BUAS 1050
COURSE

GEORGIA PIEDMONT TECHNICAL COLLEGE
INDUSTRIAL & TRANSPORTATION TECHNOLOGIES

Building Automation Systems Program

BUAS 1050 Building Automation Systems Networking

Courtesy of National Science Foundation – BEST Center
www.BESTctr.org

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BUILDING AUTOMATION SYSTEMS FUNDAMENTALS

Course Documentation

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Catalog description

Building Automation Systems (BAS) Networking presents the fundamentals concepts of data transmission in various media types. The course is closely aligned with CompTia's Network+ Certification and assists students in their preparation for that credential. Topics include network fundamentals, standards, OSI model, IP protocol, network signal transmission, media, protocols, physical topologies, logical topologies, hardware, typical BAS networks and subnetworks.

Class Hours

Lecture Hours: 30

Laboratory Hours: 31

Units

Semester Credit Hours: 3

Entry skills needed

- BUAS 1020 – Building Automation Systems Electrical Concepts I
- Basic computer skills
- College-level reading and writing skills
- College-level math skills

Syllabus

See Appendix A for sample syllabus, course schedule, and policies. For lesson topics to include in course, see Exit Skills.

Student learning outcomes

Network Fundamentals

Understand the basic terminology and principles of network communications.

Standards & Organizations

Understand the various standards and organizations which impact the information technology and communications industries.

OSI Model

Gain an appreciation of the OSI model and how that model provides a basis for understanding the levels of network communication.

Transmission Control Protocol / Internet Protocol

Understand the purpose of the suite of protocols which make up TCP/IP.

Network Signal Transmission

Understand the basics of signal transmission.

Network Media

Understand the various transmission media types and their properties.

Cabling Standards

Understand the standards which govern cabling.

Protocols

Understand the basics of communications protocols.

Physical Topologies

Learn about the physical topologies of networks.

Logical Topologies

Understand the principles of logical topologies.

Network Hardware

Gain an understanding of network hardware equipment and application.

Typical BAS Networks

Learn the fundamentals of basic BAS network types.

Exit skills

Course content to achieve outcomes listed above:

Network Fundamentals

1. List the advantages of network communications.
2. Define LAN, MAN, WAN, NIC, node, connectivity device, segment, backbone, protocol, transmission media, addressing, client, server, and workstation.

3. Explain the advantages of networks versus stand-alone devices.

Standards & Organizations

1. Discuss the purpose and functions of the following standards organizations: EIA/TIA, ANSI, IEEE, ISO, ITU, ISOC, IANA, and ICANN.

OSI Model

1. Explain the purpose of having an OSI model.

2. Discuss the seven layers of the OSI model and explain how they work together.

3. Contrast the layers of the OSI model.

Internet Protocol

1. Paraphrase the definitions and/or meanings of the following terms and concepts: unique logical addressing, dotted decimal notation, binary to decimal conversion, decimal to binary conversion, classful addressing, IPv4, IPv6.

2. Convert binary numbers to decimal and decimal numbers to binary.

3. Articulate the limitations inherent in IPv4 addressing and the need to move to IPv6 addressing.

Network Signal Transmission

1. Explain the following terms: analog signals, digital signals, simplex, half-duplex, full-duplex, multiplexing, throughput, bandwidth, noise, attenuation, latency, frequency, wavelength, phase, pulse, repeater, and amplifier.

2. Compare and contrast analog and digital signals.

3. Observe an analog signal and digital signal on an oscilloscope.

Network Media

1. Explain the theory of how signals are transmitted across coaxial, twisted pair, and fiber-optic cables and the advantages and disadvantages of each.

2. Compare and contrast the common types of coaxial cable.

3. Compare and contrast the various types of twisted pair cable.

4. Compare and contrast the types of fiber-optic cable.

5. Observe an instructor properly place an end-connector on sections of coaxial, twisted pair, and fiber optic cables.

Cabling Standards

1. Define the following terms: cable plant, demarcation point, backbone wiring, equipment room, telco closet, horizontal wiring, and work area.

2. Discuss TIA/EIA's 568 Commercial Building Wiring Standard.

Protocols

1. Summarize the function of each of the following protocols: TCP, IP, UDP, ARP, and ICMP.

2. Discuss the terms: routable protocol, TCP segment fields, flags, handshake, connection-oriented protocol, subnet mask, static IP addressing, dynamic IP addressing, Bootstrap protocol, dynamic host configuration protocol, automatic private IP addressing, domain name service, port numbers, Telnet, file transfer protocol, and packet internet grouper.

