Resource Provisioning in Hybrid Cloud Computing in the Presence of Resource Failures

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AGENDA

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- Introduction
- Hybrid Cloud Architecture
- Proposed Approaches
- Proposed Provisioning Policies
- Performance Evaluation
- Simulation Results
- Conclusions
- References

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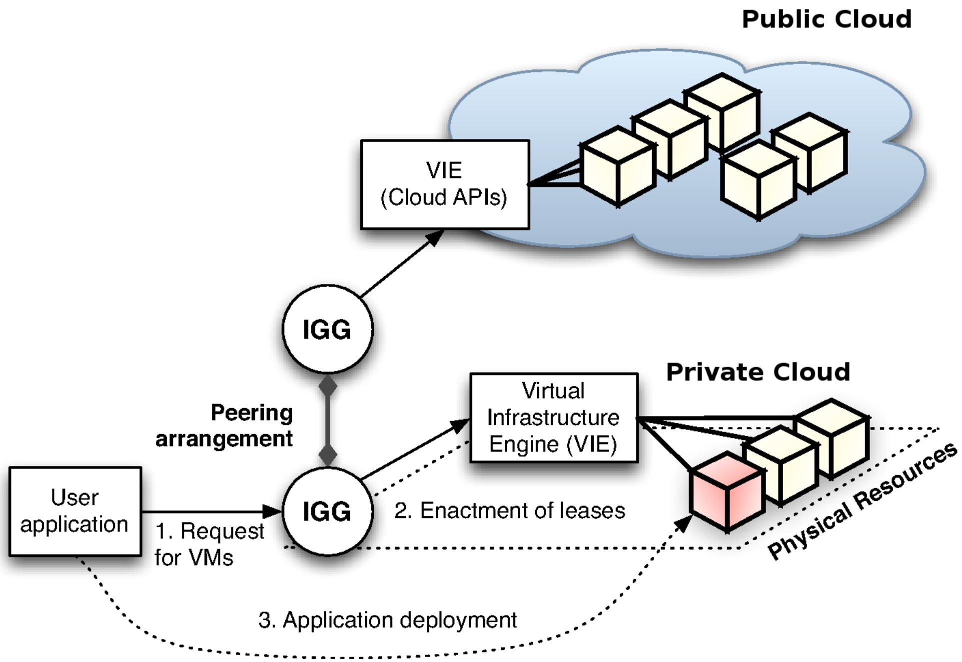
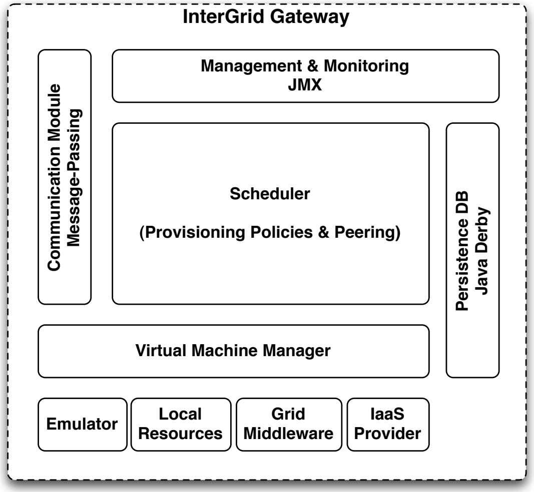
INTRODUCTION

- Hybrid Cloud Systems
  - Public Clouds
  - Private Clouds
- Resource Provisioning in Hybrid Cloud
  - Users' QoS (i.e., deadline)
  - Resource failures
- Taking into account
  - Workload model
  - Failure characteristics
    - Failure correlations
    - Failure model

Hybrid Cloud Architecture

- Based on InterGrid components
- Using a Gateway (IGG) as the broker





IGG

Workload Model

- Scientific Applications
  - Potentially large number of resources over a short period of time.
  - Several tasks that are sensitive to communication networks and resource failures (*tightly coupled*)
- User Requests
  - Type of virtual machine;
  - Number of virtual machines;
  - Estimated duration of the request;
  - Deadline for the request (optional).

