Distributed Experiment Management for Large-scale Testbeds

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Protocol Analysis and Evaluation

- Simulations allow for
  - large-scale and controlled evaluation
  - easy experiment management
  - but: hard to achieve realistic environments

- Real-world testbeds allow for
  - realistic environments, cross traffic, routing, …
  - provide realistic results
  - but: ***complex experiment management***

- Focus of this talk

Experiment management for large-scale real-world distributed testbeds

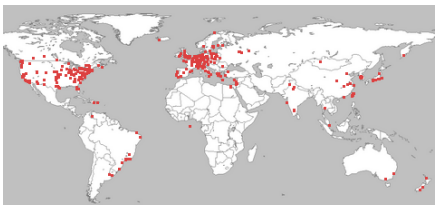
Real-world testbeds

but: ***complex experiment management***

- How we define experiment management
  1. Preparation – selection of machines, deployment of experiment package
  2. Running experiment, collecting runtime status
  3. Collecting of experiment results
- Why is experiment management complex?
  - *Example 1*: which machines are selected, how does load on the machine-set evolve?
  - *Example 2*: how are experiments deployed efficiently, status/results collected efficiently?
  - *Example 3*: very heavy load on control machine for deployment, status and result collection
    - e.g. 500 parallel ssh sessions, DDoS when status is sent back

Problems in Detail

Which machines are selected, how does load on the machine-set evolve?



PlanetLab sites

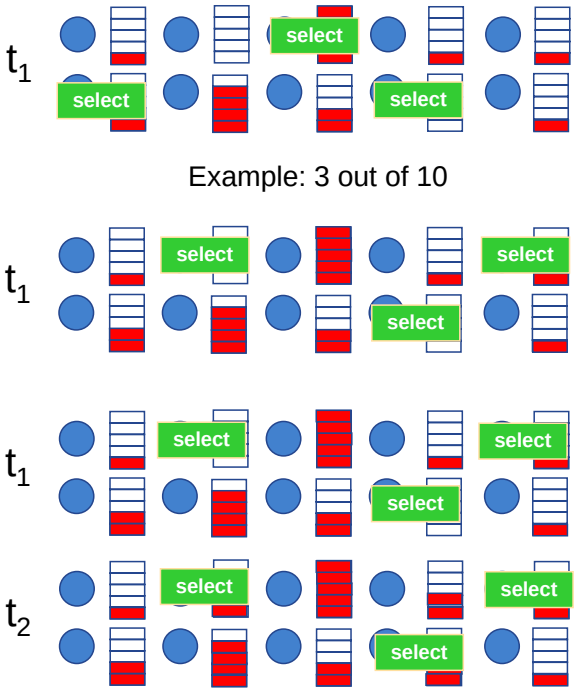
- Key challenges
  - select most appropriate nodes at experiment start
  - prevent running experiments from being degraded in quality
- Solution strategies
  - maintain pool of machines + quality estimation for selection at runtime → focus of this presentation
  - employ mechanism to replace degraded machines with more appropriate

General Selection Strategies

How does a researcher* select machines?

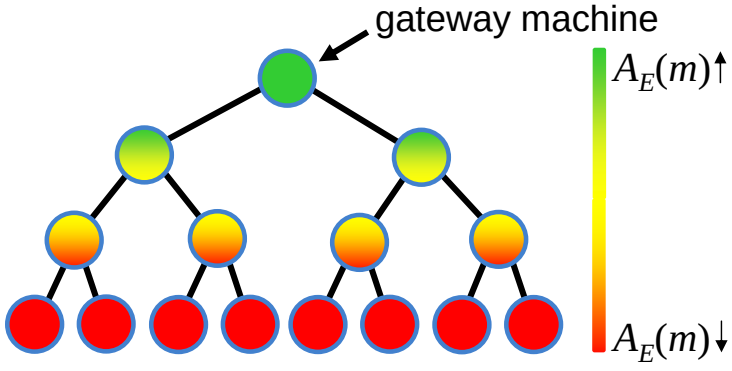
- Random
  - naive selection of nodes
  - don't care for anything
- TopNodes
  - select 'best' nodes at experiment start (t_1)
- Adaptive
  - initially like TopNodes
  - maintain at runtime
  - replace degraded nodes

*the person intending to run an experiment in a testbed



Distributed Approach

- Distributed experiment management
  - define metric $A_E(m,t)$ specific to experiment E
    - applicability of machine m for experiment E at time t
    - e.g. $A_E(m,t) = cpu\text{-}load_t^{-1} + free\text{-}mem_t$
  - all testbed machines form an overlay-based tree T that stays sorted at runtime with respect to A



