

NOTE: Since June 13, 2009, full-power television stations in the United States have been required to broadcast exclusively in a digital format. However, most existing schools have an infrastructure that was installed for analog television. The same infrastructure can be used for digital television and should not need to be replaced from the headend to the stations. The headend will most likely need some work to decode and re-modulate incoming cable television for distribution or to combine over the air signals for distribution.

6.1.2 Topology

Analog and digital television signals start at a headend and are then distributed either using a trunk and tap or home run (star) topology (See Figure 6-1 and Figure 6-2). Both trunk and tap and home run topologies use an amplifier in the headend. A trunk and tap will then use taps to provide cabling for outlets and allow the trunk to continue, whereas a homerun will use splitters to provide cabling to outlets. A subtle, but key, difference is that a tap is typically a passive device with large trunk and tap topologies, potentially requiring additional amplifiers.

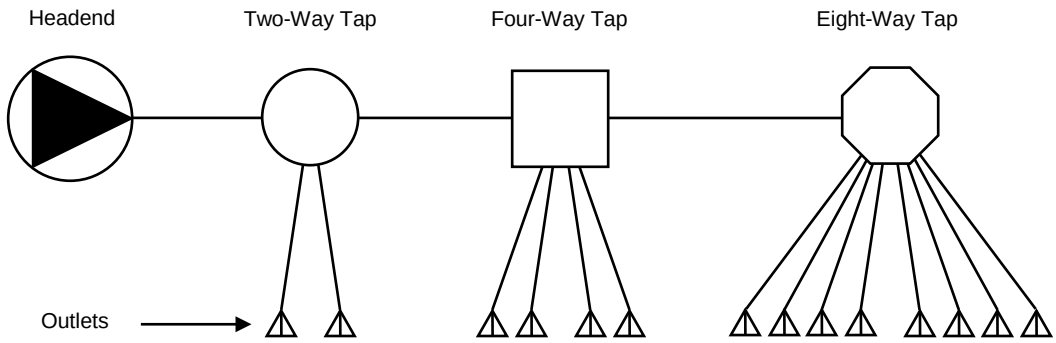

Figure 6-1
Television Trunk and Tap Topology

7 Classrooms

7.1 Introduction

As technology has evolved from the analog to the digital age the classroom access, teaching methods and learning techniques have also had to adapt. All of this must be done in a safe, secure and reliable manner while accommodating users of a wide variety of abilities and expertise. School IT departments are now responsible for networks and AV systems that must accommodate a large number of users with various school devices, utilizing high volumes of data for a variety of reasons (i.e., on-line testing, video streaming, application and lesson delivery, etc.), while trying to meet high user expectations for network uptime as well as the demand that the myriad number and types of user provided devices (bring-your-own-device or BYOD) should also be supported regardless of the additional complexity of support.

The following sections provide a general overview of the classroom needs followed by sections for elementary, middle, and high schools as well as vocational, college, and university levels to indicate some of the possible differences in the technologies that may also be required to be supported at each instructional level.

7.1.1 General Overview

The main goal of the designer is to integrate the technology into the fabric of the classroom, making it an ever-present, but not dominating, learning tool. Networking classrooms poses special challenges to the workspace and network designer. Existing schools seldom have the cabling pathways needed to support new network technologies, and classroom work surfaces must function both as computer tables and as workspaces for many, diverse learning activities.

The schools of today and the future require that new and existing classrooms provide robust and secure wireless connectivity, an interactive digital whiteboard or its equivalent touch technology, and a teacher work area centralizing all network and AV connections. It is also advisable to provide data outlets to connect devices that could require higher bandwidth or specific secure LAN connectivity. The AV connections may include large touch screen monitors or projectors with interactive whiteboard technology along with appropriate input devices. Another common method is to have “technology carts” that collect laptops and tablets, providing a central power recharge location as well as centralized software updates for all units in use.

Sound enhanced audio technologies should be considered. A sound enhancement system typically consists of a wireless microphone, that amplifies the teacher’s voice 8-10 decibels on average, and evenly distributes the sound through speakers strategically placed around the classroom (ideally located in the ceiling). These systems usually come with a hand-held microphone for the students to share when speaking aloud, so that students can also benefit from hearing their peers. This even distribution of the speaker’s voice should create a positive signal-to-noise ratio (SNR) of approximately +15 dB in ALL listening areas of the classroom. Implementing a sound enhancement system will also require an analysis of reverberant sound in older structures or in areas where the ceiling is higher than average. The addition of noise control baffles (panels) made of fiberglass or other suitable materials may be necessary to act as a sound barrier, assuring the SNR is kept within limits.

7.1.2 Elementary Classroom

7.1.2.1 Overview

In elementary classrooms, the emphasis is placed on engaging the student with the discovery of content, promoting discussions, and enhancing creativity. Safe and childproof components in classrooms used by younger students should be reviewed and specified. Quality in the installation process is important since students are curious and might attempt to disconnect components. Special consideration should be given to the use of ARC fault and GFI electrical circuitry especially in Primary (PreK-2) classrooms.

7.1.2.2 Recommendations

All aspects of the General Overview should be considered during the design. Typically in Elementary classroom, there will be some computers and/or printers/scanner that are directly connected to the local area network (LAN). Portable devices (laptops, tablets, etc.) will generally make use of the wireless networks. Due to the typical proximity of sinks and rest rooms in Primary elementary school classrooms, spillage of liquids could be a factor so appropriate distances and/or waterproof outlets should be specified.