Failures in User Requests

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- Resource failure is inevitable
  - Redundant components in public Clouds
    - highly reliable service
  - Leads to service failure in private Clouds

- Correlation in Failures → *overlapped failures*
  - *Spatial* correlation means multiple failures occur on different nodes within a short time interval.
  - *Temporal* correlation is the skewness of the failure distribution over which means failure events exhibit considerable **autocorrelation** at small time lags, so the failure rate changes over time.

FAILURES IN USER REQUESTS (CONT.)

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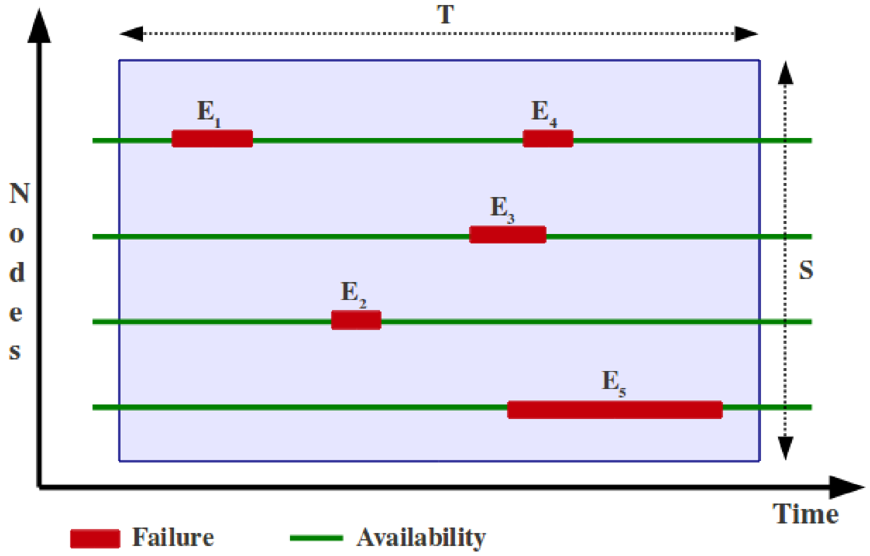

- The sequence of overlapped failures

$$H = \{F_i \mid F_i = (E_1, ..., E_n), T_s(E_{i+1}) \leq T_e(E_i)\}$$

- Downtime of the service

$$D = \sum_{\forall F_i \in H} (max\{T_e(F_i)\} - min\{T_s(F_i)\})$$

Proposed Approaches

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- Knowledge-free Approach
  - No Failure Model
  - Using failure correlation
  - Three brokering policies
- Knowledge-based Approach
  - Failure Model
  - Generic resource provisioning model
  - Two brokering policies (cost-aware)
- Workload model
  - Request size
  - Request duration

Proposed Policies

- Size-based Strategy
  - Spatial correlation : multiple failures occur on different nodes within a short time interval
  - *Strategy*: sends wider requests to more reliable public Cloud systems
  - Mean number of VMs per request
    - P_1: probability of one VM
    - P_2: probability of power of two VMs

$$\overline{S} = P_1 + 2^{\lceil k \rceil}(P_2) + 2^k\left(1 - (P_1 + P_2)\right)$$

    - Request size: two-stage uniform distribution (l,m,h,q)

$$k = \frac{ql + m + (1-q)h}{2}$$

PROPOSED POLICIES (CONT.)