Machine selection
- counter-based

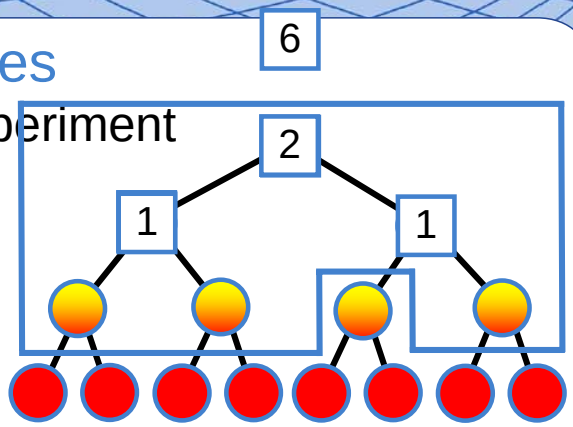
Experiment deployment
- ALM-based distribution

Result/status collection
- concast-based aggregation

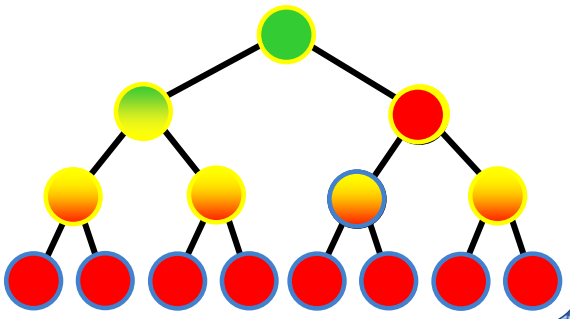
e.g. *Reliability-oriented Switching Trees*, Tan and Jarvis, IEEE Transactions on Parallel and Distributed Systems, 2007

Adaptive Machine Selection

- Initial selection of machines
  - require 6 machines for experiment
  - send experiment package with counter to gateway



- Runtime Adaptation
  - machines report metric to parents
  - switch roles, exchange experiment package, and status context
  - prefer unused machines
  - unaggressive switching, prevent thrashing



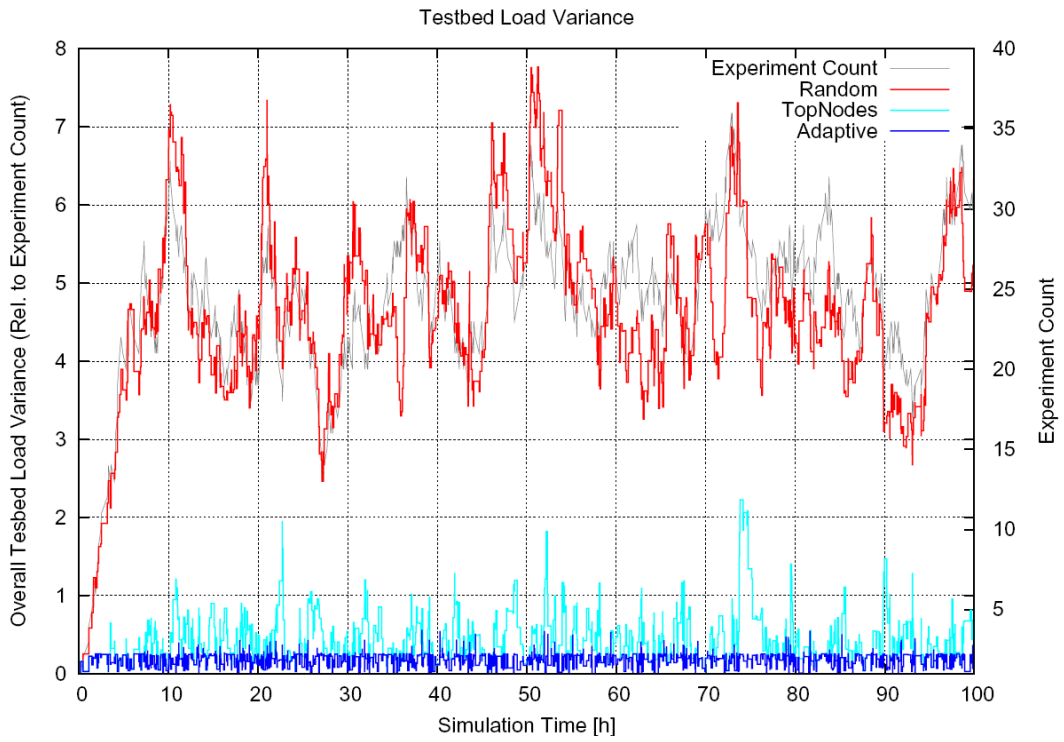
Simulation Setup

- Simulations based on OMNeT++
  - simulation environment
    - simulation-time duration of 100h
    - 100 machines, 50 overall experiments
  - experiment environment
    - lifetime distributed uniformly between 10min and 10h
    - deadtime distributed uniformly between 10min and 10h

