Bottleneck Bandwidth Sharing

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Lab № 1

Outline

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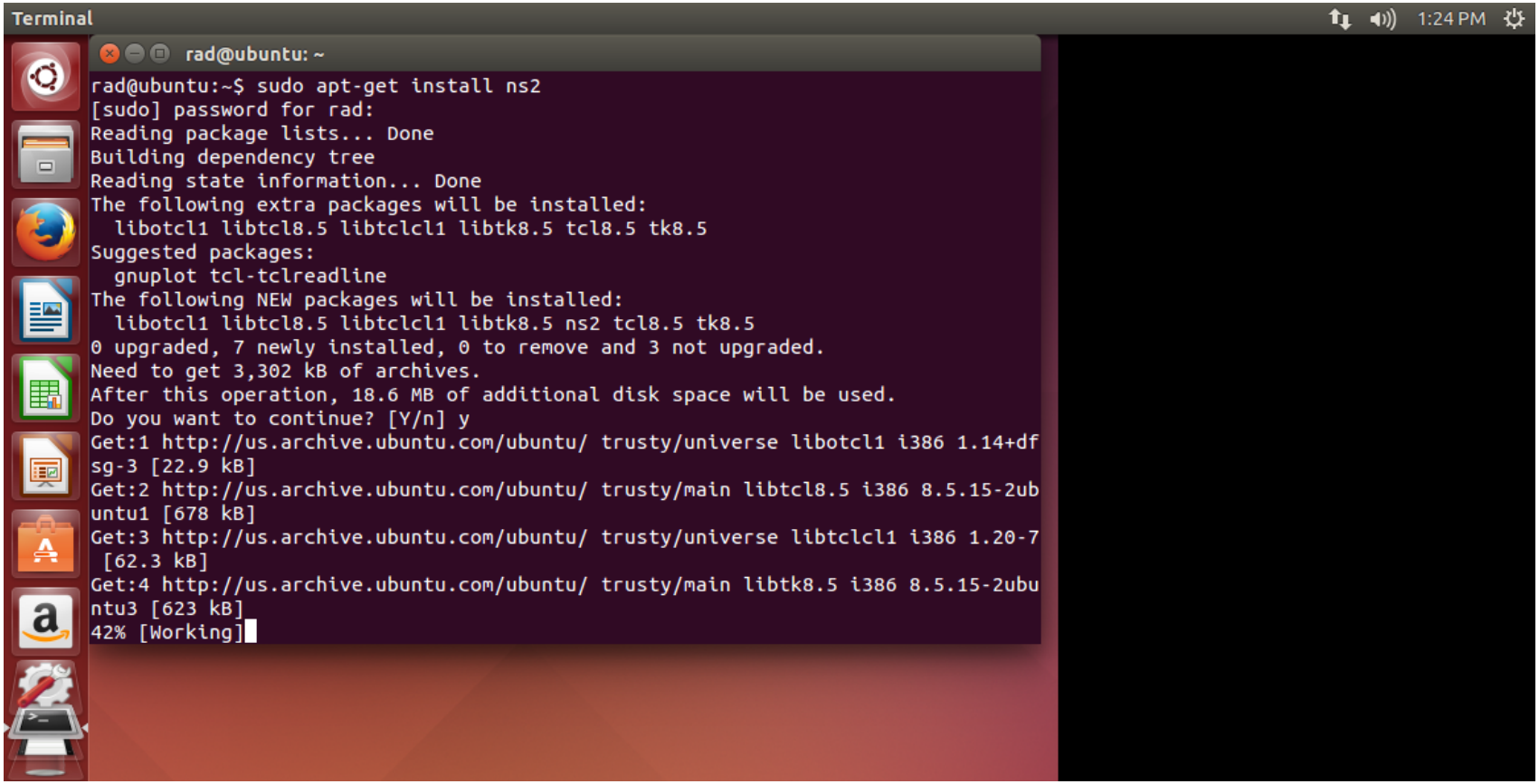
Transport Layer Protocols

- **User Datagram Protocol (UDP)**
  - Multiplexing/demultiplexing
  - Error control (optional)
- **Transmission Control Protocol (TCP)**
  - Multiplexing/demultiplexing
  - Data segmentation and ordered data transfer
  - Error control (mandatory)
  - Flow control
  - Congestion control

Outline

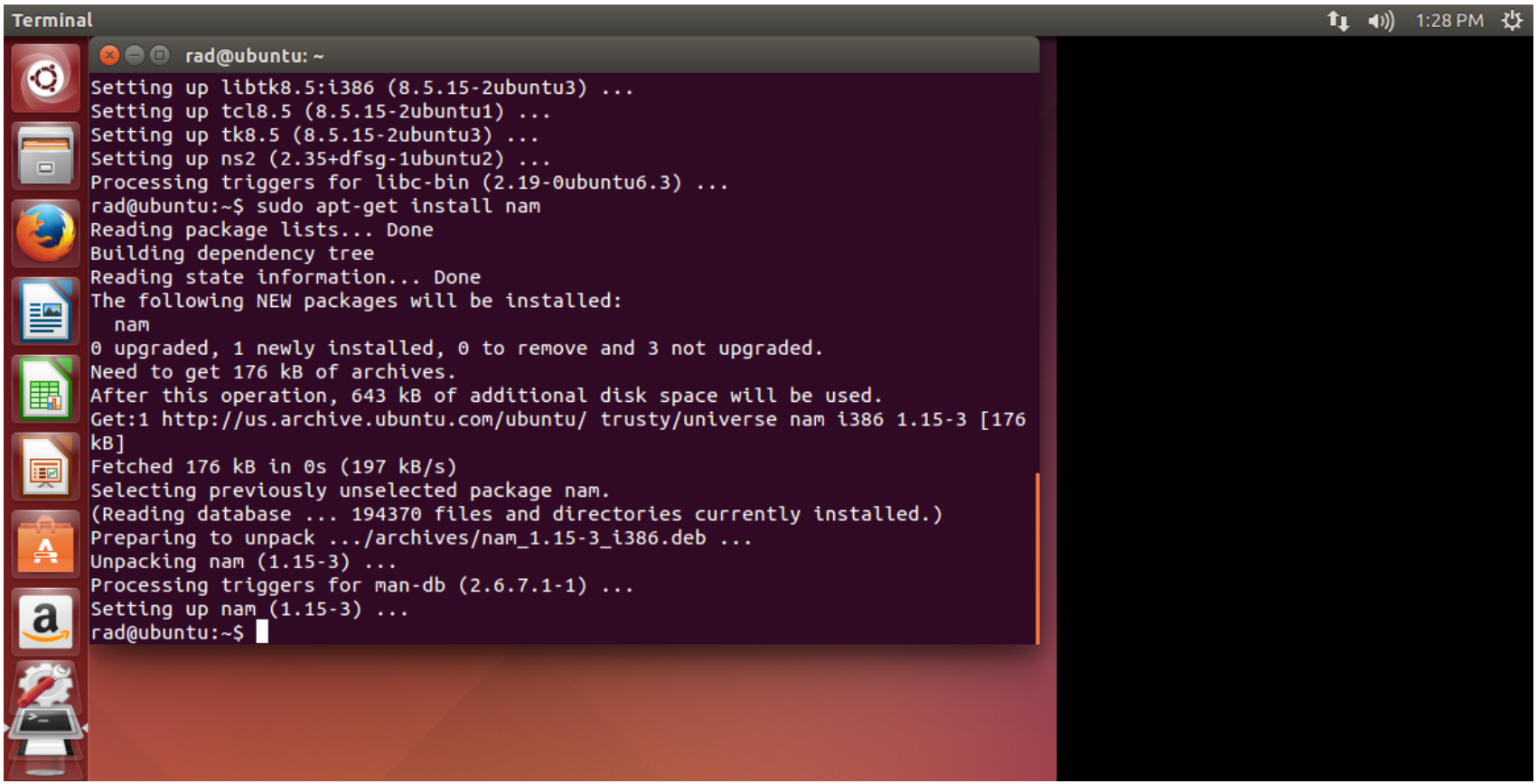
ns-2 in Ubuntu

- Install ns-2: **sudo apt-get install ns2**
  - Run **Terminal**: **<Ctrl>+<Alt>+<T>**



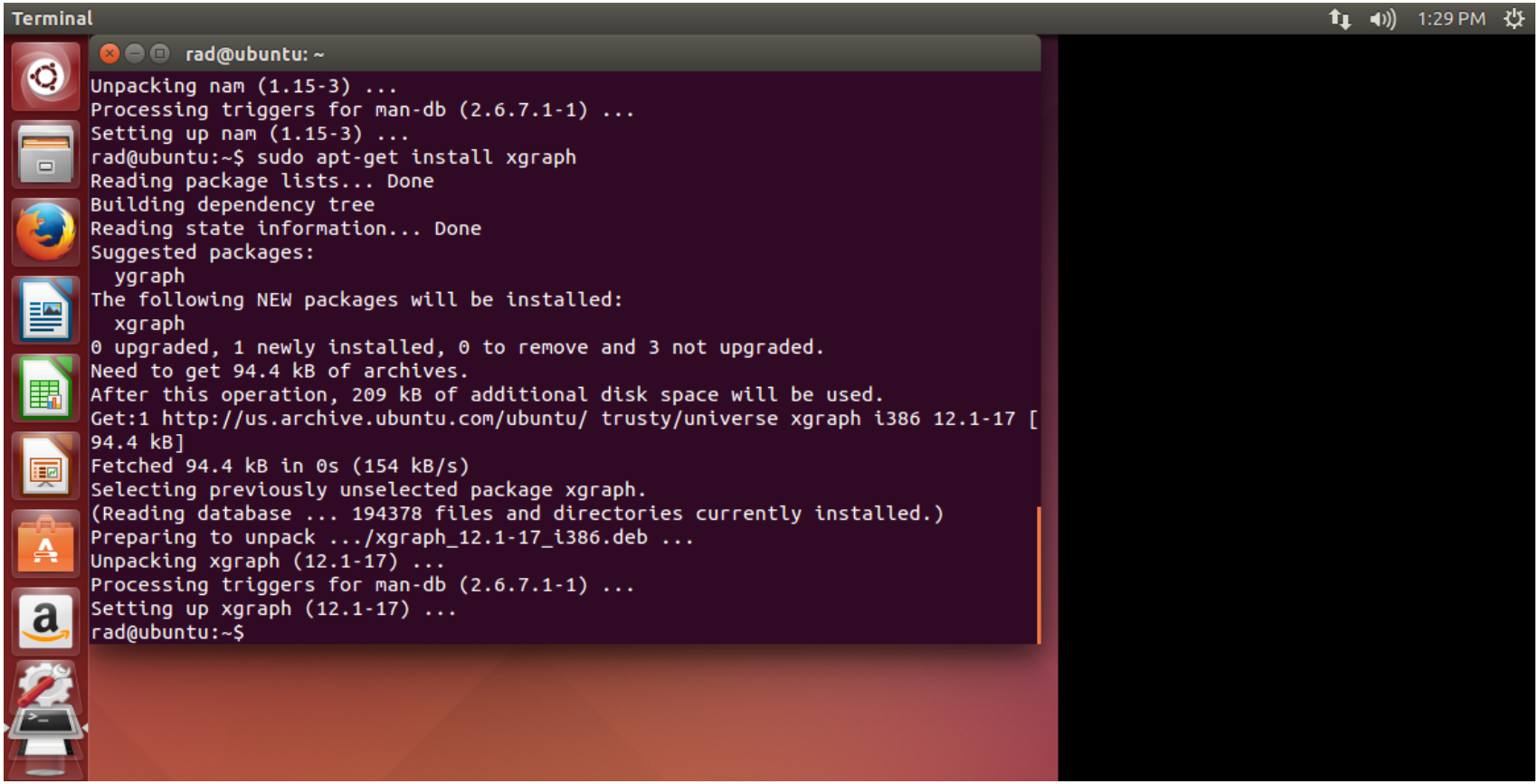
ns-2 in Ubuntu (cont'd)

- Install nam: **sudo apt-get install nam**
  - See http://askubuntu.com/questions/467901/segmentation-fault-core-dumped-in-ns2-ubuntu-14-04 ☹
  - Or use **ubuntu-12.04.5** instead of ubuntu-14.04.2



