CME 3204
Data Communications and Computer Networks
Midterm Project
2024-2025 Spring
Metropolitan Area Network Simulation

Deadline: 23 May 2025, 23:00

You will work in groups of 3. Please enter your group information at:

https://docs.google.com/spreadsheets/d/1aiW3WtLwXXrHYnNluBOQYSavt1W4Ee17xiCL_5Xhss4/edit?usp=sharing

If you can't find a group, please enter your information in the same spreadsheet.

Deadline for Group Information: 20 March 2025, 23:00. After the deadline, you will be randomly assigned to a group.

Computer Network planning and design is an iterative process that includes topological design, network architecture, and network traffic characterization. A well-designed computer network architecture should support the maximum number of network users, traffic load with minimum delay, and adequate hardware support for network expansions. However, the designer should balance the cost of network hardware and the system requirements.

In this project, you are expected to build a Metropolitan Area Network (MAN) by using Cisco Packet Tracer software.

The network requirements and specifications are given below:

1. Metropolitan area network design includes two distinct branch offices in a city, which are connected by routers (at least two routers for each branch) over an ISP (Internet Service Provider). You should also consider connection technologies between ISPs and branches.
2. The first branch's network comprises 3 distinct facilities, each with different units and requirements. All specifications for the first branch office are as follows:
   a. The first facility has 3 workstation (PC) users, 3 wireless (laptop) users, and 3 smartphone users. All of the users in this facility can browse the web, send e-mails, and transfer files using their devices.
   b. The second facility has 6 workstation users who can access the Web and FTP. Two of the workstations are used for **VoIP conference** events.
   c. c. The third facility has a server farm that includes 10 Web servers, 4 FTP servers, 1 DHCP server, 1 mail server, **and 1 domain name server (DNS).**

3. The second branch includes 3 distinct facilities, and each facility includes different units and requirements.
    a. The first facility has 5 workstation users, 5 wireless users, and 5 tablet users. These users can connect to the Internet using wireless connections, browse the Web, and use e-mail applications.
    b. The second facility has 5 workstation users and 2 smartphone users. They can browse the web, edit applications, **and transfer files**.
    c. c. The third facility has 5 workstations, and 2 mobile devices used to browse the Web and **send and receive emails**.

Simulation Scenarios

The following activities should be simulated and analyzed within your model. You should test these scenarios and **explain them in detail in your report**.

1. A wireless user from the first facility of the second branch wants to read emails and browse the Web.
2. A computer engineer from the second facility of the second branch developed a web application and wants to send his/her code files to an FTP server in the third facility of the first branch.
3. Two users from the second facility of the first branch want to talk via VoIP.
4. A user in the second facility of the first branch wants to send an email message to his friend in the second facility of the second branch.
5. A user from the first facility of the second branch pings the Web server of the second facility of the first branch.
6. A laptop user from the first branch office's first facility wants to send an e-mail to her friend in the first facility of the second branch office.
7. A smartphone user from the third facility of the second branch office wants to use SSH to connect to a Web server in the third facility of the first branch office.

You are expected to create **two more activities** to simulate and analyze your design. These activities should be <u>different</u> from those we specified. You should also define and document these activities in your report.

After the development of your system and tests:

1. Prepare an official report stating the problem, design, and design parameters, including the systematic IP addressing scheme, configuration parameters, etc.

2. In the appendix of your report, you should give your design and simulation results.

3. You have to upload your report to the system.

4. You are expected to upload your design file to the system. Please be careful during this process.

Your uploaded file should be your **<u>error-free working version</u>** of your design.

5. Your report should be converted to PDF.

Your report file name should be: `studentNumber(s)_Report.pdf`

Your design file name should be:

`studentNumber(s).Design.pka` or

`studentNumber(s)_Design.pkz`

<u>Samples:</u>

`2032510001_2032510004_2032510076_Report.pdf`

`2032510001_2032510004_2032510076_Design.pkz`

An evaluation of your homework will be carried out considering:

1. Design, contents, and presentation of your report

2. Error-free working of your project

3. Similarity of other projects. (Please prepare your <u>own</u> original design. <u>DO NOT COPY</u> the design of others.)