    → ~25 experiments alive at every time
    - experiment selects set of machines at each start

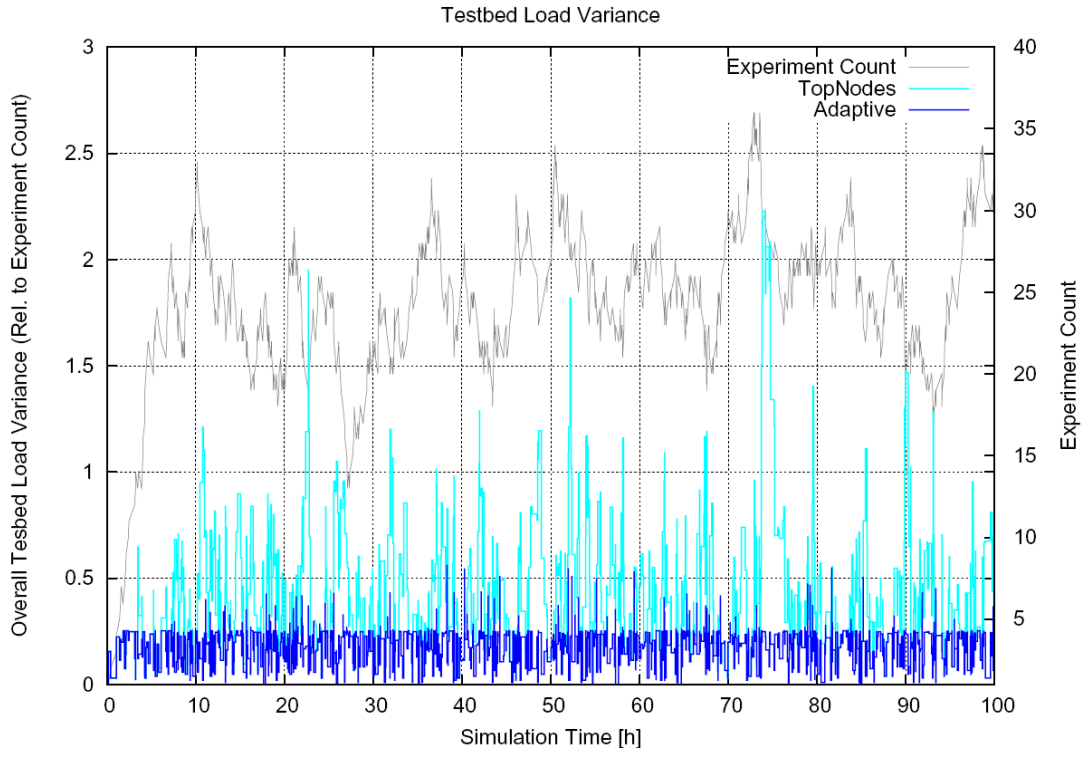
    → uniform between 10 and 90 machines
  - metric environment
    - $load_t(m)$ – load of machine m defined as number of experiments run on that machine at time t
    - $A_E(m,t) = (load_t(m)+1)^{-1}$