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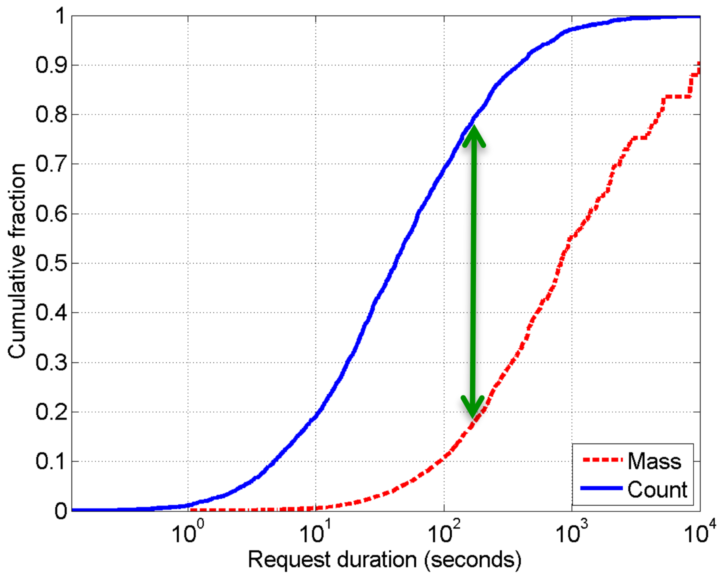
- Time-based strategy
  - Temporal correlation: the failure rate is time-dependent and some periodic failure patterns can be observed in different time-scales
  - Request duration: are *long tailed*.



- The mean request duration
  - Lognormal distribution in a parallel production system

$$\overline{T} = e^{\mu + \frac{\sigma^2}{2}}$$

Proposed Policies (cont.)

- Area-based strategy
  - Making a compromise between the size-based and time-based strategy
  - The mean area of the requests

$$\overline{A} = \overline{T} \cdot \overline{S}$$

  - This strategy sends long *and* wide requests to the public Cloud,
  - It would be more conservative than a *size-based* strategy and less conservative than a *time-based* strategy.

Knowledge-based Approach: Generic resource provisioning model

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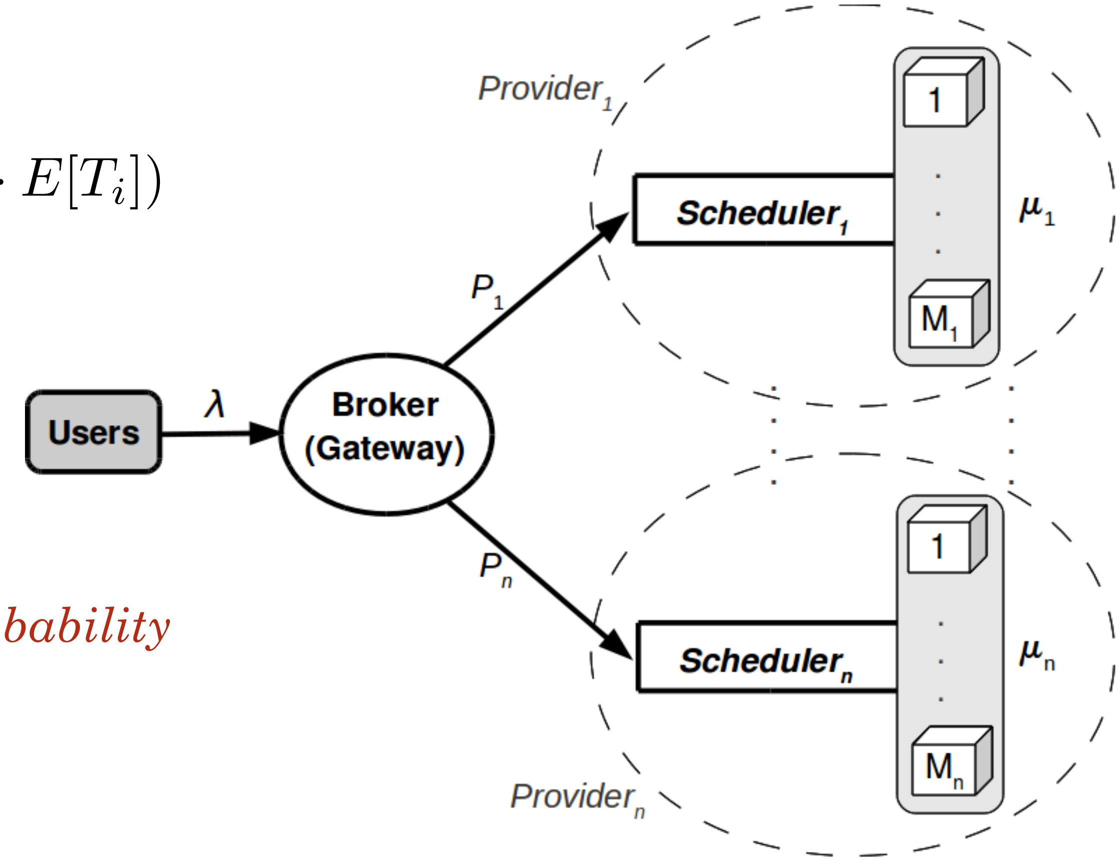
- Model based on routing in distributed parallel queue

