



Middle East Technical University



Department of Computer Engineering

## CENG 435

Data Communications and Networking

Fall 2025–2026

Assignment 1

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Due date: 2025-11-03 23:59

## 1 Introduction

This assignment will cover fundamental network measurements and will serve as an introduction to the OmNeT++ framework. This is a group homework, please pair off into groups of two to complete the assignment. Using OMNeT++ framework, you will set up simulation scenarios and measure how networks behave under different parameters. After running the measurements, you will analyze your findings in a report.

### 1.1 Installing OmNeT++

First read the relevant parts depending on your operating system from [OmNeT++ Install Guide](#). Go to [OmNeT++](#) site and install OmNeT++, version 6.2.0 and the latest INET version (4.5.4). OMNeT++ is a niche piece of software, your distribution might not have an up-to-date version of it packaged. We, as with the official installation guide, recommend using `opp_env`.

## 2 Measurement

Use [INET 4.5.4](#) measurement showcase. For the following tasks, repeat each simulation at least 20 times, for each parameter set. Plot the mean values and 95% confidence intervals. Do not produce figures that show how the measured statistic changes over simulation time. Place your parameters on the x-axis and the measured statistics on the y-axis. Note that, if the x-axis is a continuous parameter, then you can use line plots; otherwise, use box plots or violin figures. In each simulation campaign, use a reasonable `sim-time-limit`, at least 5 seconds. Use the Express Run function (F7) to disable animations and run the simulations quickly. Answer the questions for each simulation campaign by plotting figures and justify your answers based the simulation results and figures.

### 2.1 Channel Throughput

For this part, you will explore the [channel throughput](#) statistics of wired transmission medium. Note that in this part and others below, this tutorial is not enough. You will have to change the tutorial source files to run multiple simulations with various sets of parameters.

## Questions

1. How does the channel throughput change when you decrease or increase the interarrival time (iat) of packets (`*.source.app[0].source.productionInterval`)? Make sure you use exponential iat.
2. For what ranges of values of iat, does the channel capacity (`*.*.eth[*].bitrate`) saturate (i.e. even if you decrease iat, the overall throughput does not increase)?
3. How does the channel throughput change when you decrease or increase the Ethernet bitrate (`*.*.eth[*].bitrate`)?

## 2.2 Channel Utilization

For this part, you will explore the `channel utilization` statistics.

### Questions

1. How does the channel utilization change when you decrease or increase the interarrival time (iat) of packets (`*.source.app[0].source.productionInterval`)? Use exponential iat.
2. For what offered-load range does the link saturate (i.e., utilization converges to 1 and further decreasing iat doesn't increase throughput)?
3. Extend `EthernetLink` (`inet.node.ethernet.EthernetLink`) to create a custom channel. Using the bit error rate (BER) parameter, measure the utilization against BER.

## 2.3 End-to-end Delay

For this part, you will explore the `channel end-to-end delay` statistics.

### Questions

1. How does the mean end-to-end delay change when you decrease or increase the interarrival time (iat) of packets (`*.source.app[0].source.productionInterval`)? Use exponential iat.
2. Add intermediate switches (`inet.node.ethernet.EthernetSwitch`) between the source and the destination. Use 100 Mbps (`Eth100M`) links for the immediate connections from and to the source and the destination. Use 1 Gbps (`Eth1G`) links between the switches. Increase the `packetLength` slightly. How does the mean end-to-end delay change for 1, 2, ..., 8 switches?
3. Extend `EthernetLink` (`inet.node.ethernet.EthernetLink`) to create a custom channel. Add intermediate switches (`inet.node.ethernet.EthernetSwitch`) between the source and the destination. Use 100 Mbps custom links with BER of 1E-04. How does the mean end-to-end delay change for 1, 2, ..., 8 switches?

## 2.4 Packet Delay Variation

For this part, you will explore the `packet delay variation` statistics, also known as jitter. Use interarrival jitter calculations as outlined in [RFC 1889](#).

## Questions

1. How does the mean jitter change when you decrease or increase the interarrival time (iat) of packets (`*.source.app[0].source.productionInterval`)? Use exponential iat.
2. How does the mean packet delay variation (jitter) change for the bitrate of the link between the source and the destination?

## 2.5 Transmission Time

For this part, you will explore the **transmission time** statistics.

### Questions

1. How does the transmission time change when you decrease or increase the Ethernet bitrate (`*.*.eth[*].bitrate`)?
2. How does the transmission time change when you decrease or increase the packet length (`*.source.app[0].source.packetLength`)?
3. Extend `EthernetLink` (`inet.node.ethernet.EthernetLink`) to create a custom channel. Measure the transmission time against BER.

## 2.6 Propagation Time

For this part, you will explore the **propagation time** statistics.

### Questions

1. Extend `EthernetLink` (`inet.node.ethernet.EthernetLink`) to create a custom channel. Using the `length` parameter, measure the propagation time.
2. Add intermediate switches (`inet.node.ethernet.EthernetSwitch`) between the source and the destination. Use 100 Mbps (`Eth100M`) links for the immediate connections from and to the source and the destination. Use 1 Gbps (`Eth1G`) links between the switches. How does the propagation time change for 1, 2, ..., 8 switches?

## 2.7 Queuing Time

For this part, you will explore the **queuing time** statistics.

### Questions

1. How does the queuing time change when you decrease or increase the interarrival time (iat) of packets (`*.source.app[0].source.productionInterval`)? Use exponential iat.
2. Add intermediate switches (`inet.node.ethernet.EthernetSwitch`) between the source and the destination. Use 100 Mbps (`Eth100M`) links for the immediate connections from and to the source and the destination. Use 1 Gbps (`Eth1G`) links between the switches. How does the queuing time change for 1, 2, ..., 8 switches?

## 3 Specifications

- Feel free to ask questions through ODTUClass [Student Forum](#). I'm also available on [yigit@ceng.metu.edu.tr](mailto:yigit@ceng.metu.edu.tr).
- See the course syllabus for the late submission policy.
- Upload your assignment report to the ODTUClass *Report Submission*. Only one submission per group.

### 3.1 Grading

- Each question is worth 5 points. There are 18 questions.
- The structure, quality and neatness of your report is worth 10 points.