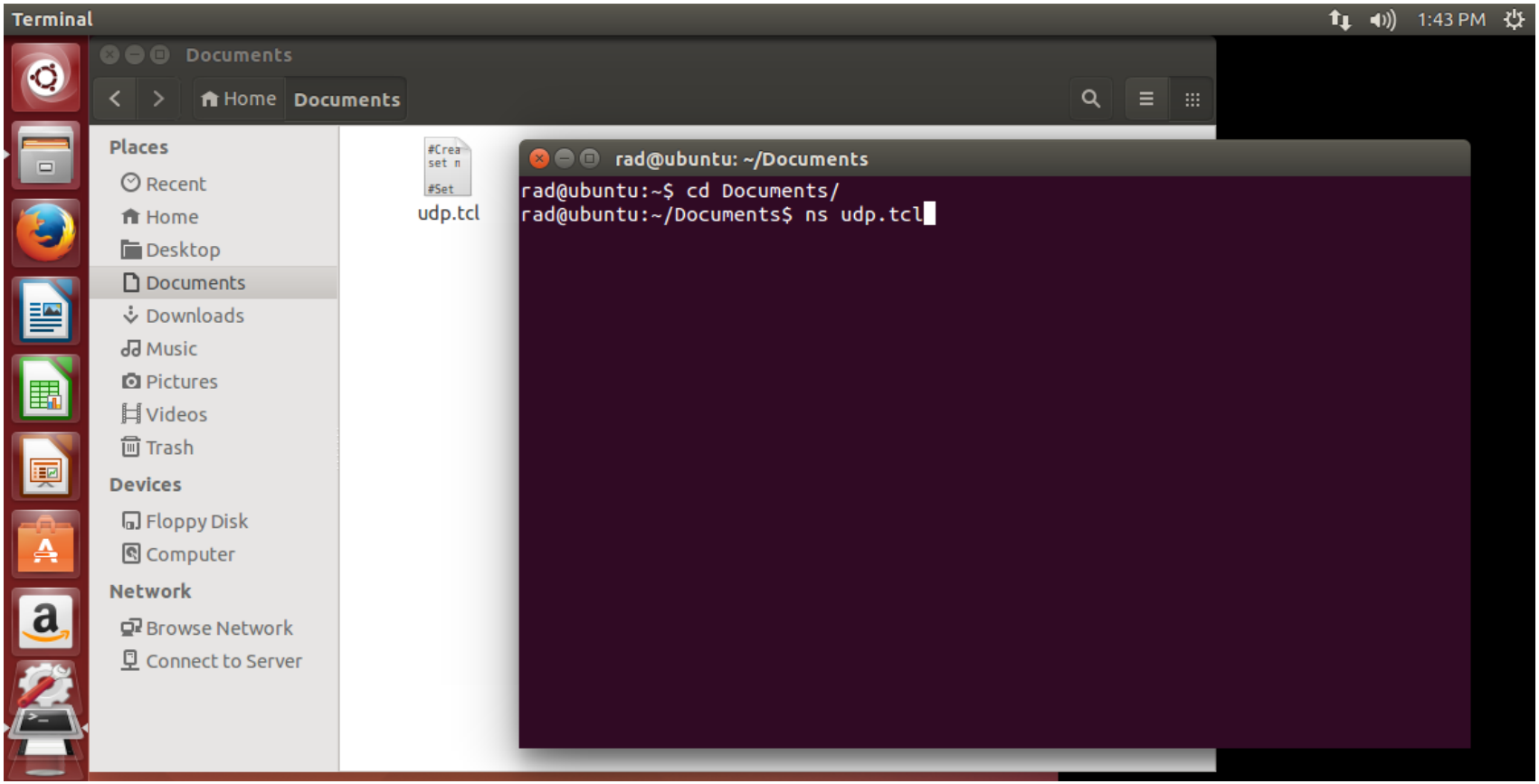
ns-2 in Ubuntu (cont'd)

- Install xgraph: **sudo apt-get install xgraph**



ns-2 in Ubuntu (cont'd)

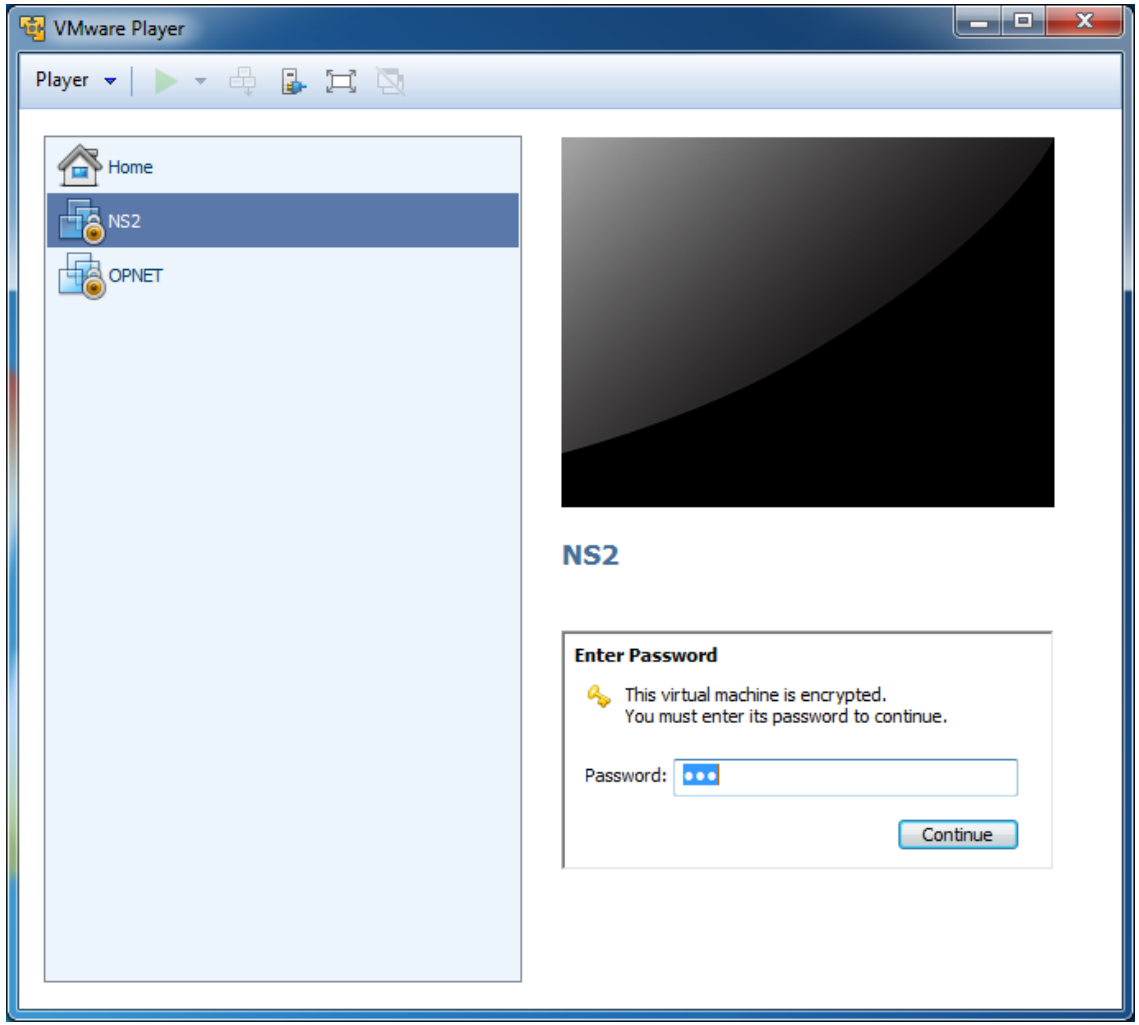
- Run simulation: **ns <name>.tcl**



Outline

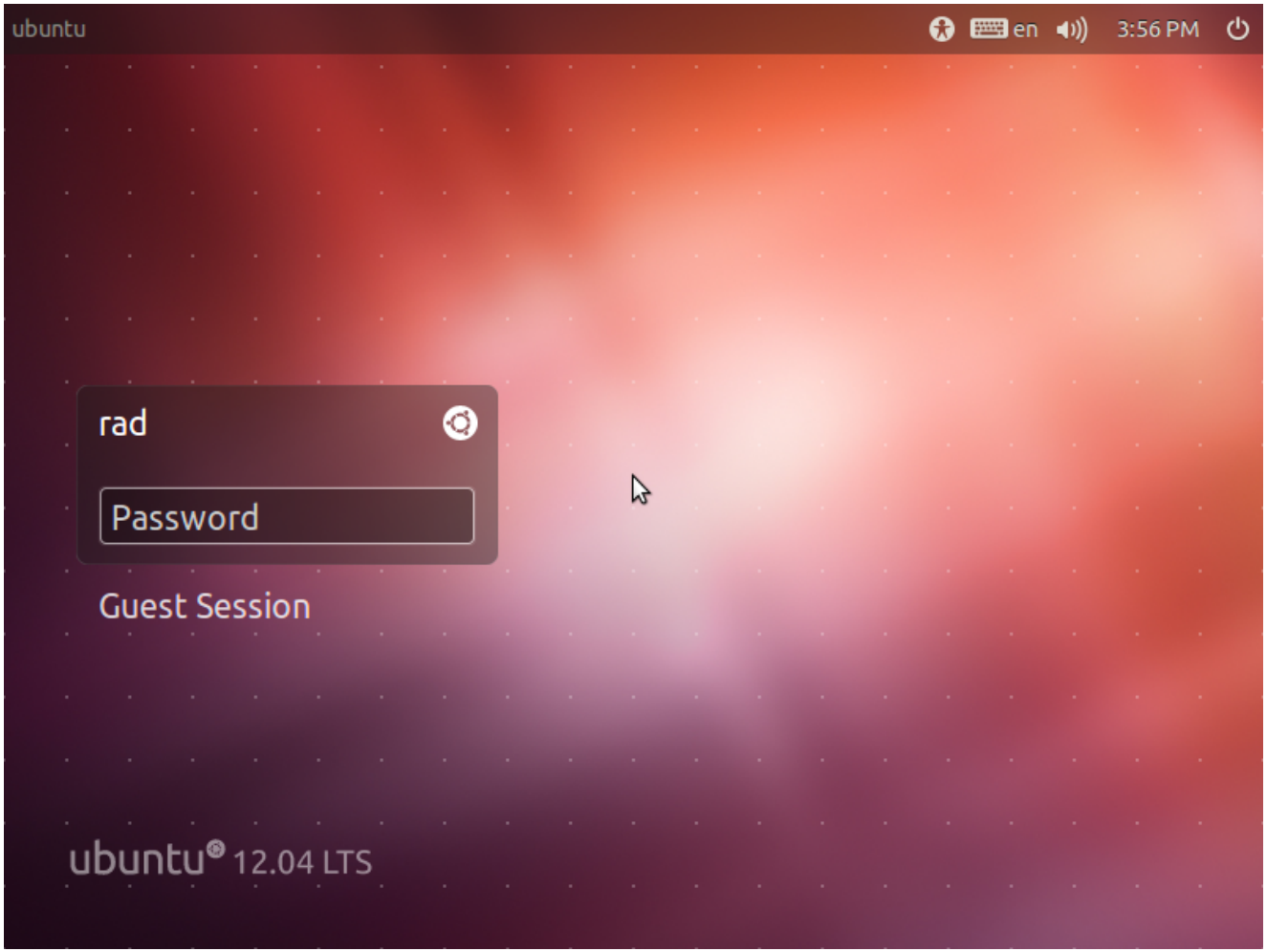
VMware Player

- Virtual machine: **NS2**
- Password to run: **123**



VMware Player (cont'd)

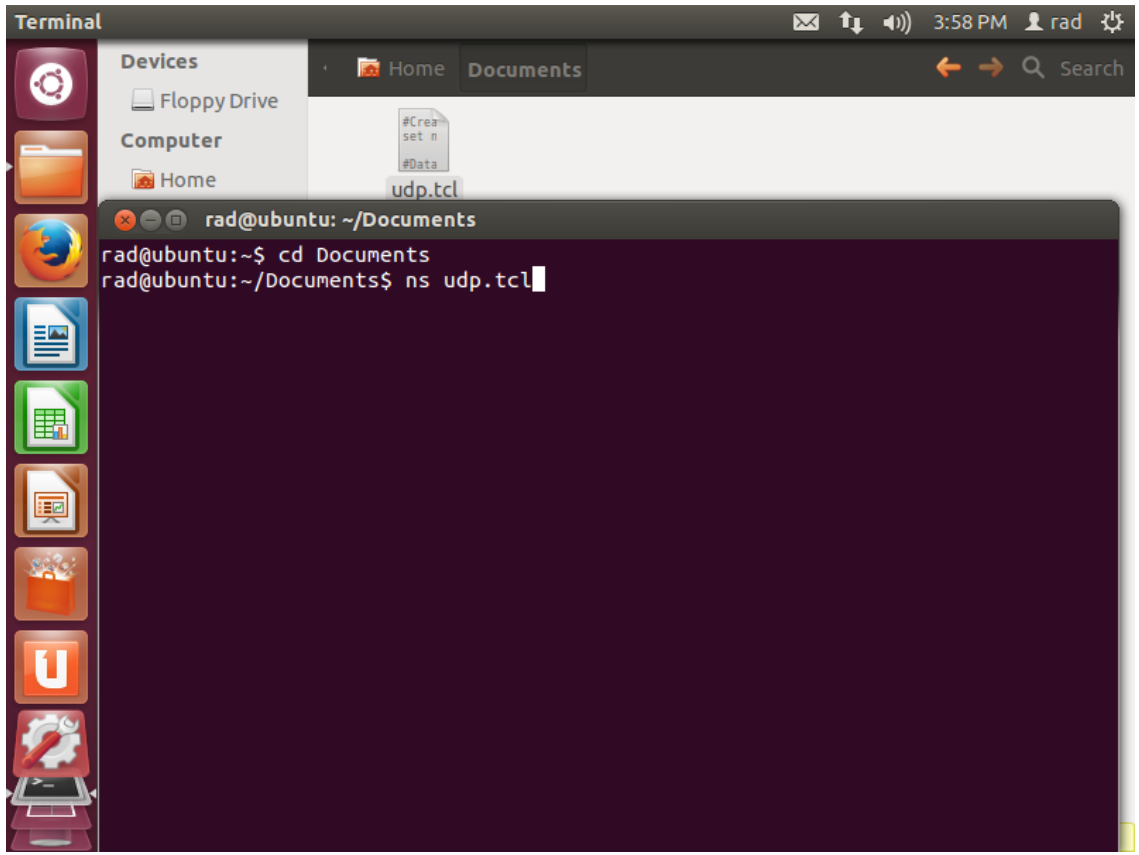
- Password: **123**
- Or run **Guest Session**