3. Compare and contrast the protocols in the TCP/IP suite.

Physical Topologies

1. Discuss the following physical topologies: bus, ring, star, star-wired ring, star-wired bus, serial backbone, distributed backbone, collapsed backbone, and parallel backbone.

2. Compare and contrast each of the major types of physical topologies and predict under which conditions each might be best applied.

Logical Topologies

1. Define the following terms: circuit switching, packet switching, multi-protocol label switching, collisions, collision detection, collision domains, and Ethernet switches.

2. Compare and contrast various Ethernet standards like 10BASE-T, 100BASE-T, 1000BASE-T, 10GBASE-T, SX1000BASE-X, etc.

Network Hardware

1. Describe the following types of network hardware in terms of name, function, and use: NIC, internet bus standard, peripheral bus standard, PCMCIA, USB, IEEE-1394, IRQs, repeaters, hubs, bridges, switches, and routers.

2. Draw a diagram using Microsoft Visio depicting a LAN, MAN, and WAN showing all the necessary devices and locations of network hardware necessary for proper functioning.

3. Construct a small network of several desktop computers and network hardware and test it for proper operation.

Typical BAS Networks

1. List the various types of network protocols and standards being used for interoperability.
2. Describe the advantages and disadvantages of BACnet, LonWorks, Niagara AX, and Modbus.
3. Compare and contrast BACnet and LonWorks.
4. Consider what advantages interoperable BAS network protocols provide to building owners and operators.

Course materials

Principal text

Dean, T. (2009). *CompTIA Network*+. Boston, MA: Cengage Learning. ISBN #: 978-1-59863-878-3

Lecture materials and handouts

This course is strictly an overview course and makes significant use of online resources.

DDC Online (Intro. to digital control systems, Input/Output tutorials):
www.ddc-online.org

Purdue Owl writing & style resources: https://owl.english.purdue.edu

Presentation tools by Prezi: www.prezi.com

Other reference materials

None required

Software needed

Microsoft Visio or equivalent; automation management software

Lab setup and materials

- Workstations with electrical outlets
- Wire strippers
- Power supplies
- Network routers
- Network hubs
- Network switches
- Cat 5 cable
- RJ45 cable crimpers
- RJ45 connectors
- RG6 coaxial cable
- Coaxial cable tools
- RG6 connectors
- 18/2 twisted shielded pair – RS485 cable
- Application specific controllers
- Control screwdrivers
- Electrical tape

Equipment & instruments required

- Multi-meter & clamp-on meter
- Voltage proximity sensor
- Scopemeter
- Oscilloscope

Samples of weekly assignments

BUAS 1050 – BAS Networks Assignment # 1 – Straight-through and crossover cables

Location: GPTC BAS Laboratory

Purpose: To learn the functions of and how to create straight-through and crossover cables.

Materials:

- Cat 5 cable
- Cat 5 crimpers
- RJ45 connectors

Description: Students will learn the pin configurations of TIA/EIA's 568A and 568B standard terminations in creating straight-through and crossover cables.

Individual students will be provided with approximately 10 feet of Cat 5 cable, wire strippers, RJ45 crimpers, and RJ45 connectors. Each student will strip the wires according to the procedures outlined in their Network+ textbook, and follow the steps in creating a crossover cable which can be used for connecting two workstations without an interposing connectivity device, or in connecting two hubs together through their data ports.

Next, the students will create a straight-through cable by creating RJ45 ends with the same TIA/EIA 568 standard; either the A or B standard is fine as long as the student uses the same standard for both ends. This cable is used for connecting a workstation to a router or hub.

Once the cables are completed, they will be given to the instructor for testing and all laboratory tools will be returned to their appropriate location.

Grading: Grading will be by rubric which is available for review in Angel LMS. Elements of grading include cable functioning, neatness, effective cable stripping, and following directions.

Project

BUAS 1050 – BAS Network Course Project

Location: GPTC C-Building

Purpose: Students will learn how to initialize controllers on an RS-485 network and how to provide a network address to two automation-level building controllers and access them through a hub.

Materials:

- Automation-level building controllers (2)
- Application-specific controllers (10)
- Transformers 120/24V, 40VA (12)
- Terminating resistor (1)
- Cat 5 cable
- Cat 5 crimper
- RJ45 connectors
- Network hub
- Wire strippers / Cable strippers
- NEMA 1 enclosures for application-specific controllers (12)
- 18/2 twisted, shielded pair (1000' roll)
- Laboratory computer with automation management software

Description:

Students will work in groups of four to initialize two automation-level building controllers and ten application-specific level controllers which will rest on an RS-485 sub-network off one of the automation-level controllers. Each student group will have one week during the semester after the mid-point (instructor-assigned) to complete the project.

