

0

Ethernet Switch/terminal Simulators for Novices to Learn Computer Networks

Yasusi Kanada

Kogakuin University, Tokyo, Japan

yasusi@kanadas.com

Outline

- **Most of available network simulators are not suited for learning Ethernet switching by novices.**
 - The author wanted to use an Ethernet simulator for educating novices in a university class of computer networks.
 - Commercial and open-source network simulators, such as OPNET or ns2, are not suited for this purpose.
 - Although Ethernet has recently become much more important, simulators for Ethernet learning is rare; that is, most simulators for education and learning are designed for IP communication.
- **The author developed a simple CLI-based Ethernet simulator called CLSim.**
 - CLSim can display contents of Ethernet packets in terminals and contents of MAC address tables in switches in “real time”.
 - CLSim is written in Python, so it runs on Windows, Macintosh, Linux, etc.
 - The author used CLSim in the university class for learning computer networks.

- **The use of CLSim was evaluated based on a report assignment.**
 - The evaluation result shows that the average score of the reports written by using the simulator was much better; however, it is not statistically significant.
 - CLSim seems to be effective to learn behaviors of Ethernet-based networks.

Background

- **Educating and learning Ethernet has become much more important because of its popularity, intelligence, and importance.**
 - **Popularity:** There have been many “layer-2” protocols, such as ATM or fiber channel; however, Ethernet has gained much more users.
 - **Intelligence:** Ethernet networks were originally broadcast networks without intelligent nodes and MAC addresses could not be redefined; however, nowadays, Ethernet packets are forwarded by **intelligent switches** that are comparable to IP routers, and MAC addresses may be redefined by software.
 - **Importance:** Ethernet was only used for LAN, but it is also used for wider area, namely, **MAN, WAN, and even used globally** now.
- **The upper sub-layer of the Ethernet protocol has become closer to “layer-3” protocols such as IP.**
 - Ethernet is usually used in combination to IP as IP/Ethernet and this fact impresses us that whole Ethernet protocol is layer 2 (lower layer) of IP.
 - Actually, the Ethernet protocol has two sub-layers.
 - The upper sub-layer belongs to network layer (L3).
 - The lower sub-layer of Ethernet protocol based on CSMA/CA is link layer (L2).
 - The textbook of Peterson and Davie describe Ethernet and IP as comparable protocols for internetworking.

Requirements

- **[Display] The behavior of simulated terminals and switches must be displayed by a proper method.**
 - **Terminal:** A simulated terminal must show the destination and source addresses and contents of packets to be sent and received.
 - **Switch:** A simulated switch should show the content of the MAC address table to show the result of address learning.
 - **Timing:** The displayed values in all the terminals and switches must be displayed in simulated “real time” and must be synchronously updated.
- **[Wiring] The specifications of wiring between the simulated terminals and switches must be easy.**
- **[Machine] Simulated terminals and switches must be able to run on a single computer.**
 - Students are not allowed to use many computers and they may use their own computer for simulation.
 - VMs are not used for this purpose because it is not easy for the available Windows machines to install VMs.