Testbed Provider Perspective



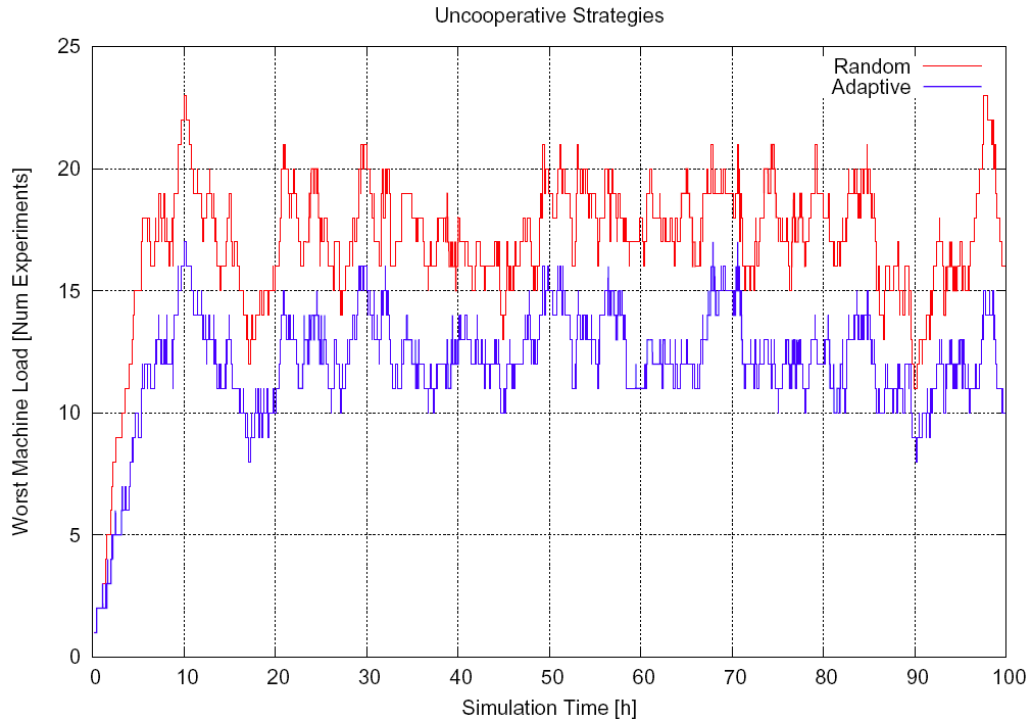
→ Lowest load variance with adaptive approach, provides best overall service

Testbed Provider Perspective



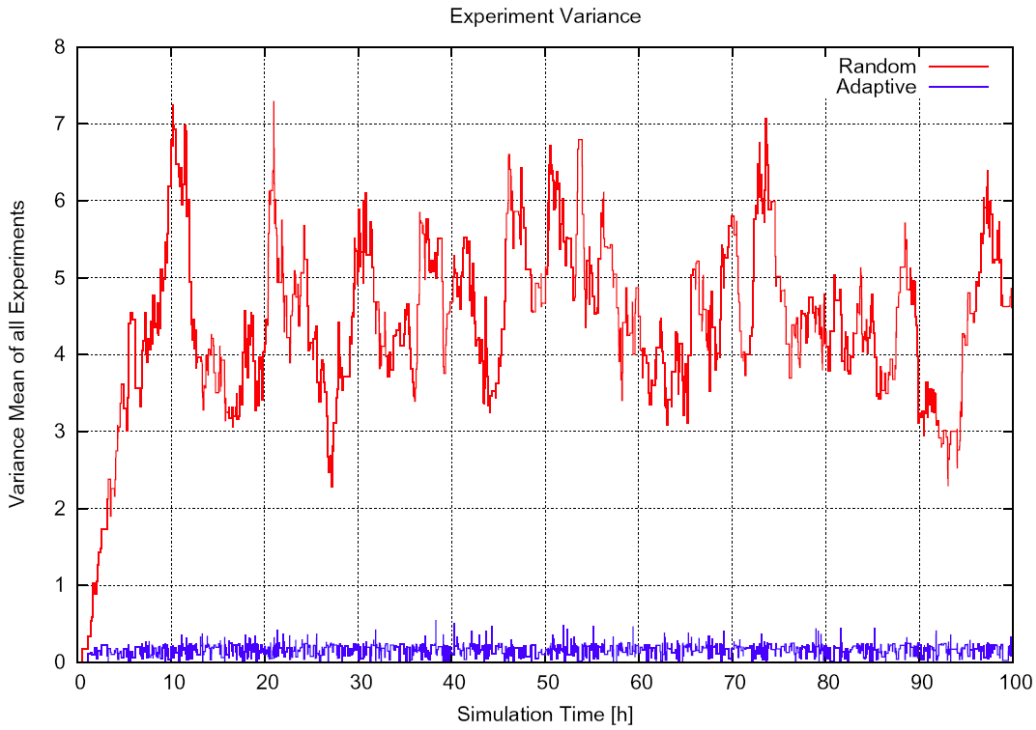
→Difference TopNodes/ Adaptive: prevention of peaks

Researcher Perspective



→ Using single Adaptive strategy against all experiments using Random strategies still lowers worst machine load

Researcher Perspective



→ Mean of all experiments load variances: smoothness increased

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Conclusion and Outlook

- Distributed Testbed Management
  - easier management, better experiment performance
    - smoother testbed utilization, better service
    - prevent heavily loaded machines
    - more efficient experiment deployment through ALM
    - more efficient status and result collection through concast
  - more realistic experiments

Testbeds do provide realistic environments, but a machine not responding to a ping for 20s is not realistic, but rather a PlanetLab-effect

- Outlook
  - still very simple view – only partially reflects reality
  - need data on experiment duration, number of experiments
  - heterogeneous machine resources, different metrics
  - cost of moving experiment from one machine to another