Outline

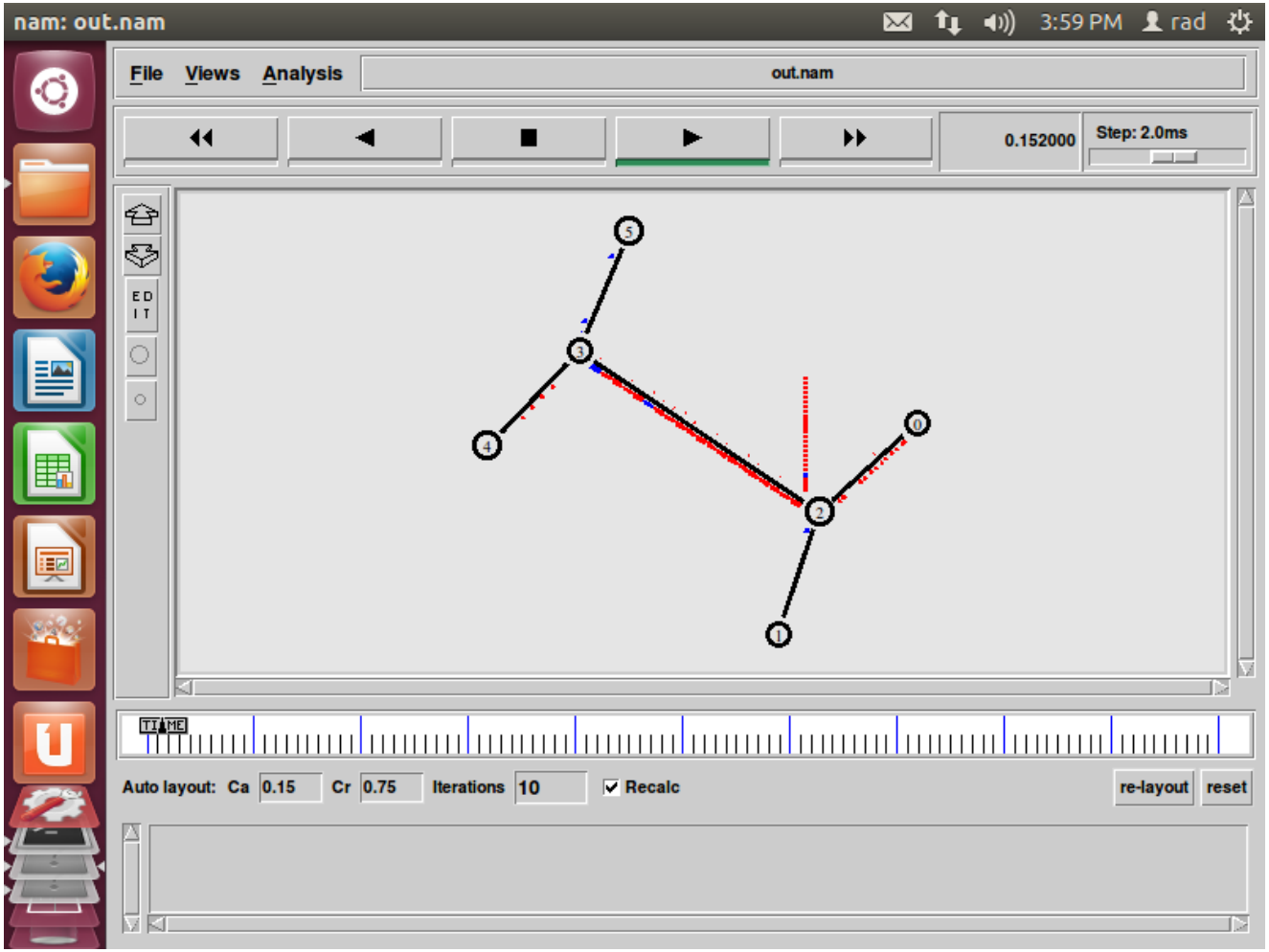
UDP vs. TCP

- Open **Terminal**: **<Ctrl>+<Alt>+<T>**
- Change directory: **cd Documents**
- Run simulation: **ns udp.tcl**



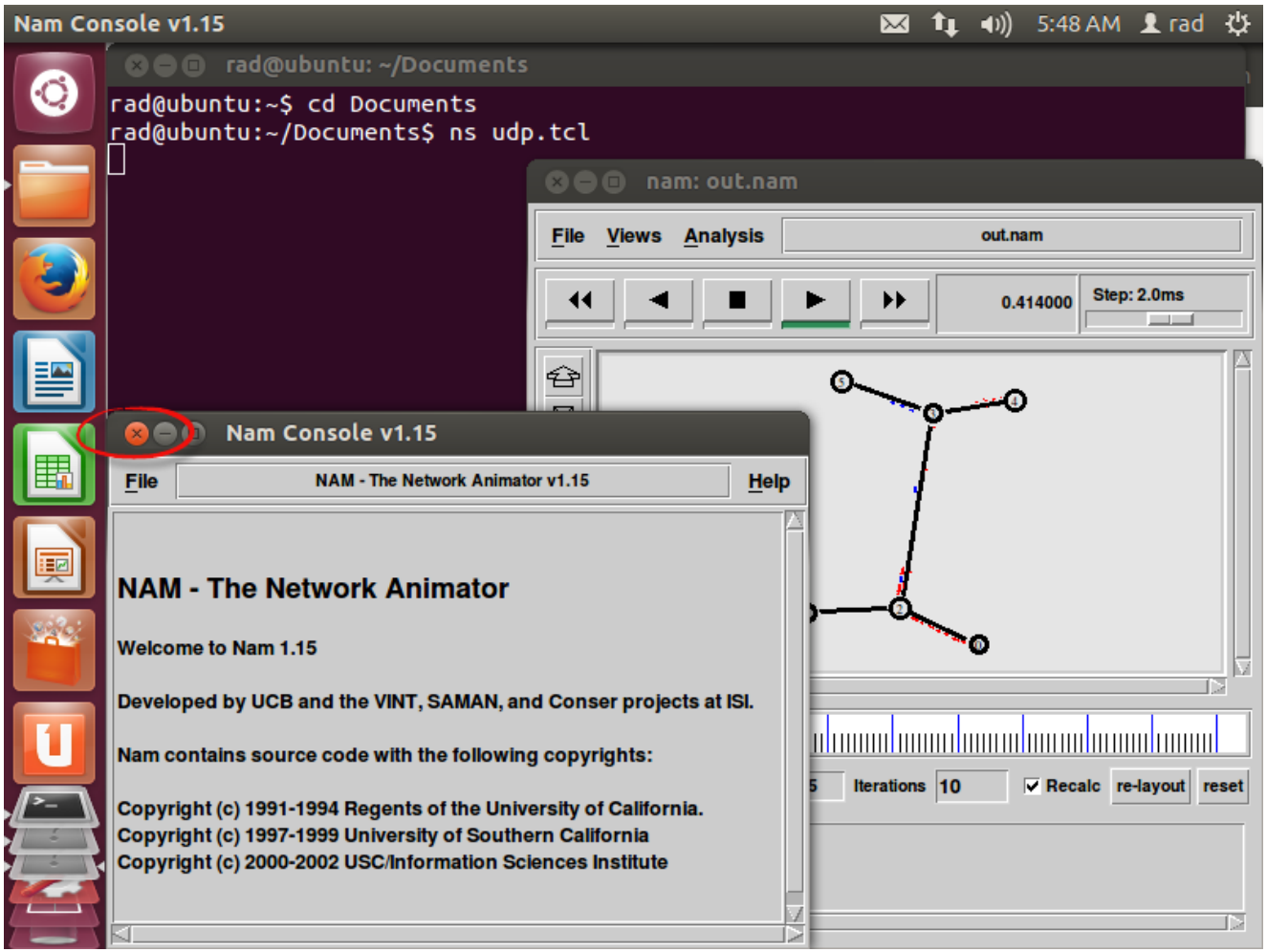
UDP vs. TCP (cont'd)

- **nam**: UDP (blue) vs. TCP (red)



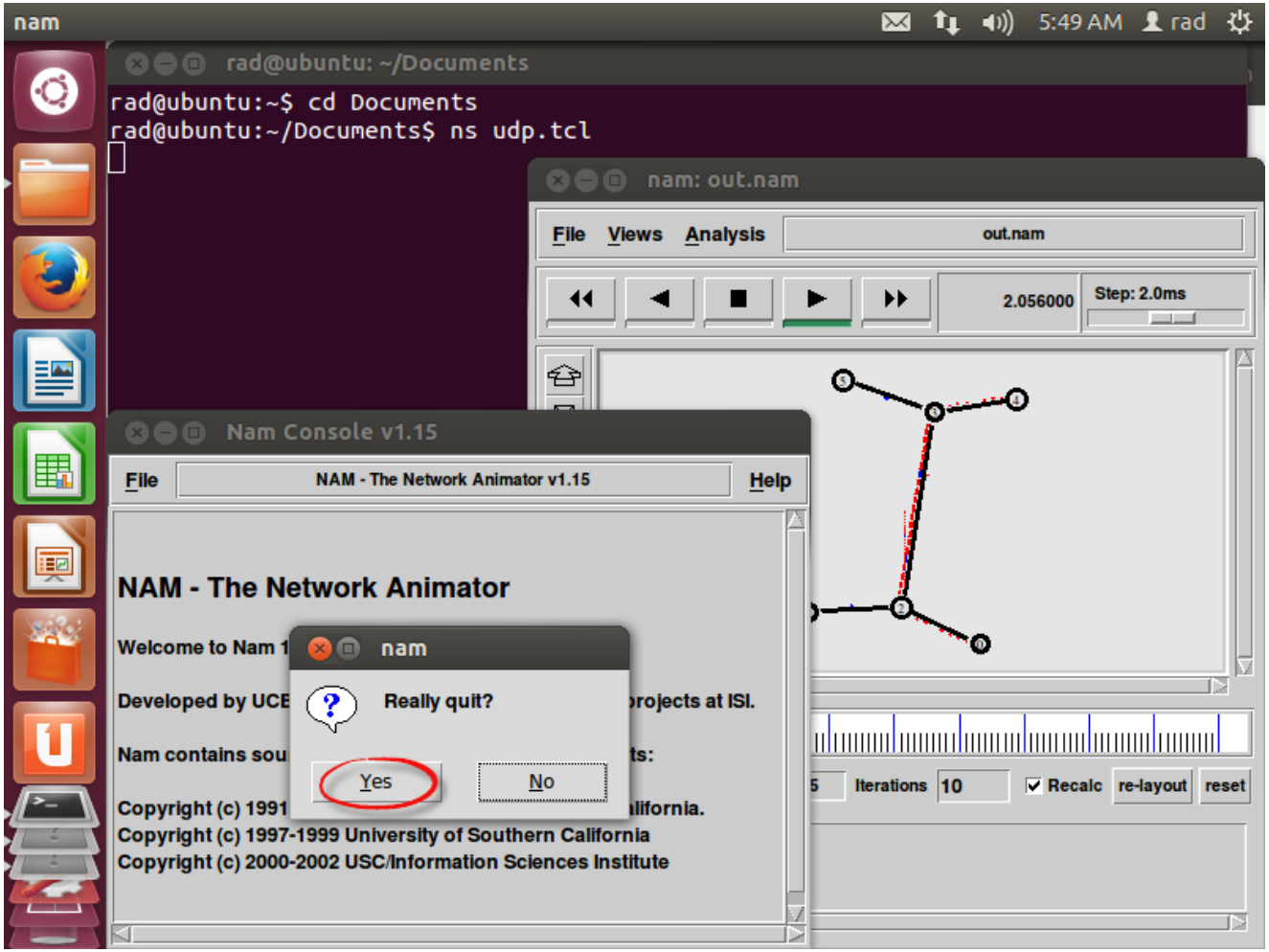
UDP vs. TCP (cont'd)

- Close **nam** (step 1)