$$min \sum_{i=1}^{n} (K_i \cdot E[T_i])$$

Pi: routing probability



Ki: price of provider *i*

Model Parameters

- Using Lagrange multipliers methods, we obtained the routing probability as follows:

$$P_i = \frac{\mu_i}{\lambda} - \frac{\sum_{i=1}^{n} \mu_i - \lambda}{\lambda} \cdot \frac{\sqrt{K_i \eta_i}}{\sum_{i=1}^{n} \sqrt{K_i \eta_i}}$$

- Private Cloud service rate

$$\mu_s = \left(\frac{\overline{W}}{M_s \cdot \tau_s} \frac{t_a + t_u}{t_a} + L_s \right)^{-1}$$

- Public Cloud service rate

$$\mu_c = \left(\frac{\overline{W}}{M_c \cdot \tau_c} + L_c \right)^{-1}$$

ADAPTIVE POLICIES

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- Adaptive with Random Sequence (ARS)
  - Routing probabilities (*Pi*)
  - Dispatch using *Bernoulli* distribution
- Adaptive with Deterministic Sequence (ADS)
  - Routing probabilities (*Pi*)
  - Dispatch using *Billiard* sequence

$$i_b = \min_{\forall i} \left\{ \frac{X_i + Y_i}{P_i} \right\}$$

Scheduling Algorithms

- Scheduling the request across private and public Cloud resources
- Two well-know algorithms where requests are allowed to leap forward in the queue
  - Conservative backfilling
  - Selective backfilling

$$XFactor = \frac{W_i + T_i}{T_i}$$

- VM Checkpointing
  - VM stops working for the unavailability period
  - The request is started from where it left off when the node becomes available again

Performance Evaluation

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- CloudSim Simulator
- Performance Metrics
  - Deadline violation rate
  - Slowdown

$$Slowdown = \frac{1}{M}\sum_{i=1}^{M}\frac{W_i + max(T_i, bound)}{max(T_i, bound)}$$

  - Cloud Cost on EC2

$$Cost_{pl} = (H_{pl} + M_{pl} \cdot H_u)\, C_n + (M_{pl} \cdot B_{in})\, C_x$$

  - Workload Model
    - Parallel jobs model of a multi-cluster system (i.e., DAS-2)

Input Parameters	**Distribution/Value**
Inter-arrival time	Weibull ($\alpha = 23.375, 0.2 \leq \beta \leq 0.3$)
No. of VMs	Loguniform ($l = 0.8, m, h = log_2 N_s, q = 0.9$)
Request duration	Lognormal ($2.5 \leq \mu \leq 3.5, \sigma = 1.7$)
P_1	0.02
P_2	0.78

Performance Evaluation (cont.)