When necessary, you may be called to explain your report or project face-to-face. Please be on time when called.

Project Report

The project report should include designed network architecture with the given requirements, network traffic analysis results and your evaluation.

The project report should be in an academic format and have at least five chapters: Introduction, Network Requirements, Network Architecture, Traffic Analysis and Simulation Results, and Conclusion. The report should also include a Content Table, Figure Table, Abstract, and References. References should comply with IEEE Citation Style.

1. Introduction

In this chapter, you should define the problem you are expected to solve and introduce the main concepts and terminology you used. You should also state the motivation and importance of the project. Moreover, you should write the background of your project and explain the tool you used.

1.1. Project Definition and Problem Formulation

You will state the project and the problems you will handle.

1.2. The purpose and motivation of the project

Which motivations are there behind this project? What are the purpose and business goals of the project? Why do you want to realize this project? ("For grade" is not a valid answer. You should assume it is a real project). What are the main benefits and risks?

1.3. Related Work

If any, others' works about network modeling/simulation and network design.

2. Method and Simulation

You should present network requirements and constraints that you consider while modeling and simulating.

2.1. Simulation and Modeling Concepts

Related definitions and issues about discrete-event simulation (yes, this project is an example of a discrete event system) and modeling.

Benefits and challenges of modeling and simulation over real implementations.

2.2. Simulation Environment/Tool

General information about simulation environments and tools

Advantages-disadvantages and concepts/approaches of simulation tool you chose.
Information about the tool:

- Architecture and modeling concepts
- What is its modeling approach?
- Capabilities and limitations
- How to program or run simulation?
- What are the modules, libraries, components etc. you will use?

2.3. Network Design Requirements

In this section, characteristics, architecture, structure, configuration, used protocols, and design of your network should be given. You are also expected to write the number and type of components, such as routers, switches, etc., and can explain interconnection topologies. Figures and tables are welcome.

2.4. Requirement Analysis

Functional requirements for different applications and services, such as "the need to support VoIP."

The performance requirements include "the number of users that the network needs to support" and "the speed of the network," etc.

Defining constraints.

2.5. Definitions of the System/Model

What assumptions do you make about the components and the system?
What is the structure of the system?
Formulations and hypotheses on the values of input parameters.

Specifications for

- Network topologies you used while designing your project?
- Network applications and services that will be modeled/deployed
- Network configuration, including addressing, routing, and equipment configuration
- Data types, data sources, Device types (hosts, managed devices, etc.)
- Destination and number of users

    …

2.6. Simulation Elements

Specifying simulation elements of your projects regarding the following categories [1] [2]:

- System entities (e.g., computer nodes, server, the queue, packets, flows of packets, etc.)
- System state variables (e.g., status of the channel, which is either idle or busy etc.),
- Input variables (e.g., arrival rate, service rate, etc.),
- Resources (e.g., bandwidth, the number of servers, transmission time, etc.)
- Activities and events (e.g., delay, queuing, packet arrival, etc.)

3. Traffic Analysis and Simulation Results

In this section you will write network simulation analysis results. Your analysis will include network functionality, information about protocol data units (frame, packet, and segment-datagram), and network traffic.

Network Functionality

You should select the proper application, make the correct configurations, and set the parameters of the PDU (Protocol Data Unit) to simulate given scenarios.

Protocol Data Units Content: In your report, you should show some activities on OSI layers and packet details using the PDU information window screenshots for each scenario.

Relevant events list: You should write scenario-relevant event lists to show traffic moving through the network.

4. Conclusion

You should summarize your project and explain incomplete works and original contributions, if any.

5. References

List the references you cited in your report using <u>IEEE Citation Style</u>.

References

[1] A. Maria, "Introduction to modeling and simulation," in *Proceedings of the 29th conference on Winter simulation*, Atlanta, Georgia, 1997.

[2] T. Issariyakul and E. Hossain, "Simulation of Computer Networks," in *Introduction to Network Simulator NS2*, Springer Science+Business Media, 2009.