



# Means for Peer-to-Peer Research

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DAS-P2P 2007, January 16, 2007



# 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

Scalable

Controllable

Resource-available

Rapid experiments

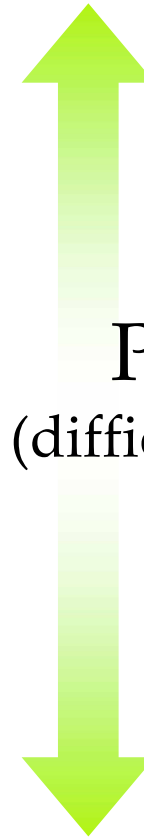
Practical

# Properties of each means

- Simulation
- Emulation
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- Wide-area testbed
- Normal use



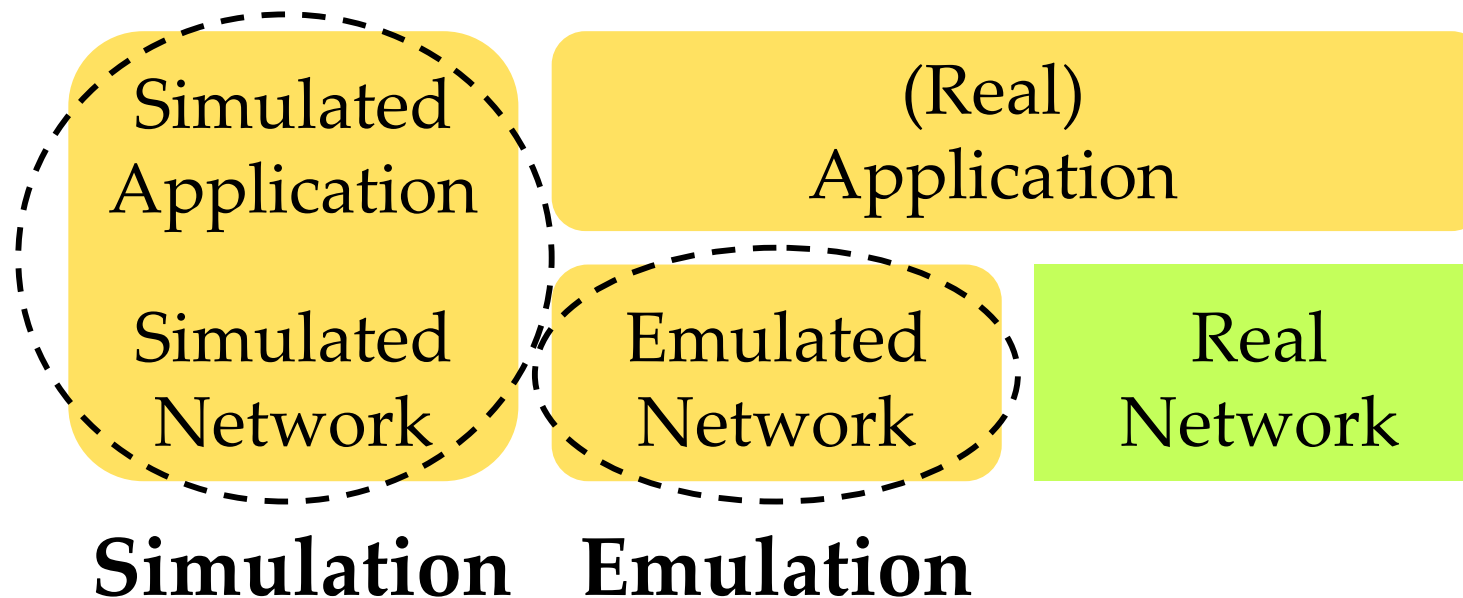
Personal  
Means



Professional  
(difficult for an amateur)  
Means

# 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:

| Simulation  | Emulation  |
|---|--|
| <ul style="list-style-type: none"><li>• <b>Scalability</b>: more nodes / PCs<br/>–with less resources.</li><li>• <b>Performance</b></li><li>• <b>Rapid / accurate experiments</b></li></ul> | <ul style="list-style-type: none"><li>• <b>Reality</b><br/>–A real app instances run.</li><li>• <b>Natural programming</b></li></ul> |

- 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

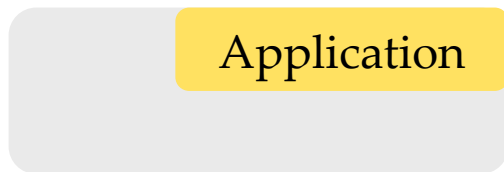
- Simulation - 1,000,000 nodes
  - **p2psim** (MIT): 3,000 nodes on a single PC
    - “we simulate Chord with 3000 nodes in a very reasonable amount of time.”
  - **OverSim** (U. Karlsruhe): 10,000 nodes in a Chord network on a single PC
  - **PIAX**: 300,000 nodes on a single PC
    - implements Skip 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, Kademia, 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

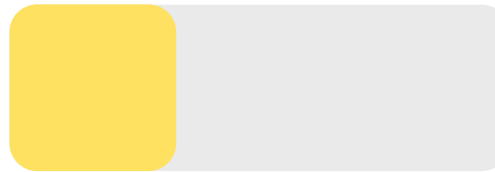
- Generally,
  - 100 nodes run fine but 1000 nodes ...
  - 1000 nodes run fine but ...
- In the first place, **what you see with X nodes?**
  - Is a 1,000,000 nodes experiment better than 1,000 nodes one? What is the difference?
  - Is larger better?
  - Countermeasures:
    - Clarify relationships between 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

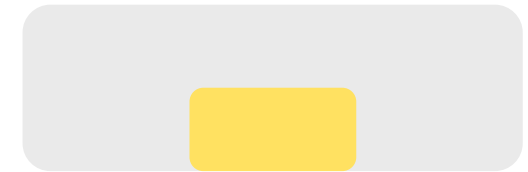


## Simulator



p2psim, PeerSim, OverSim, ...