All of the controllers will be powered up and initialized in the laboratory. Each controller will have its own transformer power supply, and will be connected one at a time based upon a drawing provided in the lab.

The automation-level controllers will be manually addressed with the integral DIP switches, and students will create both straight-through and crossover cables as necessary for connecting the controllers to the hub and the workstation to the hub. Once all connectors are completed and the automation-level controllers are powered up, the instructor will introduce the group on how to access the controllers through the automation software and through a user access object created specifically for that student group. Students will then enter the provided IP and Subnet addresses in each controller. Upon proving network communications between the automation-level controllers and the workstation, students will focus on the application-specific portion of the project.

Students will run a RS-485 network from one of the automation-level controllers to ten application-specific controllers and initialize them, one-by-one, as per specific instructions provided in the laboratory. Once all the controllers have been initialized and are communicating to the building controller, various network communication issues will be introduced and the student will record the effect.

The communication issues will be introduced in a specific way as per instructions provided in the laboratory under the following categories:

- Terminating resistor of incorrect values
- RS-485 network branching
- RS-485 network exceeding maximal length
- RS-485 shield ungrounded
- RS-485 shield not continuous
- RS-485 incorrect polarity on one application-specific controller
- RS-485 network with incorrect cable size
- RS-485 with two application-specific controllers with identical address

For each of the problems introduced, the effects will be recorded on network communications as monitored by both the Rx/Tx LEDs and the automation-level software for eventual inclusion in the project report to be turned in at the end of the semester and also the project presentation.

Grading:

Grading will be by rubric which is available for review in Angel LMS. Elements of the rubric include completeness of report, accuracy of findings, descriptions of methods, neatness, conclusions drawn, returning all materials and controllers to their original state.

Presentation grading will be by standard communications rubric and available on Angel LMS. Each group will have 10 minutes at the end of the semester to present their findings.

Assessment

Methods

- Discussion board participation (each week in Angel learning management system)
- Homework – Pre-lab completion prior to class
- Classroom participation & attendance
- Quizzes (8) – Delivered through Angel learning management system & due by Sunday night of each respective week
- Course exams (2, mid-term & final exams) – Delivered through Angel learning management system & due by Sunday night of each respective week
- Student team presentations (1 at term end, using Prezi) – Presenting their project findings
- Course project (1 assigned at mid-term) – Turned in prior to student team presentations at the end of the term

Sample test questions

From final exam:

1. What type of cable is used to connect two workstations without a connectivity device?
- ☐ Straight-through cable
- ☐ Star cable
- ☐ Parallel cable
- ☐ Crossover cable

2. Please describe how to make a crossover cable.

3. A distinct communication pathway between nodes is known as a _____.
- ☐ Channel
- ☐ Highway
- ☐ Throughput
- ☐ Network

4. What term is used to describe the situation when signals can travel in two directions over a medium simultaneously?
- ☐ Complex
- ☐ Simplex

- ☐ Full-duplex
- ☐ Half-duplex

5. What IEEE standard pertains to wireless communications?

- ☐ 802.1
- ☐ 802.3
- ☐ 802.5
- ☐ 802.11

6. Which layer is considered the lowest level of the OSI model?

- ☐ Presentation
- ☐ Network
- ☐ Physical
- ☐ Transport

7. Which organization promotes international technological standards to facilitate global exchange of information and barrier-free trade?

- ☐ ITU
- ☐ ISO
- ☐ TIA/EIA
- ☐ ICANN

8. Which network backbone is considered the most robust?

- ☐ Collapsed
- ☐ Distributed
- ☐ Parallel
- ☐ Serial

Adaptability to on-line format

Much of this course content can be delivered online with links to soft skills videos, manufacturer's presentations, tutorials, wholesaler websites, and others.

Appendix A – Sample syllabus

Georgia Piedmont Technical College
BUILDING AUTOMATION SYSTEMS NETWORKING
COURSE BUAS 1050 CRN 51111
SEMESTER SPRING 2012
OUTLINE, SYLLABUS, & ORIENTATION INFORMATION

FACULTY INFO

Mr. Brian Lovell
Clarkston Campus Office: C-13 Email: lovellb@gptc.edu Phone: 404-297-9522 Ext.: 1265
Office Hours: M, T 9:00 - Noon (By Appointment)

Division Chair: Ms. Natalie Kostas
Clarkston Campus Office: Industrial Dept.
Email: kostasn@gptc.edu Phone: 404-297-9522 Ext.: 1216

CLASS TIMES

Monday / Wednesday: 7:00 pm - 8:15 pm

CREDIT HOURS & PREREQUISITES

The federal definition of a semester credit hour is one hour of classroom instruction and two hours out of class student work each week.
3 / BUAS 1040

INTRODUCTION& COURSE DESCRIPTION

BAS Networking provides the student a framework for understanding the basics of networked systems.