- Failures from Failure Trace Archive (FTA)
  - http://fta.scem.uws.edu.au/
  - Grid'5000 traces
    - 18-month
    - 800 events/node

Parameters	Description	Value (hours)
t_a	Mean availability length	22.25
σ_a	Std of availability length	41.09
t_u	Mean unavailability length	10.22
σ_u	Std of unavailability length	40.75

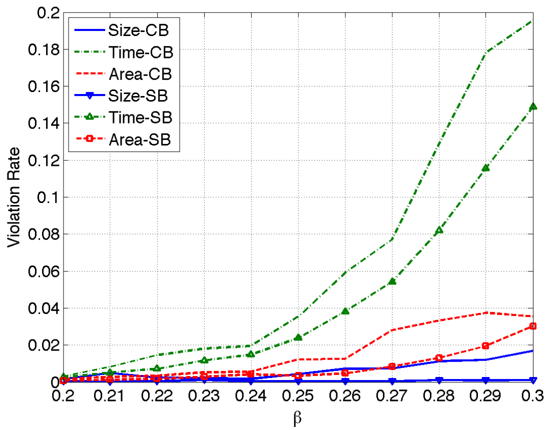
- Synthetic Deadline

$$d_i = \begin{cases} st_i + (f \cdot \ ta_i), & \text{if } [st_i + (f \cdot \ ta_i)] < ct_i \\ ct_i, & \text{otherwise} \end{cases}$$

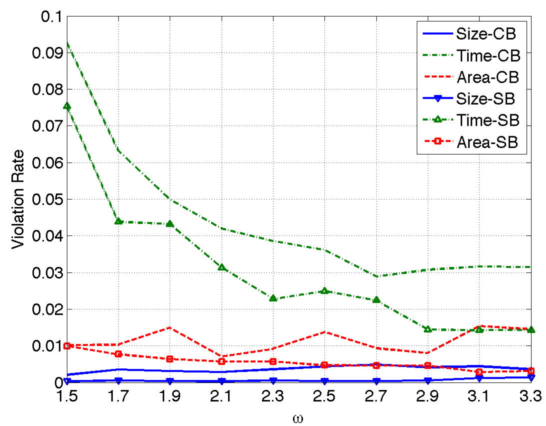
  - f: stringency factor
  - f>1 is normal deadline (e.g., f=1.3)
- $N_s = N_c = 64$

SIMULATION RESULTS

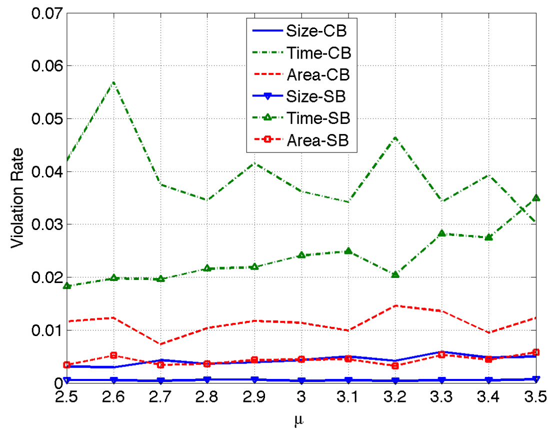
- Violation rate (knowledge-free policies)



Request arrival rate



Request size



Request duration

Simulation Results (cont.)