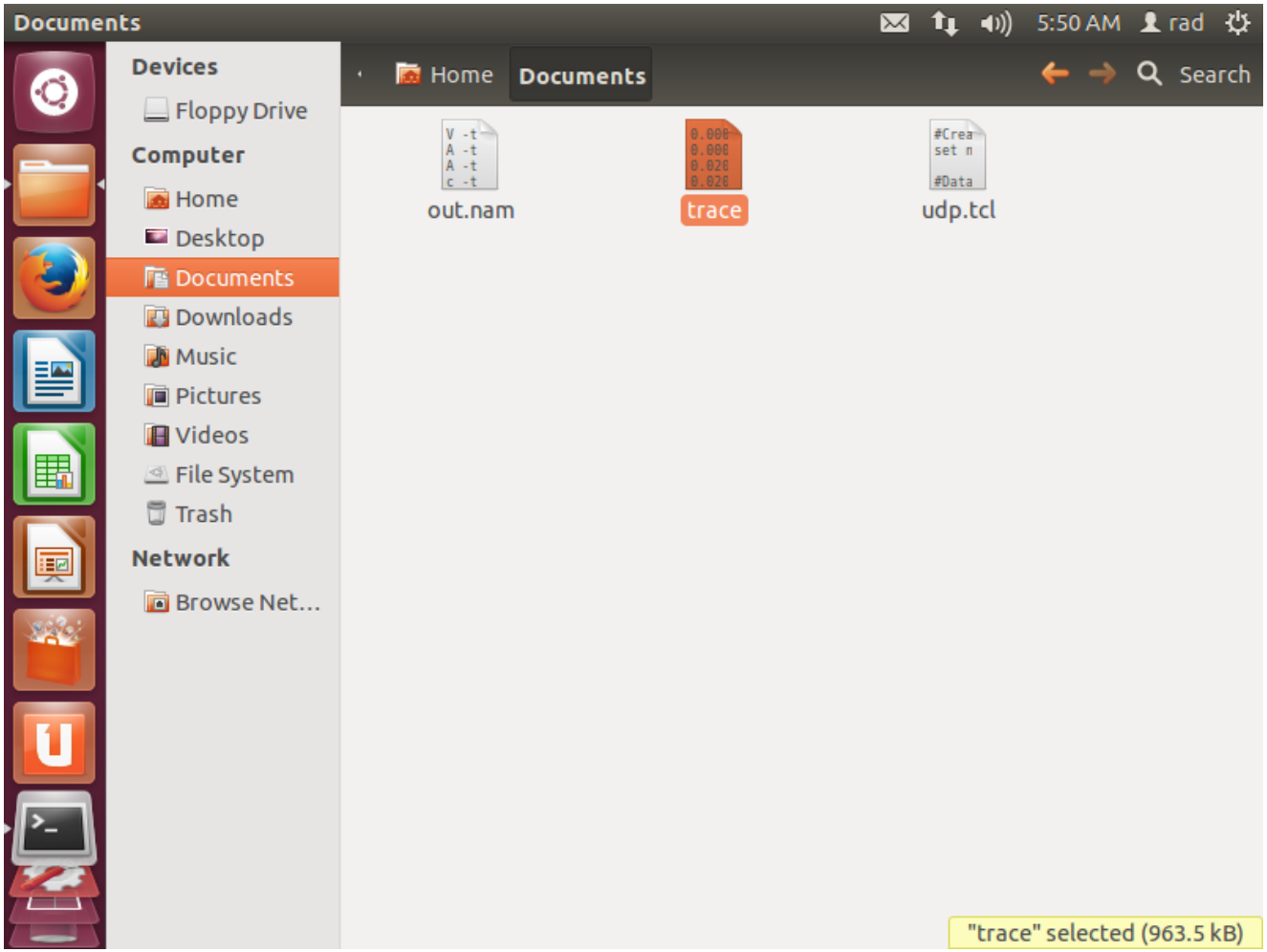
UDP vs. TCP (cont'd)

- Close **nam** (step 2)



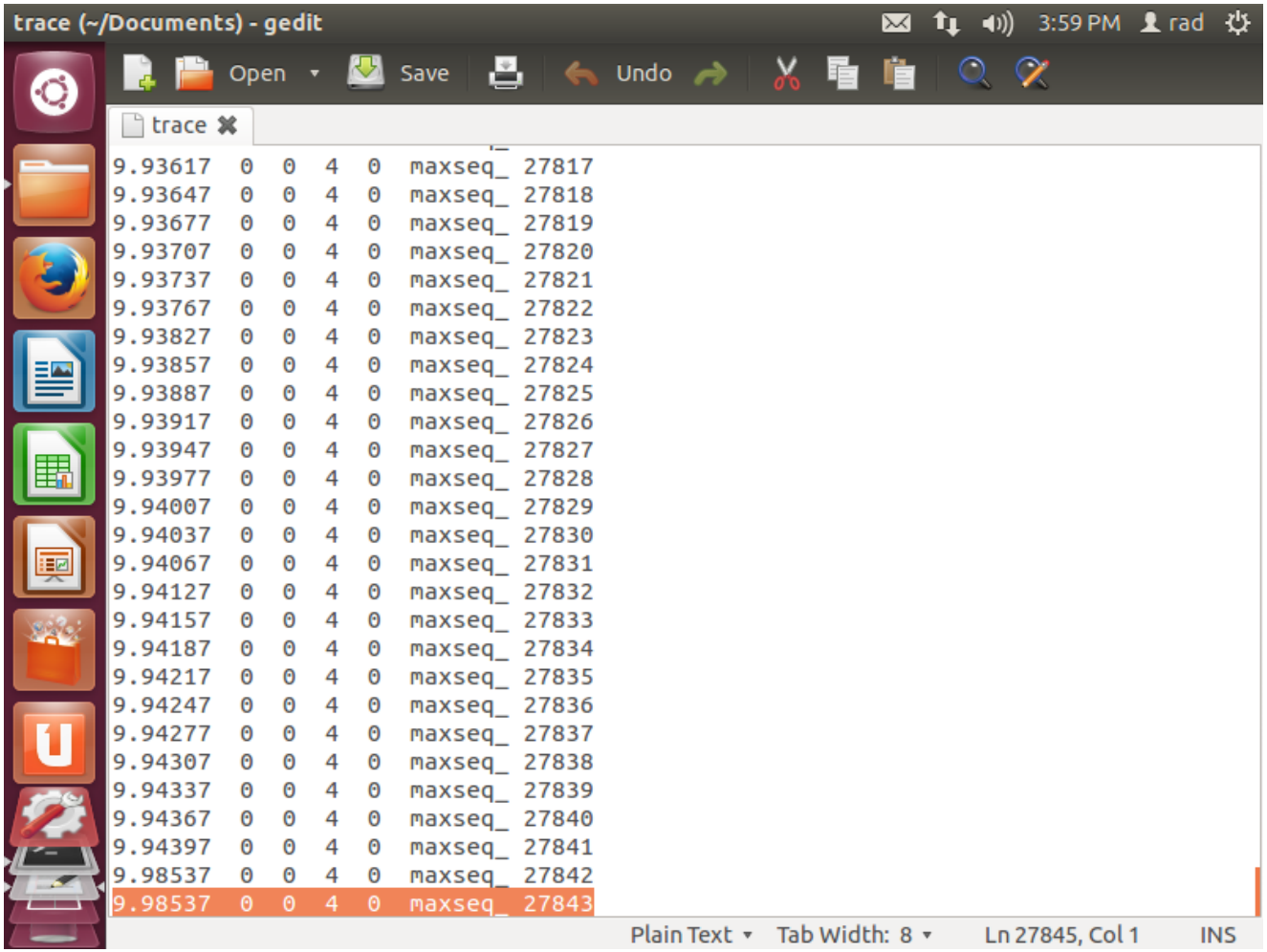
UDP vs. TCP (cont'd)

- Open **trace**



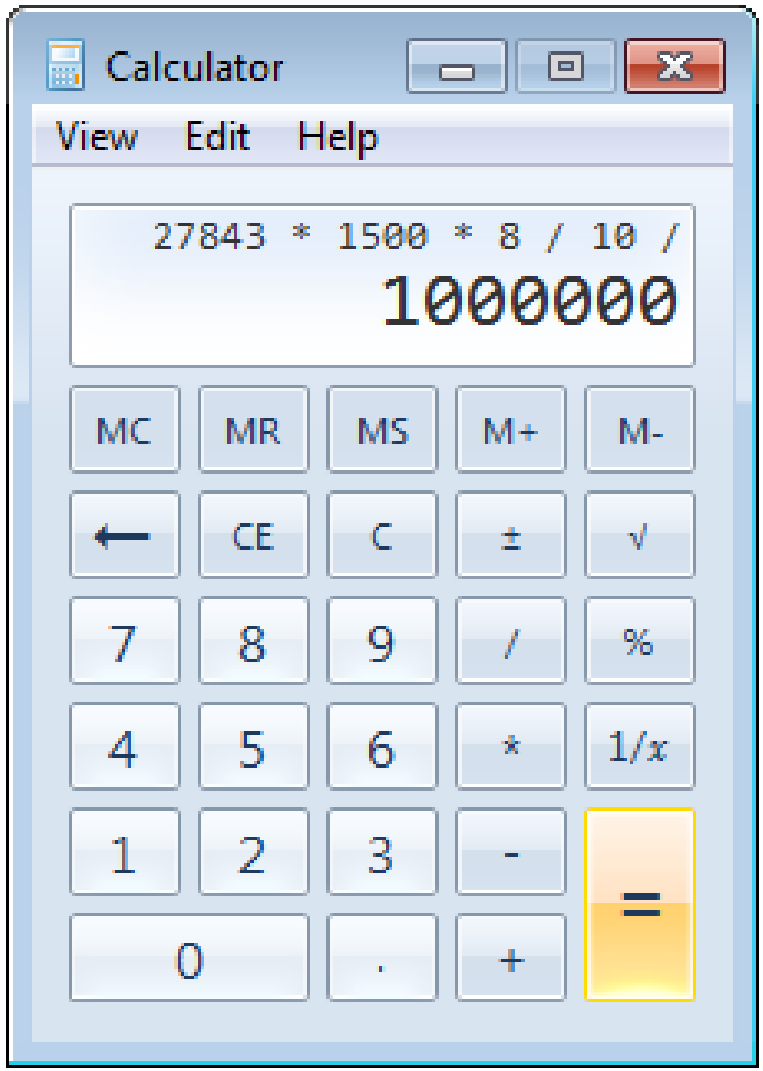
UDP vs. TCP (cont'd)

- **trace**: TCP goodput



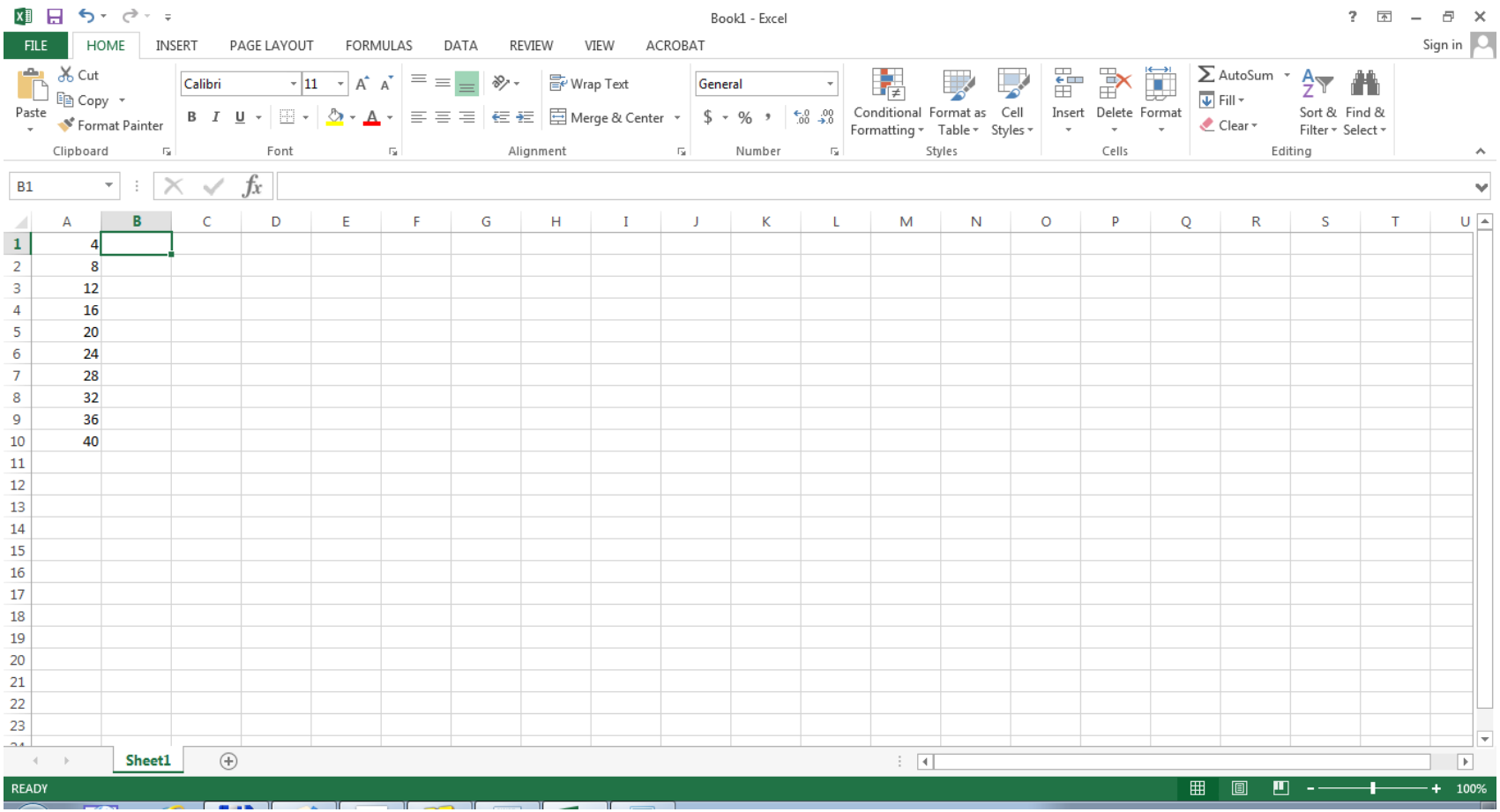
UDP vs. TCP (cont'd)

- **Calculator**: TCP goodput in "Mb/s"



