HYBRID PERFORMANCE MODELING APPROACH FOR NETWORK INTENSIVE DISTRIBUTED SOFTWARE

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Performance consideration is essential for distributed application

- Key factors are network latency and application behavior
  - Existing software performance models do not handle the network features well
- Performance consideration should be done during the design phase

Hybrid modeling approach

- Modeling formalisms best suited for system aspect
  - LQN model (software architecture)
  - Network model
- Combined performance evaluation of software and network
- Optimization of the software and network design
Overview of framework
Related work

- **SMART project (Stochastic Model checking Analyzer for Reliability and Timing)**
  - Tool for the logical and stochastic modeling of discrete state systems
  - Multi formalism
    - Stochastic Petri nets
    - Queuing networks
  - Disadvantage
    - Formalism should be modified

- **Hybrid performance estimator**
  - Using existing, stand-alone solvers to process the models
    - No need to modify existing tool, or create new tools
  - Any new formalism could be combined
Layered queuing network

- Widely used performance model
- Represent simultaneous resources in a simple way

Main features
- Task - software or other functional entities
- Processor - all type of hardware devices
- Arc – service requests
Performance parameter of LQN

entry E1
[Z = pure delay]
[s = hostDemand]
... by phases, [s1, s2]

Call
(y = mean no of calls)
... by phases, (y1, y2)

entry E2
[Z] [Z1] [Z2]

Task T1
[m = multiplicity]
[p = priority]
[d = discipline]

Processor P1
[m = multiplicity]
[d = discipline]
[relative speed]

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Background – NS-2 (1/2)

- Network simulator (NS-2)
  - Widely used discrete event network simulator
    - Communication protocols (TCP, UDP)
    - Routing algorithms (both static and dynamic)
    - Network architectures (wired and wireless)
  - Main features
    - Node – resource
    - Links - connection
    - Agent – packet processing
Background – NS-2 (2/2)

- Example of NS-2

Diagram showing network topology with nodes and connections, including labels for bandwidth (BW), type (type), size (size), and delays (δ).
Overview of hybrid modeling framework

1. input model – LQN and network model
2. input model transformation
3. iteratively processing the framework
Hybrid modeling framework (2/6)

- Input models
  - Software layer – LQN
  - Network layer – network model
Initial model transformation

- LQN and ns-2 have different level of abstraction
  - Adjust the throughput in the LQN model to correspond with that of NS
Initial model transformation (cont’d)

- Asynchronous call
  - Network delay
    - Represent the delay incurred by the network
  - Network throughput
    - Actual network throughput calculated from the ns model
Initial model transformation (cont’d)

- Synchronous network calls
  - Network shaper
    - Control the packets in the network
    - Limit the call rate of the client
  - Network delay
    - To assure the correct network delay to be represented in the LQN model
Processing of the Models

1. Solve the LQN model using LQNS
2. Framework extract the throughputs of network from the LQNS output.
3. Modified network models are simulated by the NS-2
4. New network delay extracted by the NS-2
5. Change the LQN model according to the network delay
Case study (1/3)

- A distributed multiplayer on-line game architecture
  - Additional server generating extra network traffic
Case study (2/3)

- Input models
  - LQN for software
  - NS for network
Case study (3/3)

- Modeling results
  - Bottleneck of the system according to the network overload
A framework for the hybrid modeling for distributed software systems

- Two different models are combined
  - Best suited model for the domain
  - LANS and NS-2
- If there is a change, only the related models are modified
Discussion

- Two performance models are combined
  - Using existing tool, no modification
- More study for the hardware level is needed
- Lack of validation
  - Comparing with performance evaluation of distributed application using LQN model only
  - Comparing with other hybrid modeling approach