COURSE COMPETENCIES

See Exit Skills in this document.

STUDENT LEARNING OUTCOMES

See Learning Outcomes in this document.

TEXTBOOK TITLE (required)

"CompTIA Network+ 2009" by Tamara Dean

OTHER TEXTBOOK INFORMATION

N/A

ADDITIONAL RESOURCES

Throughout the semester, additional resources may be used. They may include the Internet, newspapers, and professional publications.

EVALUATION

Discussion Board Activity……10%
Classroom Participation……10%
Homework Assignments..…….20%
Weekly Quizzes….....10%
Course Assessments…….….20%
Written Final…….15%
Course Project……...15%

SCHEDULE

1/9 - Review Syllabus
Reading Assignment - Chapter 1

1/16 - MLK Jr. Holiday

1/23 - Introduction to Networking (Ch. 1) Lecture (Lecture on ANGEL - Do not come to class)
Reading Assignment - Chapter 2
Chapter 1 Quiz - Due 1/29 NLT 11:55 pm

1/25 - Lab 1 - (Pre-lab on Angel LMS)

1/30 - Networking Standards and the OSI Model (Ch. 2) Lecture I
Reading Assignment - Chapter 2

2/1 - Lab 2 - (Pre-lab on Angel LMS)

2/6 - Networking Standards and the OSI Model (Ch. 2) Lecture II
Reading Assignment - Chapter 3
Chapter 2 Quiz - Due 2/12 NLT 11:55 pm

2/13 - Transmission Basics and Networking Media (Ch. 3) Lecture I
Reading Assignment - Chapter 3

2/15 - Lab 3 - (Pre-lab on Angel LMS)

2/20 - Transmission Basics and Networking Media (Ch. 3) Lecture II
Reading Assignment - Chapter 4
Chapter 3 Quiz - Due 2/26 NLT 11:55 pm
Mid-Term Assessment (Covers all material through 2/20) - Due 2/26 NLT 11:55 pm

2/22 - Lab 4 - (Pre-lab on Angel LMS)

2/27 - Introduction to TCP/IP Protocols (Ch. 4) Lecture I
Reading Assignment - Chapter 4

2/28 - Lab 5 - (Pre-lab on Angel LMS)

3/5 - Introduction to TCP/IP Protocols (Ch. 4) Lecture II
Reading Assignment - Chapter 5
Chapter 4 Quiz - Due 3/11 NLT 11:55 pm

3/7 - Lab 6 - (Pre-lab on Angel LMS)

3/12 - Topologies and Ethernet Standards (Ch. 5) Lecture I
Reading Assignment - Chapter 5

3/14 - Lab 7 - (Pre-lab on Angel LMS)

3/19 - Topologies and Ethernet Standards (Ch. 5) Lecture II
Reading Assignment - Chapter 6
Chapter 5 Quiz - Due 3/25 NLT 11:55 pm / Course Project Assigned

3/21 - Lab 8 - (Pre-lab on Angel LMS)

3/26 - Network Hardware (Ch. 6) Lecture
Reading Assignment - Chapter 7
Chapter 6 Quiz - Due 4/1 NLT 11:55 pm

3/28 - Lab 9 - (Pre-lab on Angel LMS)

4/2 - WANs and Remote Connectivity (Ch. 7) Lecture
Reading Assignment - Chapter 8
Chapter 7 Quiz - Due 4/8 NLT 11:55 pm

4/4 - Lab 10 - (Pre-lab on Angel LMS)

4/9 - Wireless Networking (Ch. 8) Lecture
Reading Assignment - None
Chapter 8 Quiz - Due NLT 4/15 11:55 pm

4/11 - Lab 11 - (Pre-lab on Angel LMS)

4/16 - Working Session for Student Projects / Review for Final Exam

4/18 - Lab 12 - (Pre-lab on Angel LMS)

4/23 - Project Presentations

4/25 - Written Final Assessment due Wednesday, 4/25 NLT 11:55pm (Cumulative)

COLLEGE POLICIES

Please refer to documentation for courses BUAS 1010, 1020, 1030 or 1040 for specifics of GPTC's policies re: grading, attendance, etc.

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation