Research and Development Methods for Overlay Networks

Outline

- Mathematical modeling (not covered in this lecture)
- Real implementations
- Simulation
- Emulation
- Practical exercises

Real Implementations

- Letting real users to run the software
- Running on testbeds such as PlanetLab

Real Implementations Demo

- PlanetLab

  http://www.planet-lab.org/

Simulation

- Simulation means imitating the key characteristics of a system in a controlled setting

  → Real software is seldom used in simulations.

- Typically happens in *simulation time,* not in real time

  Exceptions: Compiling real software against a simulation framework. Using a bridge between real software and the simulation framework.

Simulation types

- Mathematical
- Ad-hoc
- Discrete-event

Mathematical Simulation

- Often utilizes tools such as MATLAB or Mathematica
- Example: calculating numerical results from a Markovian model

Ad-Hoc Simulation

- Simple simulation programs written “just for the purpose” with a programming language of choice
- Testing of algorithms without network simulation
- Example: Comparing different piece selection algorithms of BitTorrent

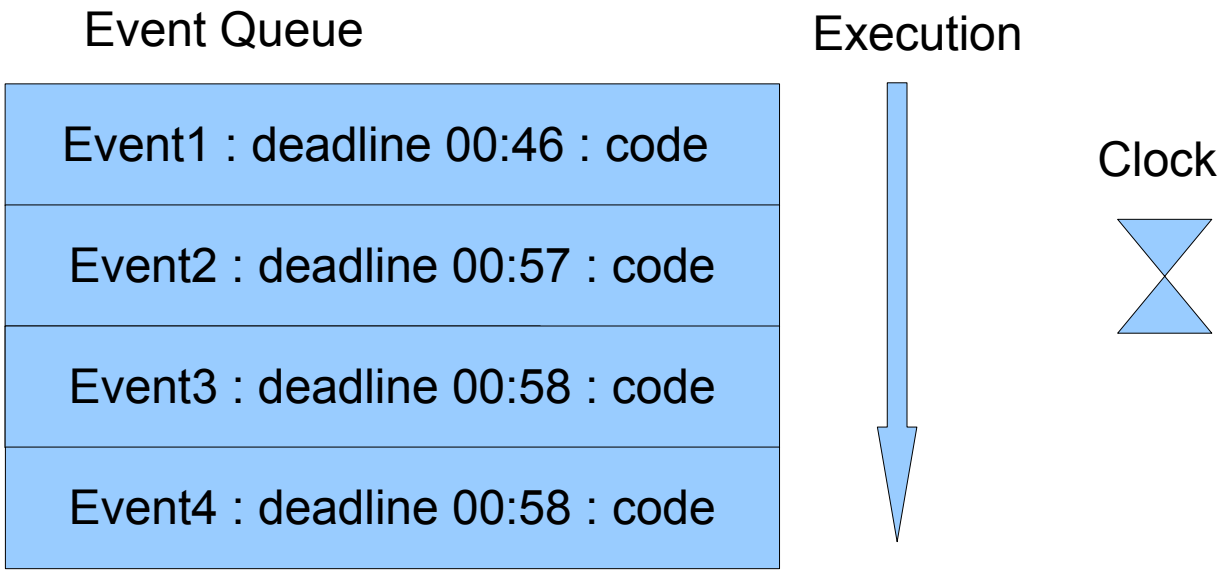
Ad-Hoc Simulation Demo

- A BitTorrent piece selection algorithm simulator written in Java.

Discrete-Event Simulation

- Using discrete-event frameworks for simulating the overlay network, including the networking stack

Discrete-Event Simulation



Discrete-Event Simulation Frameworks

- OMNet++
- NS2
- NS3

Discrete-Event Simulation Frameworks Demo

- OMNet++ OverSim

  http://www.oversim.org/wiki/OverSimFeatures

- Source code of a ns3 simulation

  http://thisblog.runsfreesoftware.com/?q=2009/04/16/first-example-ns-3-comments-explain

Emulation

- Running real software in an emulated network in real time

Emulation Tools

- Bandwidth limitation with Trickle
- Introducing delays and packet loss with NetEM
- Virtual machines with virtual TUN/TAP network interfaces

Emulation Tools Demo

- Trickle

  http://monkey.org/~marius/trickle/trickle.pdf

- NetEM

  http://swik.net/netem/Examples+of+Use

Simulation vs. Emulation

- Simulation is run in simulation time

  → better scalability

- Simulation allows experimentation in more versatile network conditions and topologies
- Simulation usually involves running simplified software, not real software

  → Less reliable results in research, difficulty of using simulators as development tools

Combining Simulation and Emulation

- Benefit: possibility to run real software with simulator-like scalability

Combining Simulation and Emulation

- Use a discrete-event simulator for simulating the network
- Trick virtual machines to run in simulation time
- Example: SliceTime

Combining Simulation and Emulation Demo

- SliceTime

http://www.comsys.rwth-aachen.de/fileadmin/papers/2011/2011-weingaertner-nsdi-slicetime-camera_ready_14P.pdf

Practical Exercises

- Goal: Learn to develop real overlay networking software while using a network simulator as a development tool

Exercise Environment

- Operating system: Linux
- Programming language: C++
- NS3 network simulator
- A class library developed at the department that allows for compiling the same code as a NS3 simulation executable and as real software

Excercise Environment Demo

- The design of the class library to be used in the exercises

Excercise Groups

- Group work allowed, groups of 3 persons maximum
- At least one group member should have C/C++ programming experience
- Groups will be agreed on during this lecture. If you did not attend the lecture and you would like to join a group, please send email to

  petri.savolainen ät hiit.fi

  It is also allowed to do exercises on your own without joining group.