Summer Fellowship Report

On

Creating Spoken Tutorials for ns-3

Submitted by

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December 13, 2023

Acknowledgment

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Chapter 1

Introduction

The Spoken Tutorial project is an online learning platform that hosts video tutorials on Free and Open Source Software (FOSS). The tutorials are developed and intended to allow the learner to learn at their own pace, from anywhere with a computer and an internet connection. Effort is made to make the tutorials as simple as possible, with minimum pre-requisite knowledge required.

To promote practical learning, maximum duration of the tutorial is devoted to demonstration of the topic, and all the required files for learning, including the source files used in the tutorial, are provided to the learners. To enable the learners to get a better grasp of the concept, practice problems are given at the end of each tutorial, that can be solved using the concepts covered in that tutorial. To get better clarity, the learners can post their queries to the tutorial-specific forum, where domain experts resolve them by providing explanation.

The Spoken Tutorial project also offers certifications, that require the learners to pass an online assessment.

Chapter 2

Tutorials on ns-3

ns-3 is a command line tool to simulate computer networks, based on C++. It enables creating different types of network topologies, like point-to-point, CSMA bus, star etc. It includes classes and methods to create nodes, set network parameters, configure client and server applications, send packets, etc. NetAnim is a visualising tool that comes bundled with an ns-3 installation. It allows the users to visualize the networks created in ns-3.

This tutorial covers ns-3 and NetAnim from the very beginning, from creating nodes and connecting them using a point-to-point network. To the end of the series, more advanced concepts, like congestion control, and WiFi networks are also demonstrated. The tutorials are aimed at undergraduate and graduate students, who have basic understanding of networking concepts and have hands-on experience with Linux and C++ programming language.

2.1   Creating a point-to-point communication link

This tutorial demonstrates the creation of a point-to-point communication link between two nodes in ns-3. Since it is the first tutorial in the series after installation, the structure of an ns-3 program, and the various classes and methods used are also explained.

The tutorial covers the following:

- Structure of an ns-3 program and topology helpers

- Creating nodes

- Configuring a point-to-point communication link

- Adding network interface to nodes

- Installing an internet stack on the nodes

- Associating network devices with IP address

- Configuring client and server applications

- Running the simulation

- Visualising the network in NetAnim

2.2   Network performance analysis

This tutorial builds up on the learnings from the previous tutorial, and introduces the concept of tracing. Through trace sources, network parameters including transmission delay, propagation delay, and round-trip-time are calculated.

The tutorial covers the following:

- Introduction to trace sources

- Trace sources used in the tutorial

- Callback functions

- Connecting trace sources to callback functions

- Analysing the simulation output and calculated metrics

2.3   Connect multiple networks with router

This tutorial demonstrates connecting multiple networks, using router. The networks used in the tutorial comprise of a star, and a CSMA bus network. The tutorial also covers the basics of creating a star network. The routing is visualized using NetAnim.

The tutorial covers the following:

- Configuring a star network

- Configuring a CSMA bus network

- Assigning IP addresses to the networks

- Connecting the networks using a point-to-point link

- Installing server and client applications on the nodes

- Observing output on the terminal

- Visualising the network in NetAnim

2.4   Dynamic Routing Protocol

This tutorial demonstrates OSPF dynamic routing protocol in ns-3. We intentionally deactivate one of the links (shortest) between the source and the destination node, such that, after deactivation, the next shortest path is chosen automatically.

The tutorial covers the following:

- Overview of the OSPF dynamic routing protocol

- Enabling dynaming routing

- Creating On/Off applications

- Creating routing tables

- Selecting link to deactivate

- Setting down time for the link

- Analyzing routes file

- Visualising the network in NetAnim

2.5   Analysing TCP congestion window

This tutorial demonstrates congestion control in network. We intentionally cause packets to fail to reach the destination node, by using a rate error model. Using trace sources, the size of the congestion window is traced. The gnuplot is used to plot the change in congestion window size over time.

The tutorial covers the following:

- Overview of the TCP New Reno congestion control algorithm

- Overview of the TutorialApp class

- Creating a RateErrorModel object pointer

- Creating a TCP socket with TCP New Reno congestion control algorithm

- Creating a file stream

- Configuring gnuplot

- Observing change in congestion window size in terminal

- Generating plot

Chapter 3

Code and Script Writing

For the tutorials listed in the previous chapter, I developed the source code, and the corresponding script with the visual cues and the narration. The scripts were written by strictly following the Spoken Tutorial norms. Effort was put on explaining each and every bit of the code, and relevant references were provided if a concept required pre-requisite knowledge and could not be covered in the tutorial itself.

The source code and the corresponding scripts can be found in the following links:

- Creating a point-to-point communication link

  Code: point-to-point.cc

  Script: Tutorial-2_P2P-Network_Script.docx

- Network performance analysis

  Code: p2p_performance.cc

  Script: Tutorial-3_Performance-Analysis

- Connecting multiple networks with router

  Code: router.cc

  Script: Tutorial_5-Router_Script.docx

- Dynamic routing protocol

  Code: DynamicRouting.cc

  Script: Tutorial-6_Dynamic-Routing-Protocol

- TCP congestion control

  Code: tcp-congestion.cc

  Script: Tutorial-8_TCP-Congestion_Script

Chapter 4

Creating slides

Following the development of code and script, I also developed slides for each tutorial. These slides contain the introduction, the system requirements and the prerequisites, and the network topology diagram. Additionally, for some tutorials, the slides also contain brief theory on the topic. The concluding slides give a summary of the concepts covered in the tutorial, and give some practice problems for the learners to solve.

The slides for the tutorials can be found at the following links:

- Creating a point-to-point communication link

- Network performance analysis

- Connecting multiple networks with router

- Dynamic routing different

- Analysing TCP congestion window

Chapter 5

Code and Script Checking

After the code, scripts, and the slides were written for all the tutorials, a series of checks were done by the Spoken Tutorial team to ensure that the content follows all the norms and rules, and that it is well explained.

5.1 Novice Check

Novice check is a process wherein, the script and source code files are given to a person who does not have any prior knowledge on the topic of the tutorial. The person then follows the script and performs the tasks and operations mentioned in it. He or she then gives their feedback whether the script is easy enough to follow for a complete beginner, and if all the steps could be followed without encountering any errors or issues.

The Novice check for my tutorials were performed by Ms. Vineeta from the Spoken Tutorial team. She performed the check multiple times to ensure that the content is well explained and that the source code is bug-free.

5.2 Domain Check

In domain check, source code and scripts are analysed by subject experts, to ensure that the code is correct, and that the terms used and explanations provided are satisfactory. The domain check was performed by Dr. Anita X and Dr. Radha R from VIT Chennai, and Dr. Moyukh Laha from IIT Kharapgur.

5.3 Admin Check

After the domain check and the novice check, the admin check is done to check if all the norms are followed, and if any improvements can be made to make the tutorials easier to follow or provide better clarity. The admin check was done by Ms. Nirmala from the Spoken Tutorial team.

Chapter 6

Conclusion

The FOSSEE fellowship, apart from giving me an opportunity to contribute to the Spoken Tutorial learning platform and exercise my programming skills, also helped me pick up skills like project management and team work. While writing the scripts, I learned the importance of writing clean code and good documentation, to provide the best learning experience for the viewers. I also discovered the wide formatting capabilities of LaTeX while creating the slides for the tutorials.

I would again like to thank the Spoken Tutorial team and my mentors at VIT Chennai for providing me this opportunity.

Reference

- https://www.nsnam.org/

- https://spoken-tutorial.org/