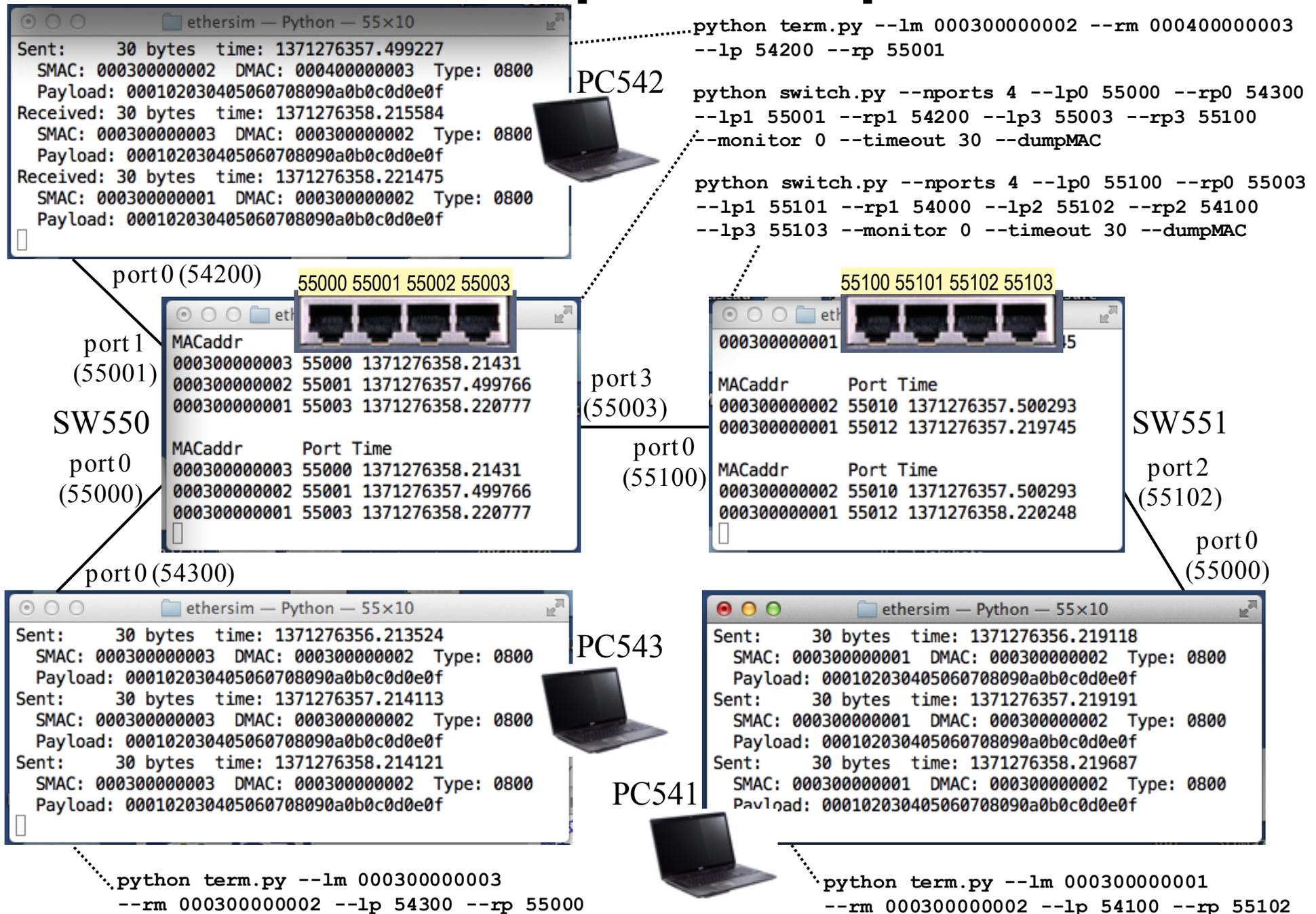
5

- [Environment] **The simulator must run on an environment that every student can easily set up.**
 - CLSim must be thus supplied as an executable binary file or by using a widely and easily available execution environment.
- [Development] **Easiness of development or low development cost.**
 - No budget was available for this development, the author himself developed the simulator.
 - The available development time was very limited.
 - The implementation must therefore be simple even if the usage is constrained.

Design

- [Display, Wiring, Machine] **Each terminal or switch is implemented as a process (in a window in a PC) communicating by UDP.**
 - Each process should run in a separate window – laborious but simple and intuitive for students.
 - UDP port numbers are used to distinguish both devices and physical ports of the devices.
- [Environment] **Python 3 was used for programming the simulator.**
 - Python 3 does not restrict the environment runs on Windows, Macintosh, Linux, etc.
 - Python 3 is installed to many PCs in the university.
- [Development, Display] **CLI was chosen for the user interface.**
 - A graphical user-interface (GUI) is more user-friendly than a command-line interface (CLI); however, students in ICT-related departments should learn CLI and use of CLI-based simulator may be a good chance to study CLI.

Simple Example



Evaluation

- **CLSim was used for an assignment of reports on Ethernet.**
 - The students of a computer network class were asked to hand two reports.
 - The first report should describe the design and rough behavior of an Ethernet-based network manually.
 - When writing the second report that described the network behavior in detail, the students were encouraged to use the simulator (that is, students who used the simulator got additional marks but simulator use was not a must).

- **Major results**

- The table seems to show a difference in these percentages, i.e., 67% and 48%.
- This difference may be caused by the effect of using and learning from the simulator or by knowledge.
- The difference is not statistically significant because the number of samples is small.

Item	Number of students	2nd report score
1st report submission	21	-
2nd report submission	13	61%
Using the simulator	9	67%
Not using the simulator	4	48%

- **Other issues**

- **Several students seemed to try but to abandon the simulator because of several reasons.**

- 1) The difficulty of wiring terminals and switches for the simulator; that is, it was difficult for them to prepare parameters of switch and terminal commands consistently.
 - 2) Some students did not know how to use the CLI (i.e., the command prompt). Especially, it was difficult for some students to set up the current directory and the path for executing Python.
 - 3) The simulator was distributed by a zip file but at least one student did not know how to decompress it.

- **Other reasons of failures**

- At least two students used the simulator but did not obtain correct results. The reason may be the difficulty of wiring devices.
 - At least one student failed to install Python, but the reason was unknown because she did not know the reason and the author could not see the reason either because it was her own PC.
 - At least one student correctly used the simulator but he seems failed to understand switch behavior. The author found it because his score of the final examination were very low.

Conclusion

- **A CLI-based Ethernet simulator called CLSim was developed for a university class.**
 - CLSim can display contents of Ethernet packets in terminals and contents of MAC address tables in switches in “real time”
 - Each simulated terminal or switch is a process and they are “wired” by UDP.
 - CLSim was used in the university class and the use was evaluated based on a report assignment.
- **The evaluation result shows the average score of reports written by using the simulator was better, but it is not statistically significant.**
- **The simulator seems to be effective to learn behaviors of Ethernet-based networks.**