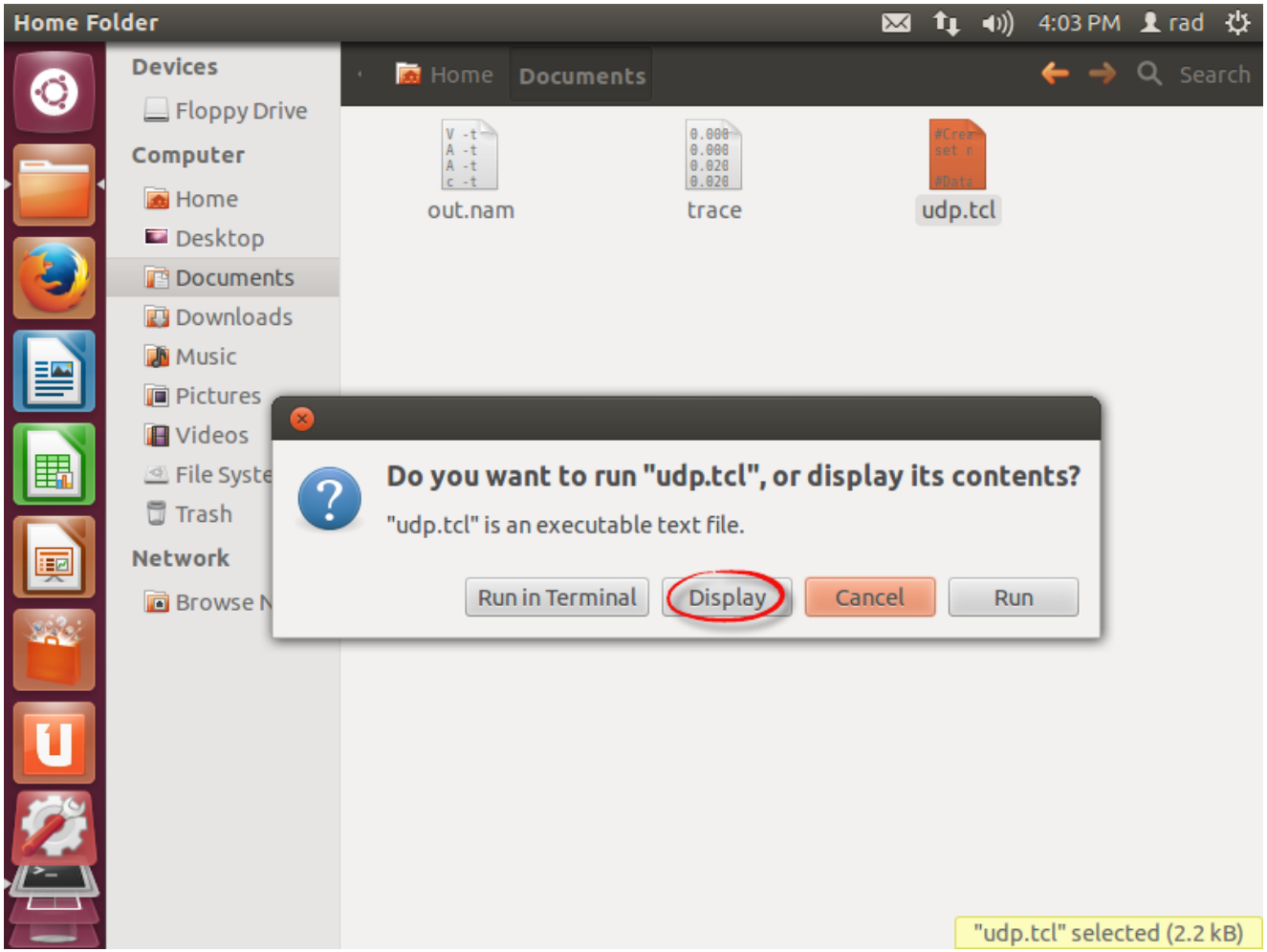
UDP vs. TCP (cont'd)

- **Excel**: UDP vs. TCP graph



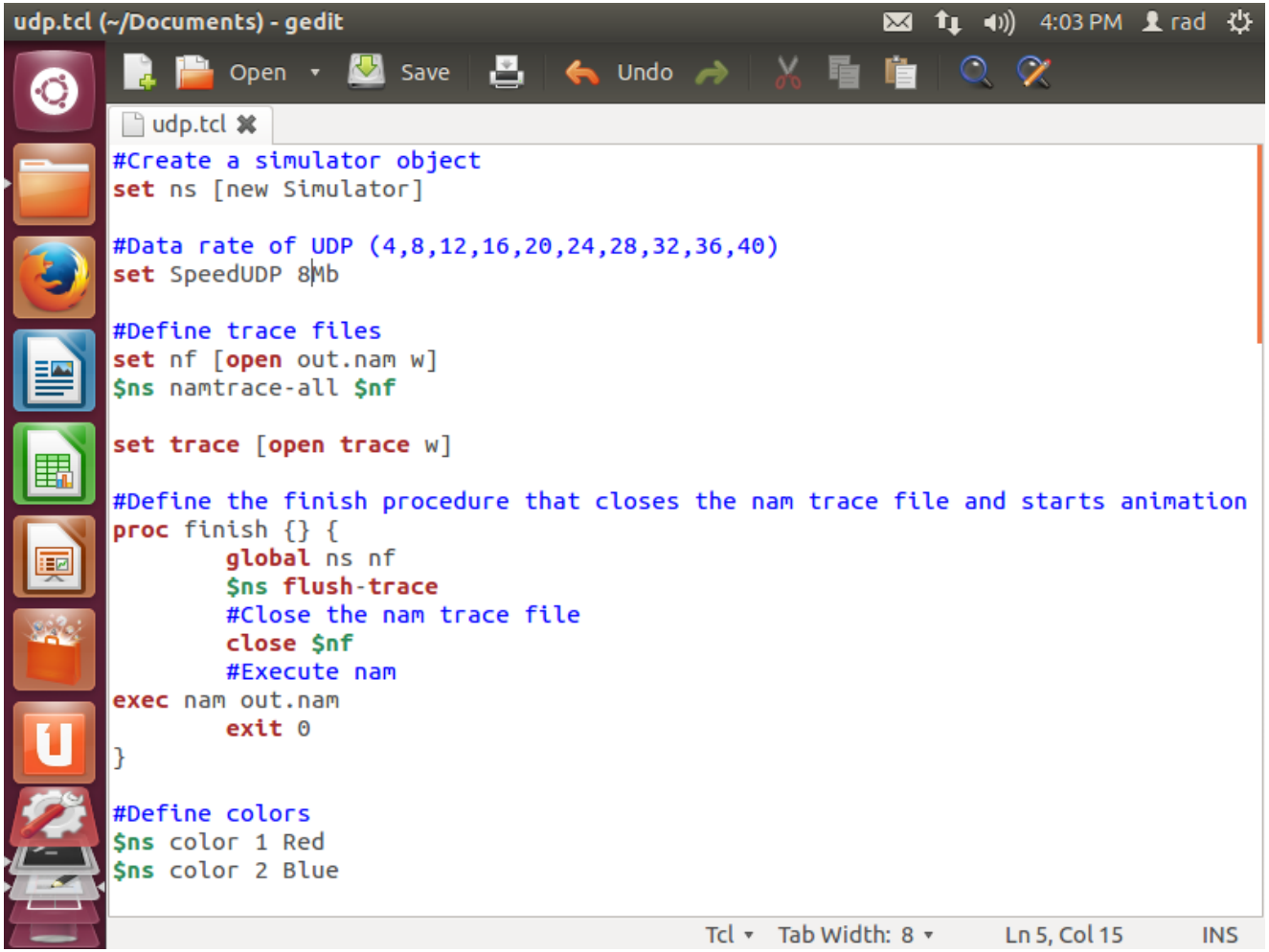
UDP vs. TCP (cont'd)

- **udp.tcl**: increase the data rate of UDP



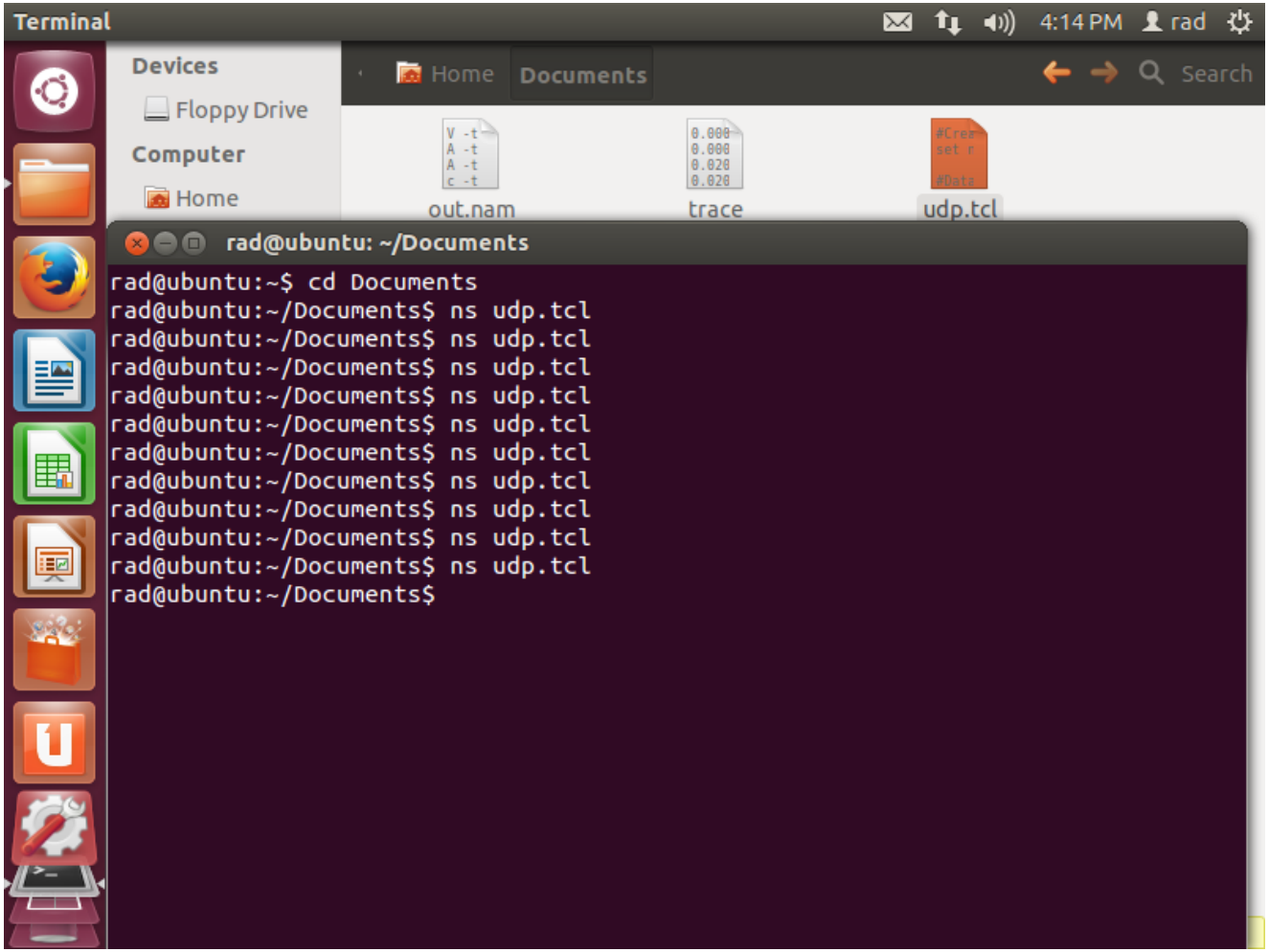
UDP vs. TCP (cont'd)

- **udp.tcl**: 4, 8, 12, 16, 20, 24, 28, 32, 36, 40 Mb/s



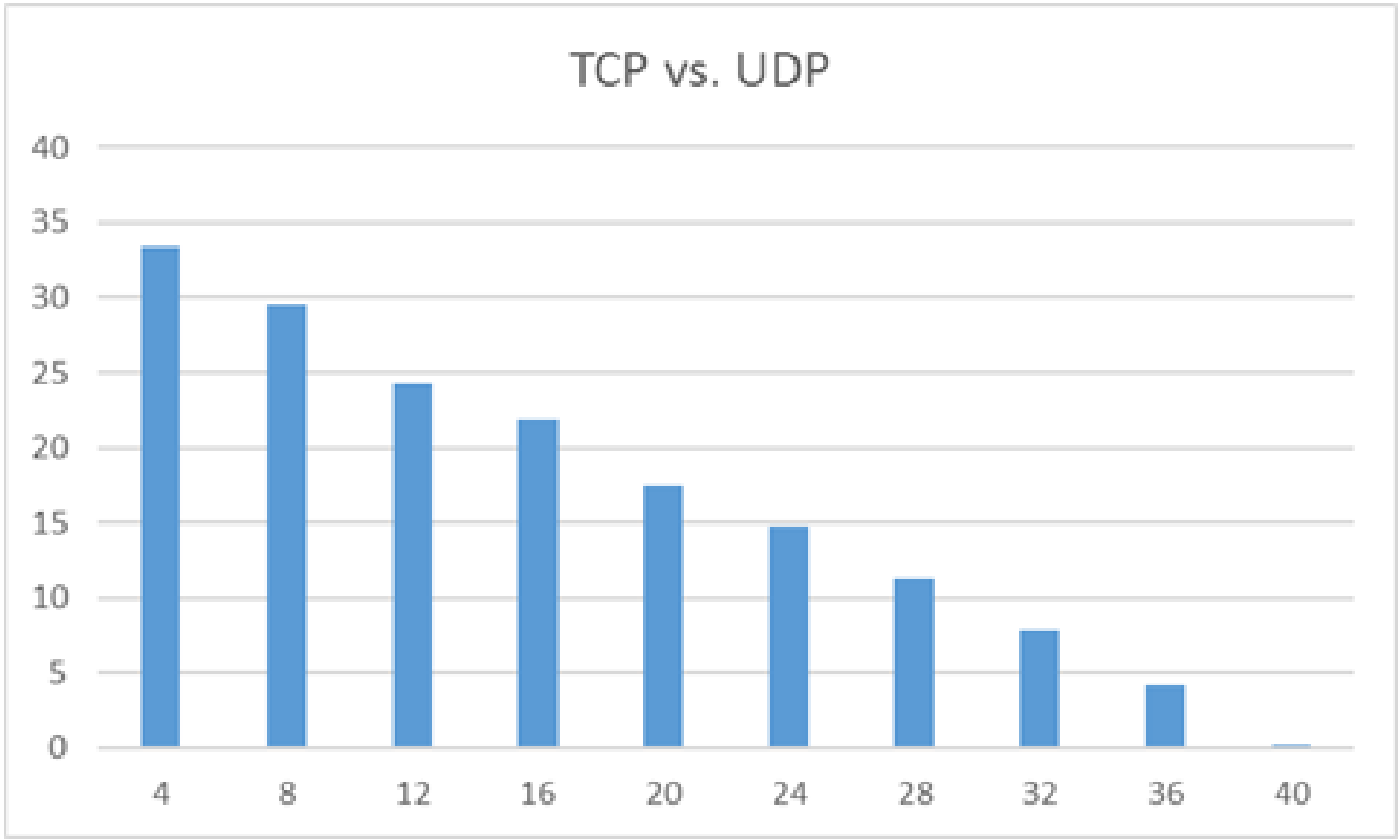
UDP vs. TCP (cont'd)