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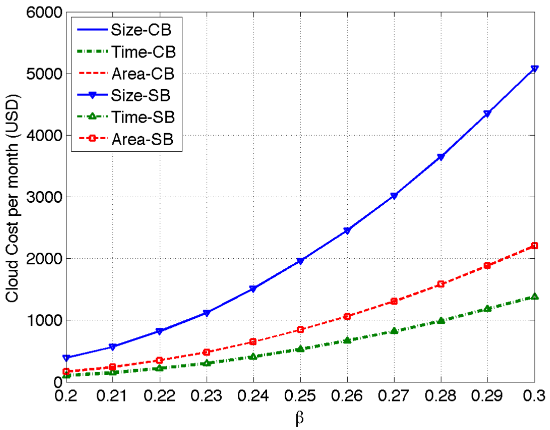
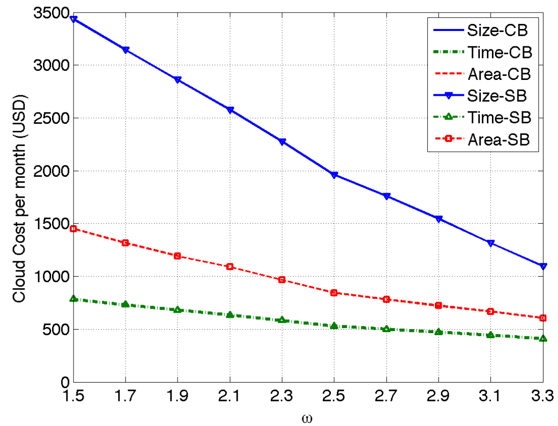
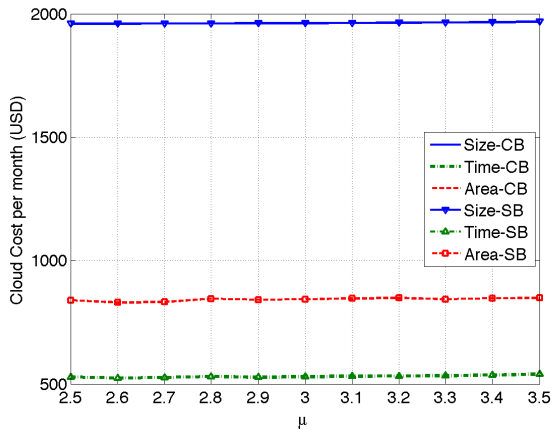
- Cloud Cost on EC2 (knowledge-free policies)



Request arrival rate



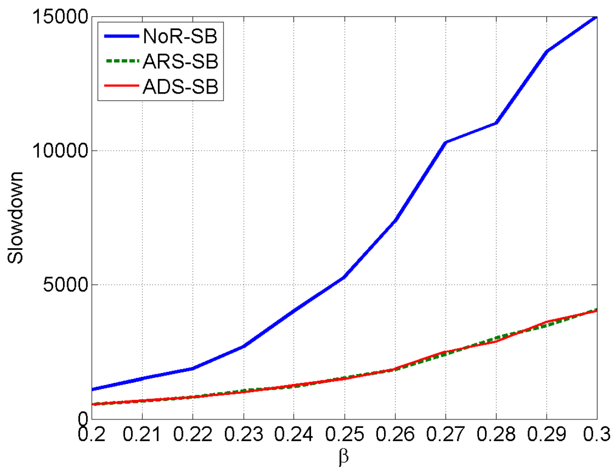
Request size



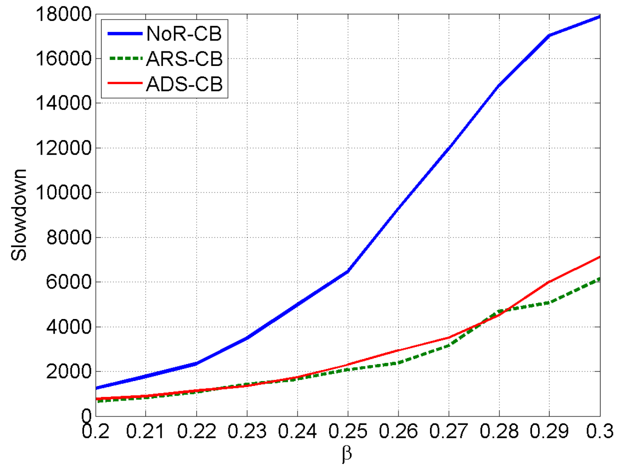
Request duration

Simulation Results (cont.)

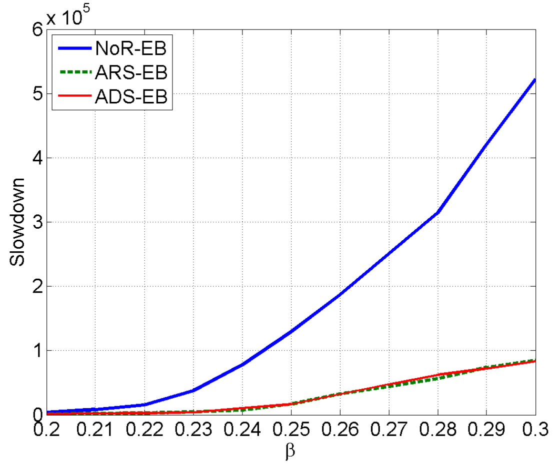
- Slowdown (Knowledge-based policies)