## Emulator



ModelNet, peeremu, ...

*A model of peer-to-peer research tools*

Simulated  
Application

Simulated  
Network

**Simulation**

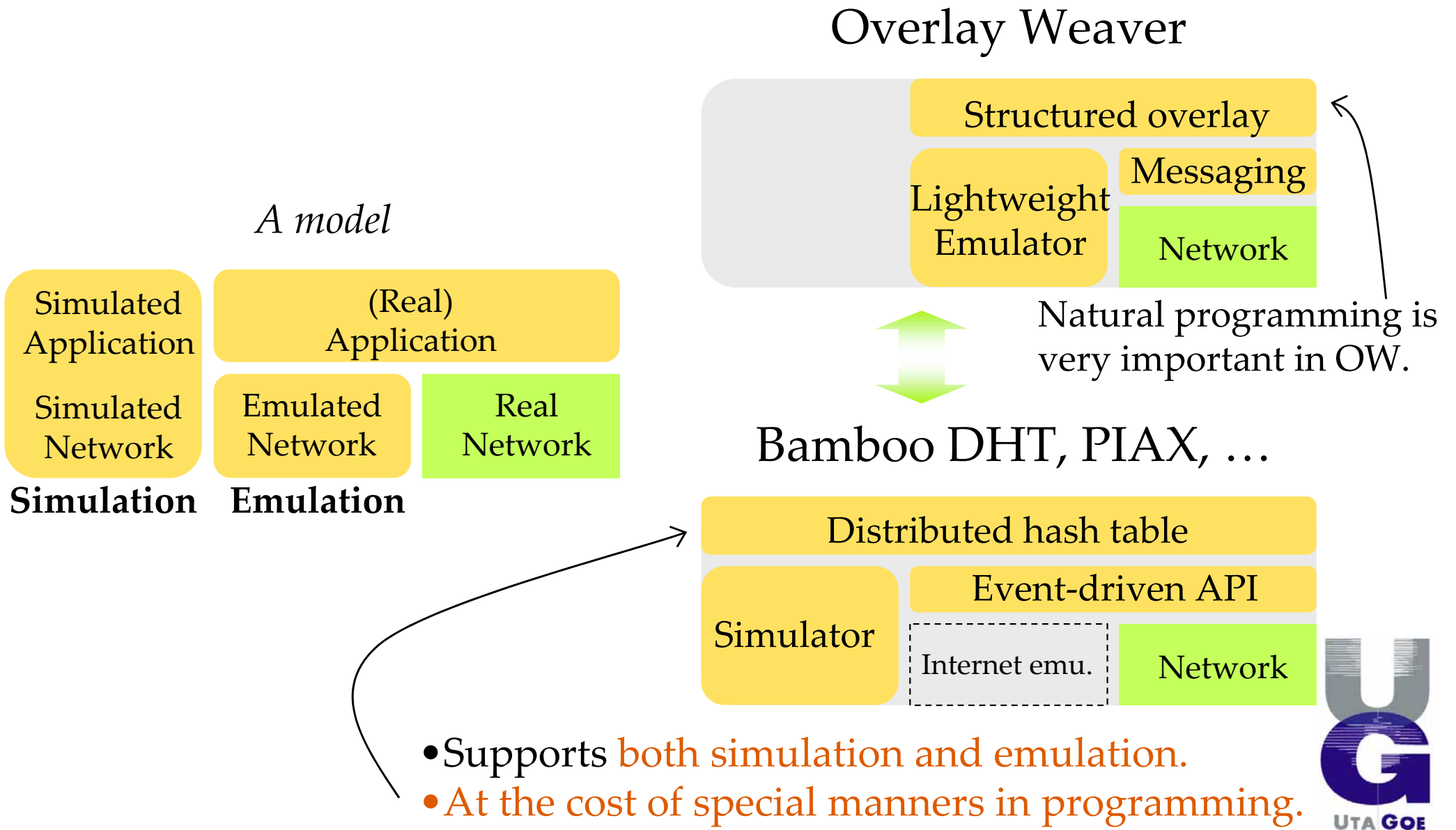
(Real)  
Application

Emulated  
Network

**Emulation**

Real  
Network

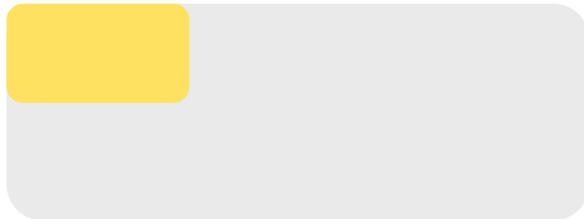
# Research tools



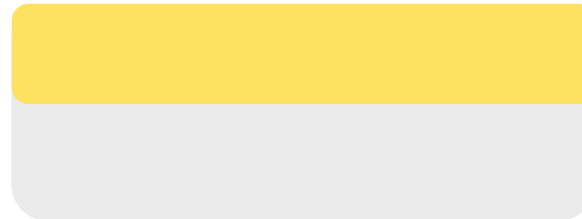
- Supports both simulation and emulation.
- At the cost of special manners in programming.

# Research tools

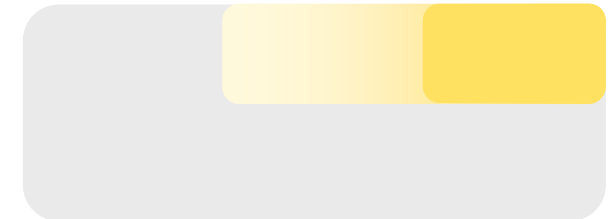
Simulation



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*