- **udp.tcl**: 4, 8, 12, 16, 20, 24, 28, 32, 36, 40 Mb/s



UDP vs. TCP (cont'd)

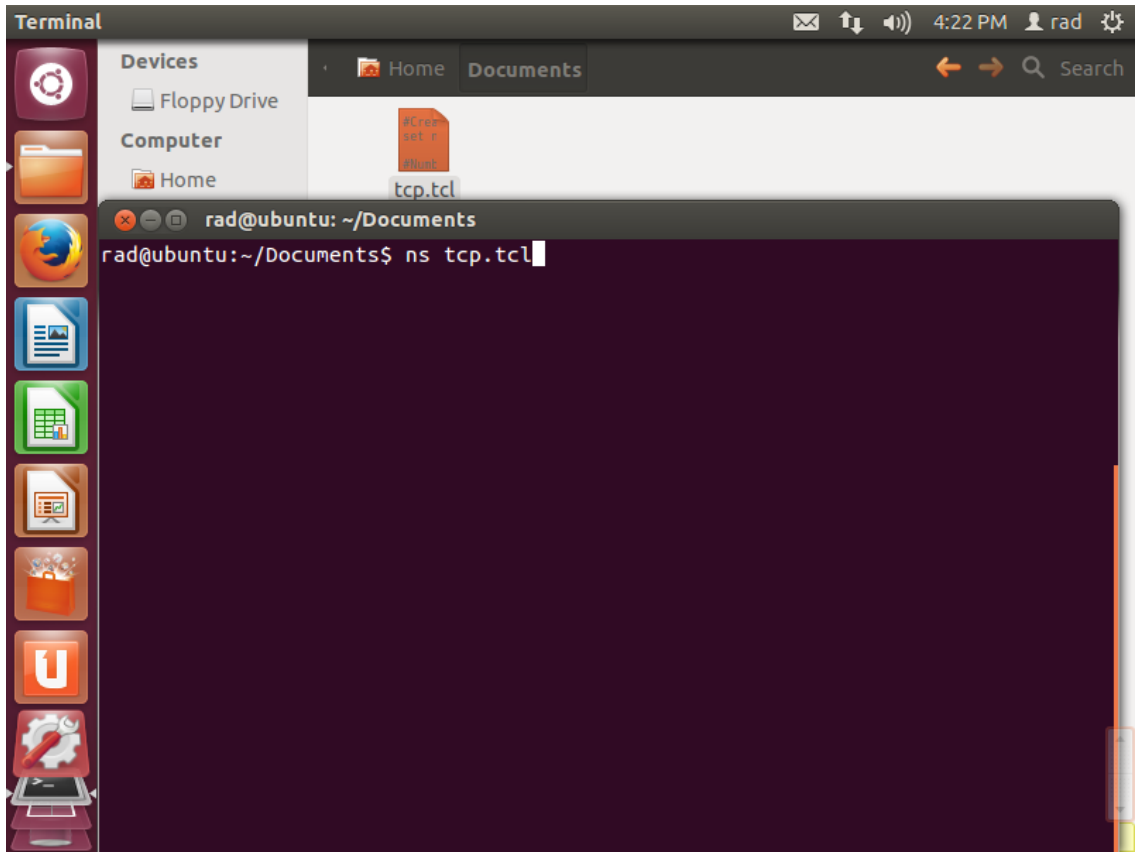
- UDP vs. TCP



Outline

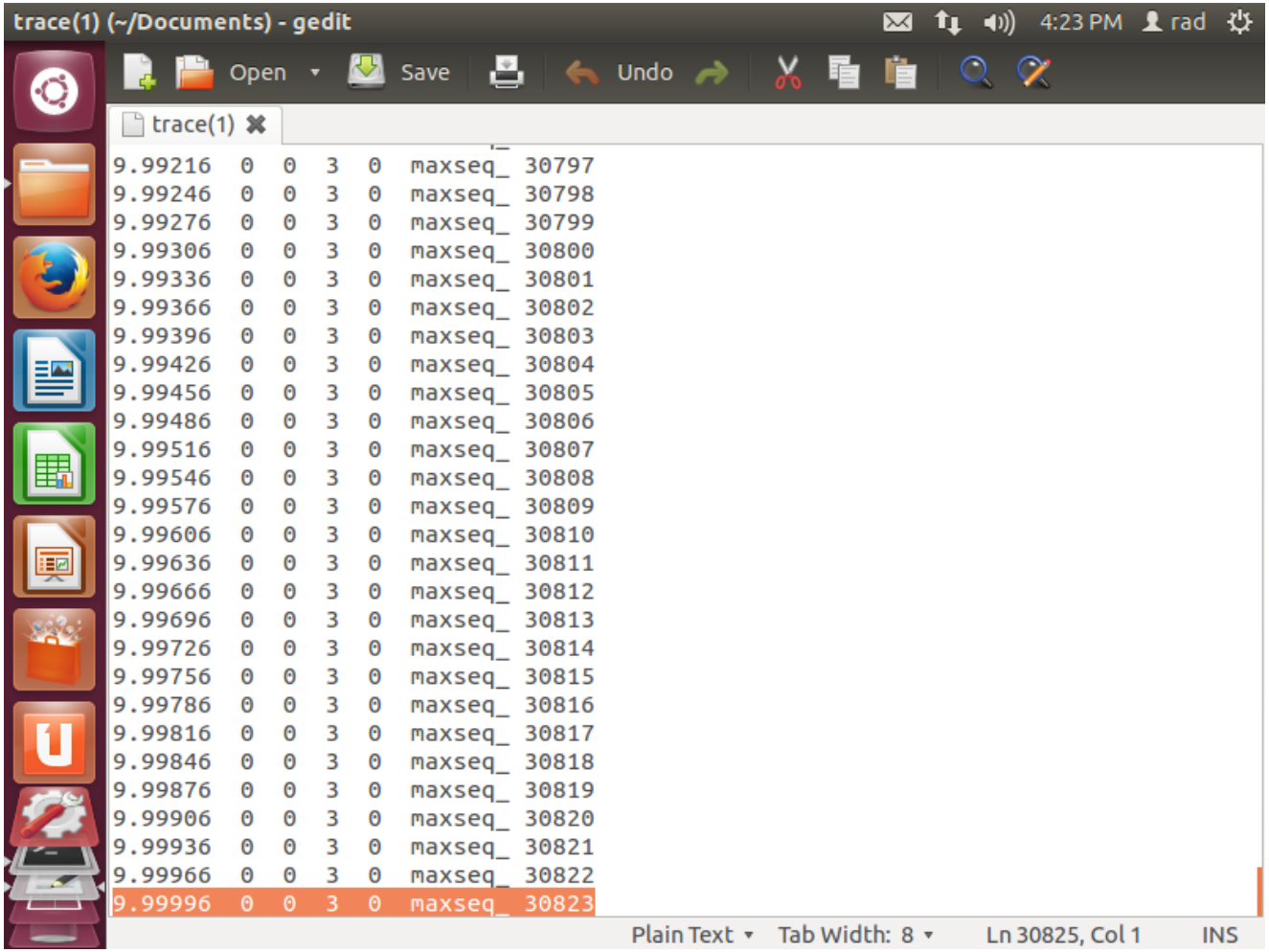
TCP vs. TCP

- Open **Terminal**: **<Ctrl>+<Alt>+<T>**
- Change directory: **cd Documents**
- Run simulation: **ns tcp.tcl**



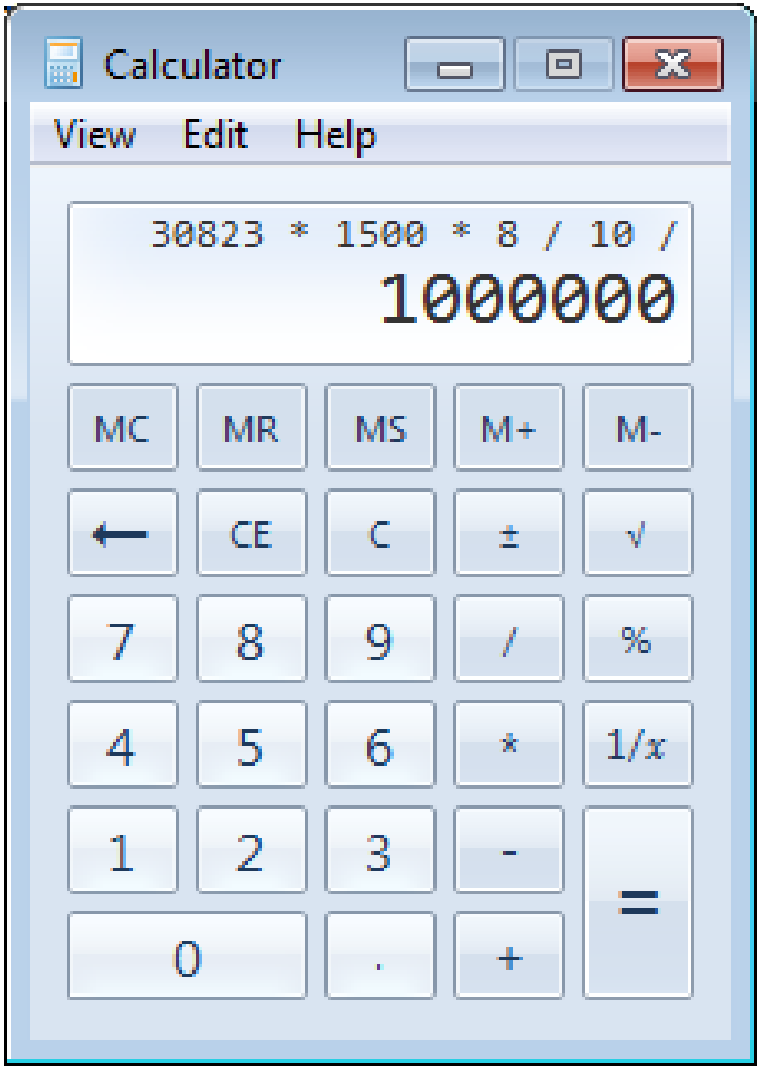
TCP vs. TCP (cont'd)

- **trace(1)**: TCP1 goodput



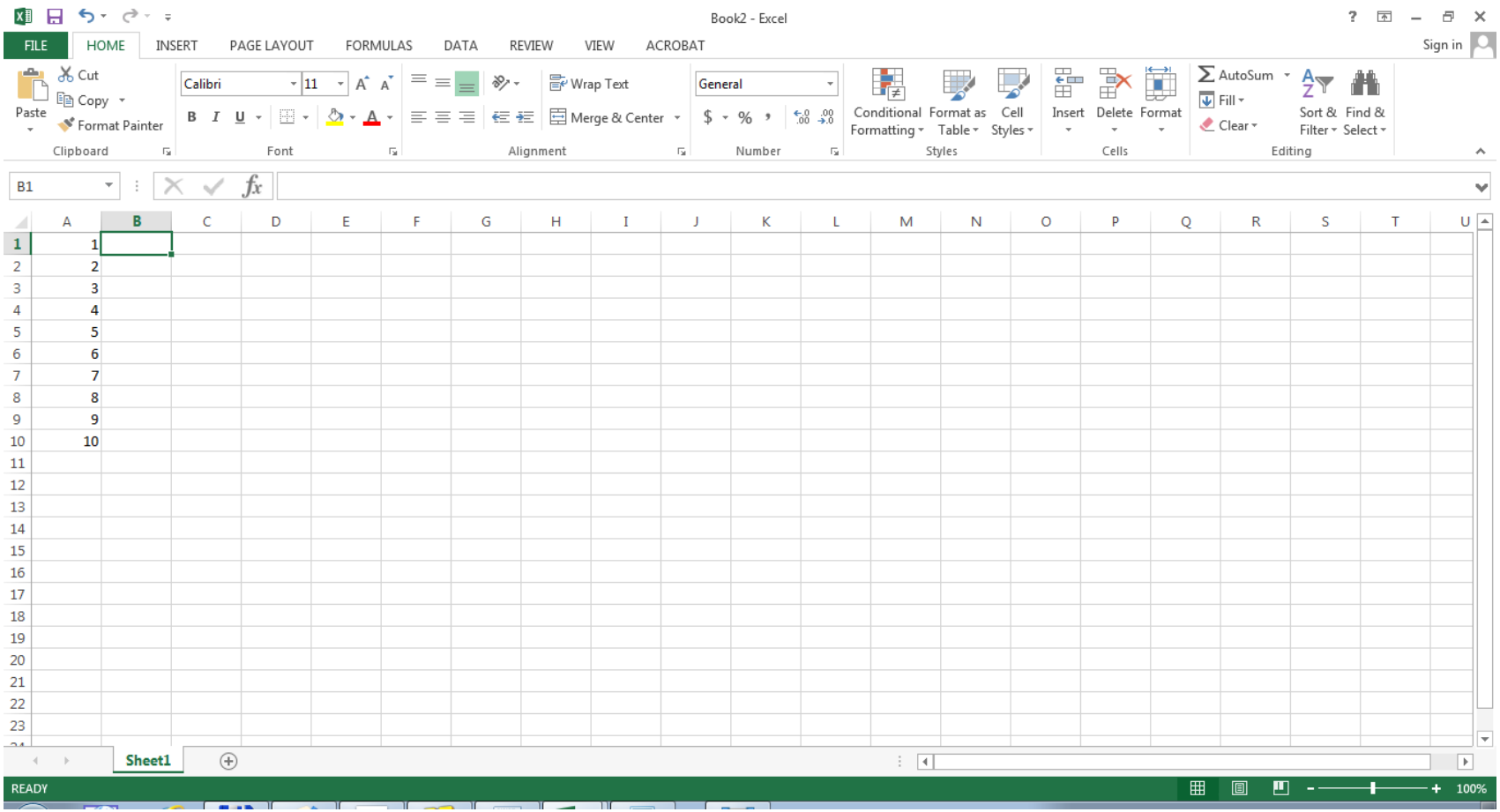
TCP vs. TCP (cont'd)