Request arrival rate (SB)



Request arrival rate (CB)



Request arrival rate (EB)

FAILURE TRACE ARCHIVE (FTA)

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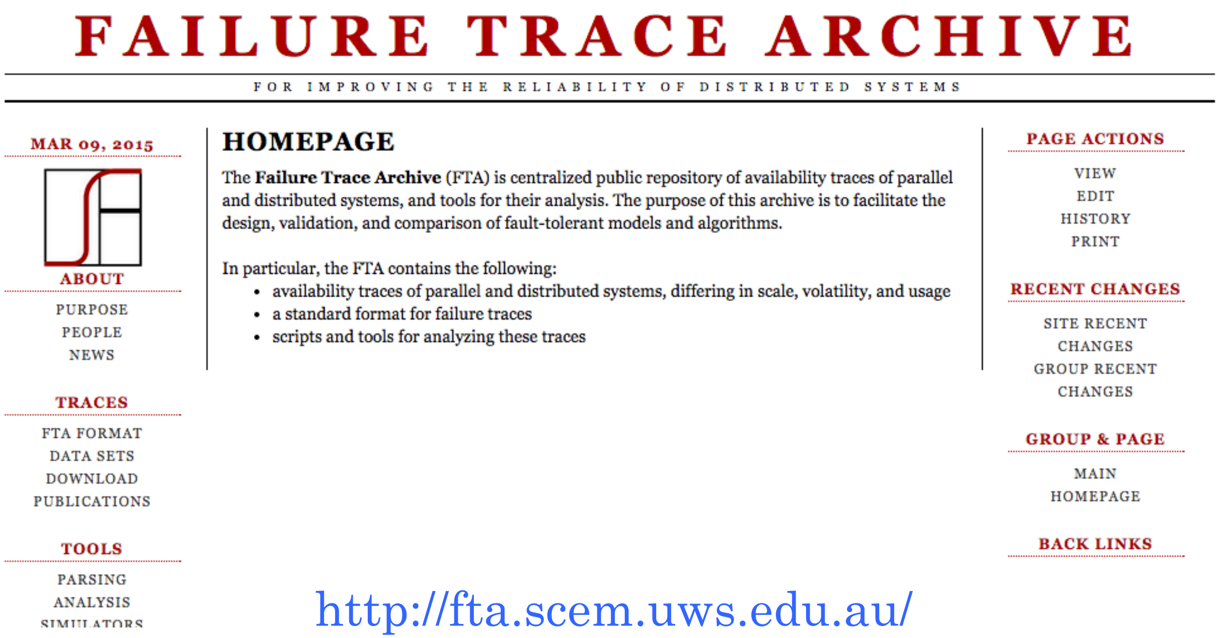
- 27 Failure Traces
  - Supercomputers, HPC, Grid, P2P
- FTA Format
- Simulator and Scripts



http://fta.scem.uws.edu.au/

CONCLUSIONS

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- Adaptive resource provisioning in a failure-prone hybrid Cloud system
- *Flexible* brokering strategies based on failure correlation/model as well as workload model
- Improve performance of hybrid Cloud
  - Knowledge-free approach: 32% in terms of deadline violation and 57% in terms of slowdown while using 135$/month on EC2
  - Knowledge-based approach: 4.1 times in terms of response time while using 1200$/month on EC2

OPEN QUESTIONS

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- Recourse Failures vs. Energy Consumption for Cloud Systems
  - How they are related?
- Reliability-as-a-Service (RaaS) in Cloud Computing
  - Providing reliability on demand based on the users' requirements (e.g., Amazon Spot Instances)
- Cost Model for Resource Failures in Cloud Systems
  - Repair …. Replacement

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