Means for Peer-to-Peer Research

Kazuyuki Shudo

Requirements

• Peer-to-peer algorithms and systems …
  – involve massive number of nodes.
    • To 1,000,000s or more.
  – required to work in real environment.
    • i.e. on Internet, ad-hoc wireless network, …

• Researchers and developers want/have to confirm/prove scalability and practicality of their idea or software. They have …
  – a paper to be accepted
  – software to launch
Experiments

- Some experiments required to confirm/prove scalability and practicality.
  - even only to convince a reader, especially a reviewer😊

- Various means to make experiments have its own strengths and weaknesses.
  - Means: simulation, ...
  - Properties: scalability, ...

- Software design should reflect what we confirm/prove because it determines (restrict) means.
Means

• (With a piece of paper and a pen)
• Simulation
  – of an algorithm
• Emulation
  – of a distributed environment / network
• On a PC cluster / LAN
  – e.g. StarBED, …
• On a wide-area testbed
  – e.g. PlanetLab, XXX Grid, …
• Normal use
  – by the developer, friends or customers.
Properties of each means

- Simulation
- Emulation
- PC cluster / LAN
- Wide-area testbed
- Normal use
Properties of each means

- Simulation
- Emulation
- PC cluster / LAN
- Wide-area testbed
- Normal use

Personal Means

Professional Means (difficult for an amateur)
Simulation vs. Emulation

- Simulation of an application / algorithm
  - A simulated appl / algo generally does not run on a real network.

- Emulation of a distributed environment
  - An emulated network hosts real applications.
Simulation vs. Emulation

- Strength of each means:

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Emulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scalability</strong>: more nodes / PCs</td>
<td><strong>Reality</strong></td>
</tr>
<tr>
<td>- with less resources.</td>
<td>- A real app instances run.</td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td><strong>Natural programming</strong></td>
</tr>
<tr>
<td><strong>Rapid / accurate experiments</strong></td>
<td></td>
</tr>
</tbody>
</table>

- A simulated appl / algo is more lightweight than real software.
  - A real appl is tied to (heavy) OS resources such as processes and threads.
- It is not necessary for a simulated clock to be bound with a real clock.
  - Faster experiments and accurate simulation for a longer time.
- But it is difficult for simulation to be compatible with natural programming.
  - e.g. A sim. does not allow new Thread() and new Socket() in Java.
  - A sim. requires its own dedicated manners to write code for it.
Scalability: Examples

- Simulation - 1,000,000 nodes
  - p2psim (MIT): 3,000 nodes on a single PC
    - “we simulate Chord with 3000 nodes in a very reasonable amount of time.”
  - OverSim (U. Karlsruhe): 10,000 nodes in a Chord network on a single PC
  - PIAX: 300,000 nodes on a single PC
    - implements Skip Graph to support location-based (2-D range) search.
    - Runs on a real network

- Emulation - 10,000 nodes
  - ModelNet (Duke U.): 1,000 DHT nodes on 40 PCs (in a Bamboo paper)
    - An Internet emulator imposing network topology, wide-area delay and bandwidth restrictions.
  - Overlay Weaver (AIST, Kazuyuki Shudo): 4,000 nodes on a single PC
    - supports DHT and ALM as services, and Chord, Kademlia, Koorde, Pastry and Tapestry as overlay algorithms.
    - # of nodes limited by # of threads Linux kernel supports.
  - peeremu (NEC): 1120 nodes = 80 nodes x 14 PCs
    - supports packet delay / loss.
Scalability: an open problem

• Generally,
  – 100 nodes run fine but 1000 nodes …
  – 1000 nodes run fine but …

• In the first place, what you see with \( X \) nodes?
  – Is a 1,000,000 nodes experiment better than 1,000 nodes one? What is the difference?
  – Is larger better?

  – Countermeasures:
    • Clarify relationships between a scale and its characteristics.
    • Set the number based on a real numbers.
      – E.g. 40 millions households in Japan.
    • Do not mention 😊
Research tools

(Usual) Application

Simulator

Emulator

p2psim, PeerSim, OverSim, …

ModelNet, peeremu, …

A model of peer-to-peer research tools

Simulated Application

Simulated Network

(Real) Application

Emulated Network

Real Network

Simulation Emulation
Research tools

Overlay Weaver

- Structured overlay
- Lightweight Emulator
- Messaging
- Network

Simulated Application
(Real) Application
Emulated Network
Real Network

Bamboo DHT, PIAX, …

Distributed hash table
Event-driven API
Simulator
Internet emu.
Network

A model

Simulation
Emulation

- Supports both simulation and emulation.
- At the cost of special manners in programming.

Natural programming is very important in OW.
Research tools

Simulation  Both  Normal use (and emulation)

Which one is your software?

• Each one has its advantages and disadvantages.
• Fixed at an early stage of software design and to be considered carefully.

A model

Simulated Application  (Real) Application
Simulated Network  Emulated Network  Real Network
Simulation  Emulation