- **Calculator**: TCP goodput in "Mb/s"



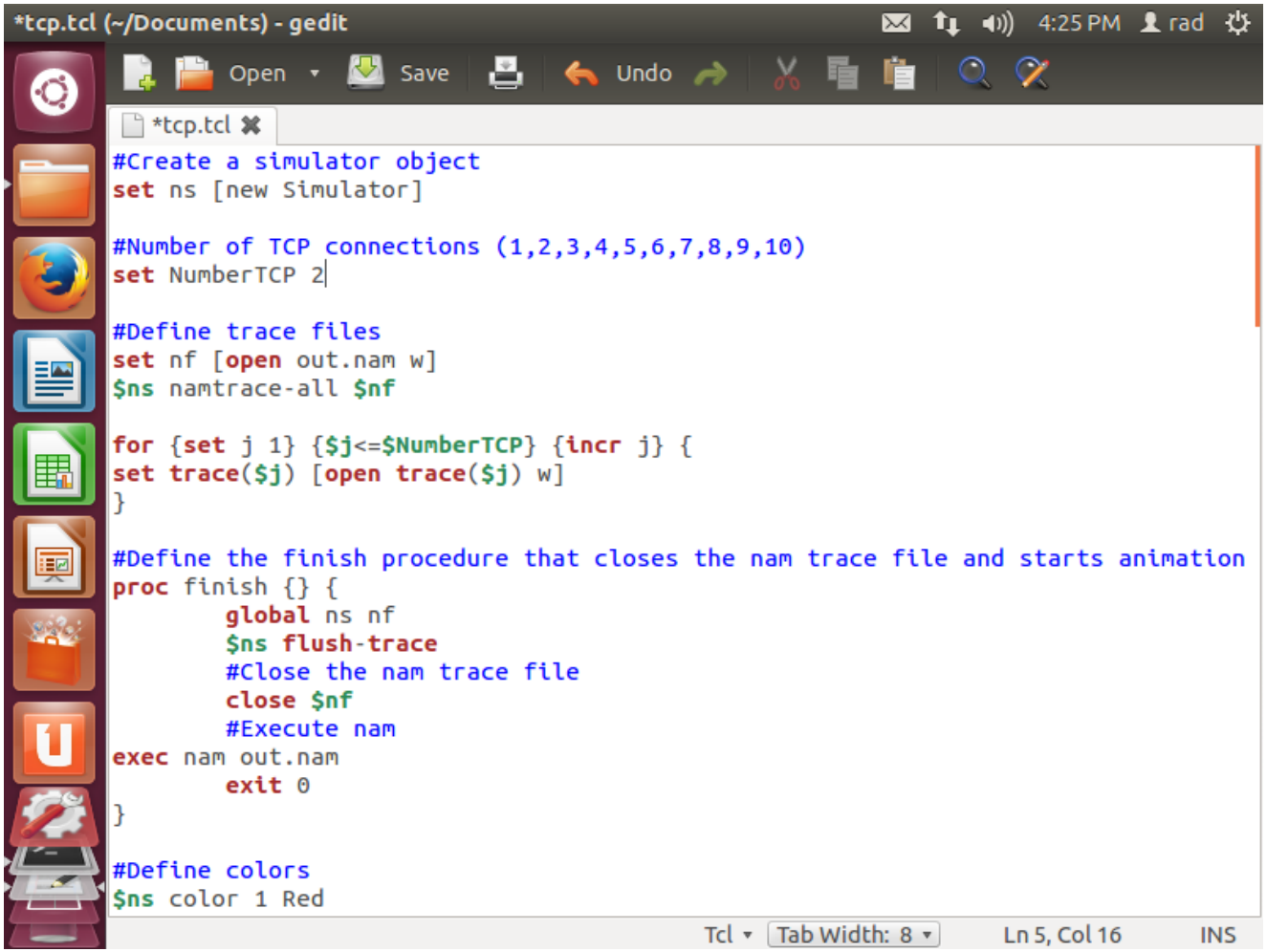
TCP vs. TCP (cont'd)

- **Excel**: TCP vs. TCP graph



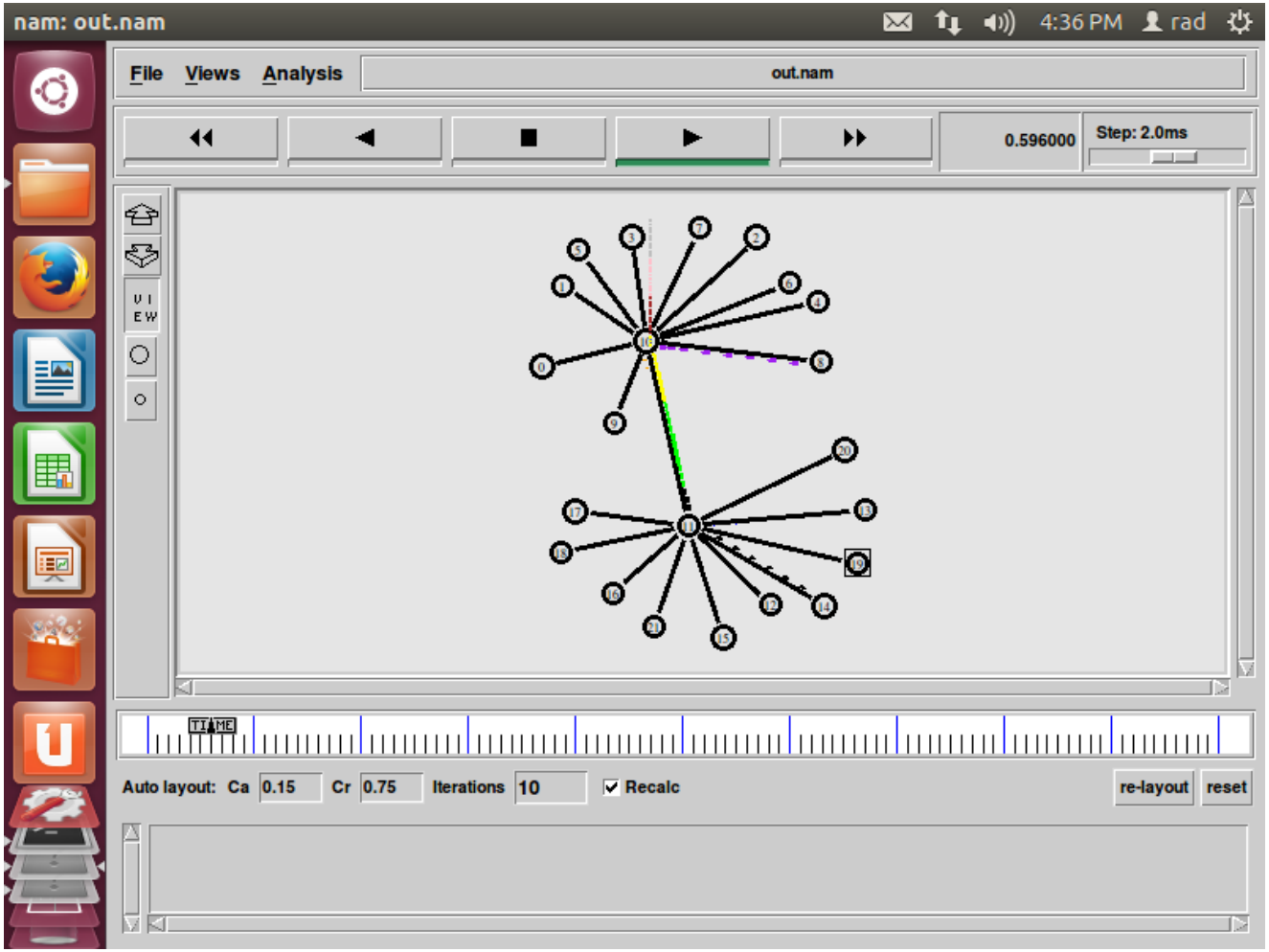
TCP vs. TCP (cont'd)

- **tcp.tcl**: increase the number of TCP connections



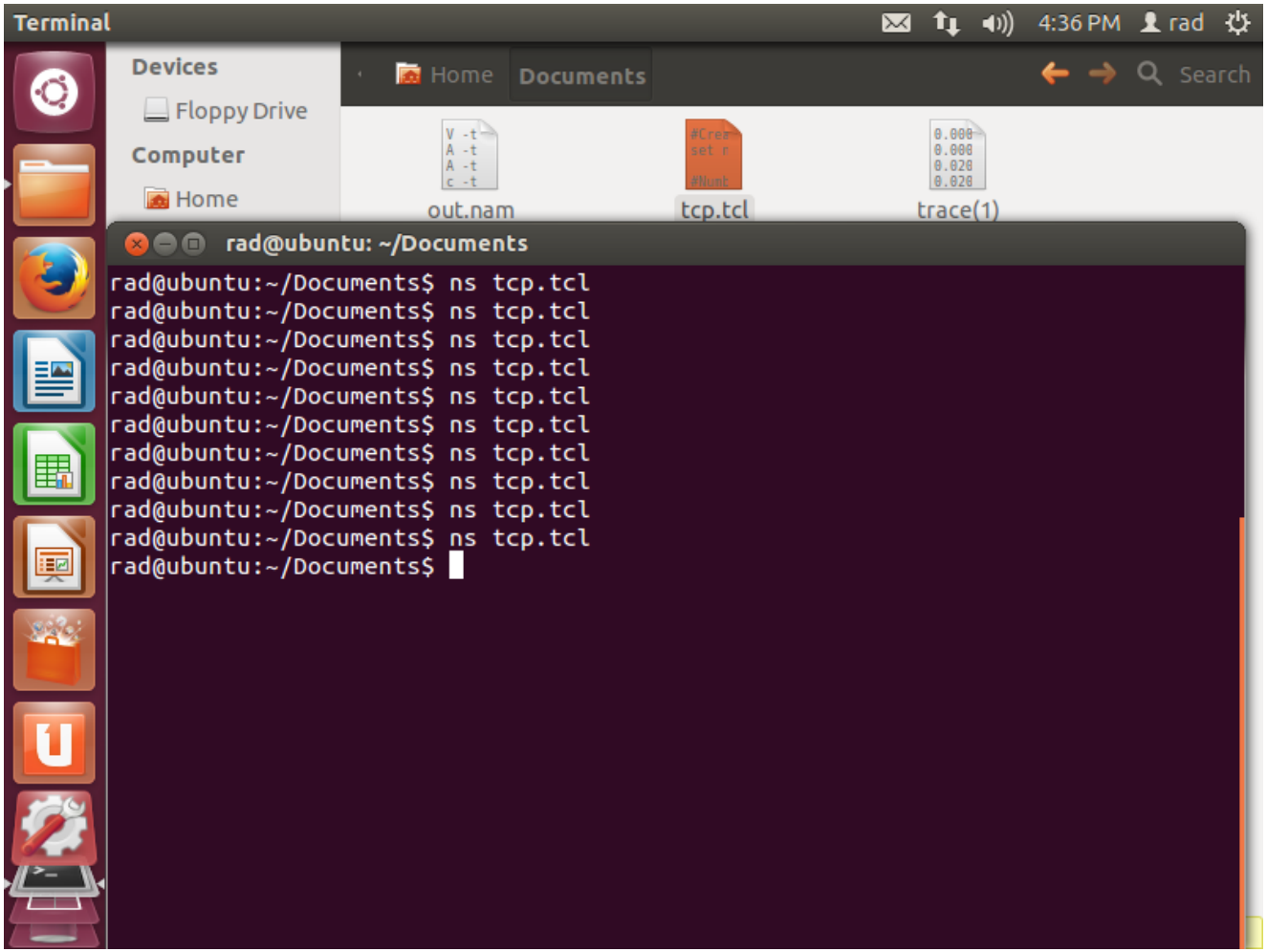
TCP vs. TCP (cont'd)

- **nam**: TCP vs. TCP



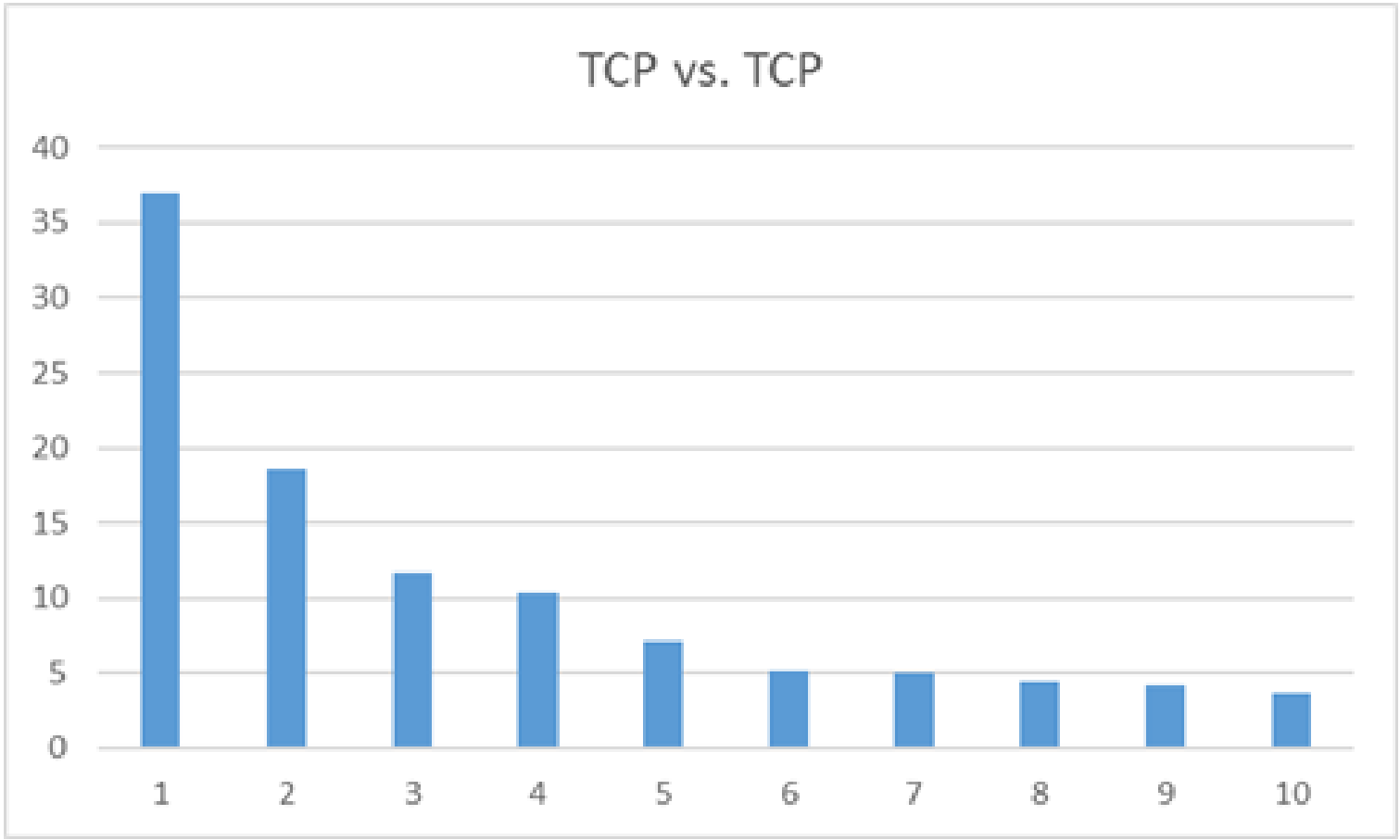
TCP vs. TCP (cont'd)

- **tcp.tcl**: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 connections



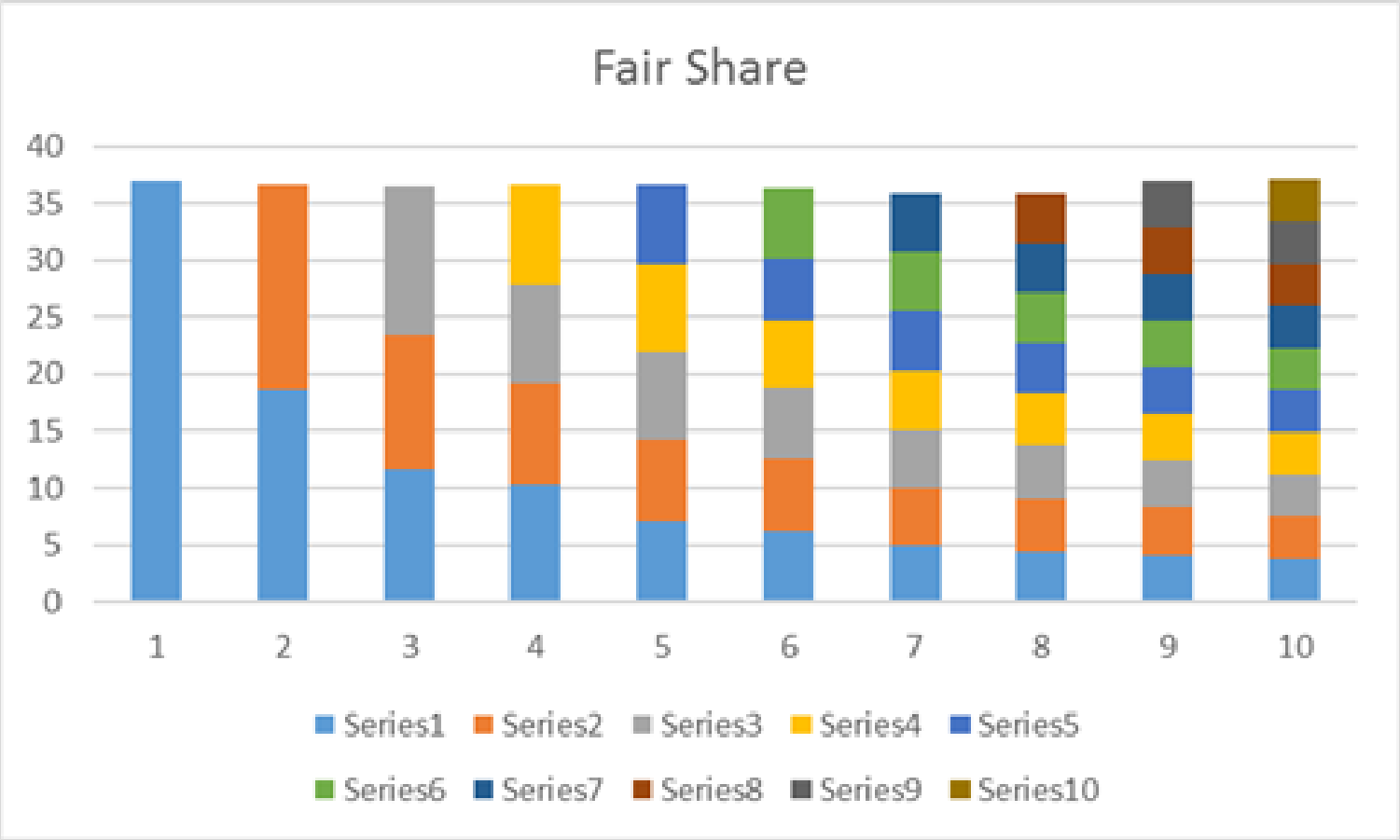
TCP vs. TCP (cont'd)

- TCP vs. TCP



TCP vs. TCP (cont'd)

- Fairness



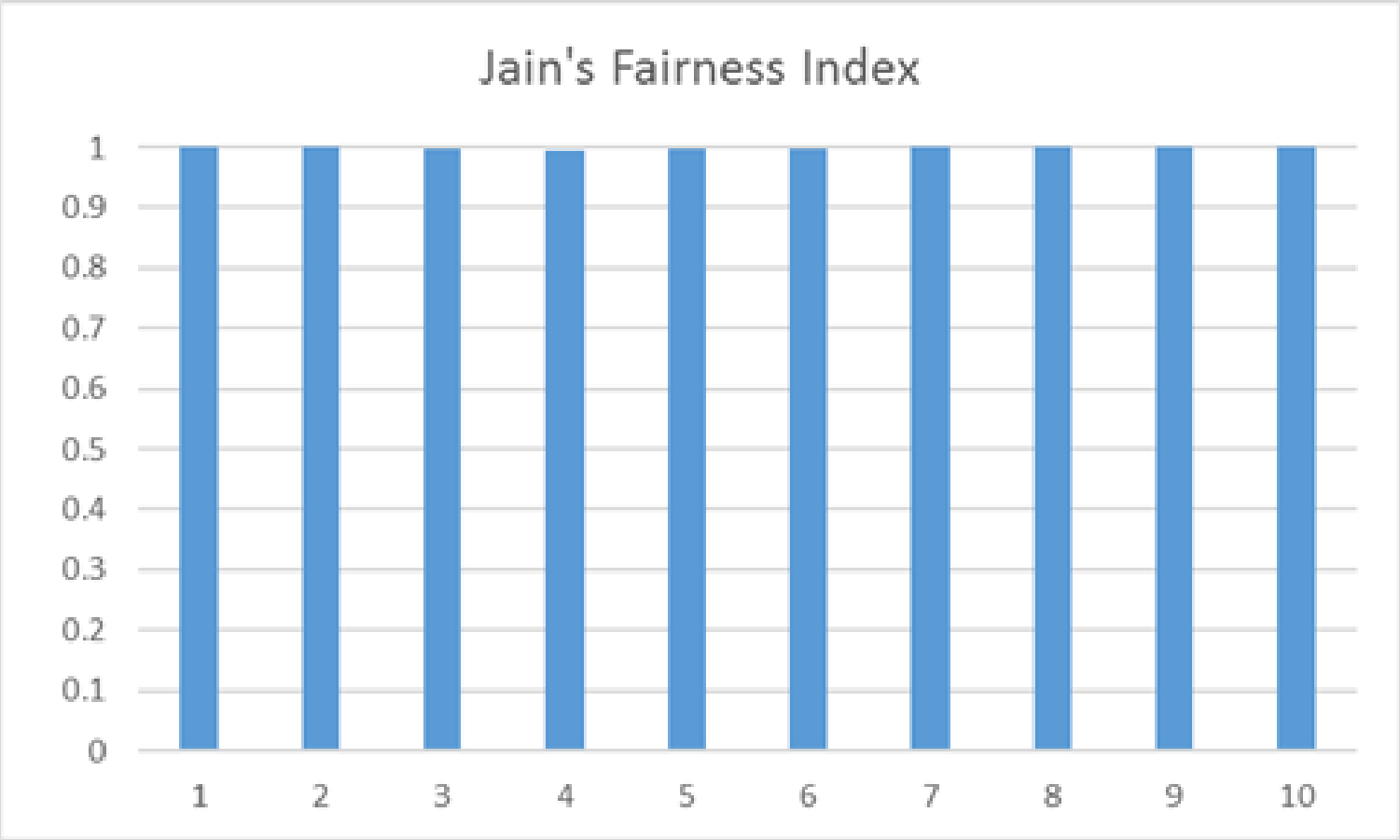
TCP vs. TCP (cont'd)

- Fairness can quantified using **Jain's fairness index**
  - Prof. Raj Jain
- If the system allocates rates to N contending users, such that the i-th user receives a rate allocation x_i, the fairness index $f(x)$ is defined as:

$$f(x) = \frac{(\sum_{i=1}^{N} x_i)^2}{N * \sum_{i=1}^{N} (x_i)^2}$$

TCP vs. TCP (cont'd)

- Jain's fairness index



Outline

RTTs and DelAck

- *J. Lee, S. Bohacek, J. Hespanha, K. Obraczka, 'A study of TCP fairness in high-speed networks,' University of Southern California, Technical Report 05-854, 2005*

- 2 TCP connections:

- RTT1 = 20 ms, RTT2 = 20 ms
  - Goodput1 = ? Mb/s, Goodput2 = ? Mb/s, Jain = ?

- **RTT1 = 40 ms**, RTT2 = 20 ms
  - Goodput1 = ? Mb/s, Goodput2 = ? Mb/s, Jain = ?

- RTT1 = 20 ms, RTT2 = 20 ms, IW = 2, **TCP1 = DelAck**
  - Goodput1 = ? Mb/s, Goodput2 = ? Mb/s, Jain = ?

RTTs and DelAck (cont'd)

- *J. Lee, S. Bohacek, J. Hespanha, K. Obraczka, 'A study of TCP fairness in high-speed networks,' University of Southern California, Technical Report 05-854, 2005*

- 2 TCP connections:

- RTT1 = 20 ms, RTT2 = 20 ms
  - Goodput1 = 19.9 Mb/s, Goodput2 = 19.4 Mb/s, Jain = 1

- **RTT1 = 40 ms**, RTT2 = 20 ms
  - Goodput1 = 15.1 Mb/s, Goodput2 = 24.3 Mb/s, Jain = 0.948

- RTT1 = 20 ms, RTT2 = 20 ms, IW = 2, **TCP1 = DelAck**
  - Goodput1 = 9.8 Mb/s, Goodput2 = 29.8 Mb/s, Jain = 0.797