Dynamic request management algorithms for Web-based services in Cloud computing

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Request management for Cloud Computing

- **Cloud: large architecture based on virtualization**
- **On-demand scalability**
  - OK for slowly changing workloads
- **Problems for highly variable workloads**
  - Flash crowds
  - Slashdot effect
- **→ issues in request management**
- **Dispatching:**
  - Coarse grained decisions
- **Redirection:**
  - Last defense line against overload
  - Operates at the server level, with fine grained decisions

Redirection algorithms

- **Redirection → two decisions to take:**
  1. Should request *r* be processed locally or redirected?
  2. If *r* is redirected, which is the best alternative server *sb*
     → exploit existing algorithms (e.g., K-least loaded)

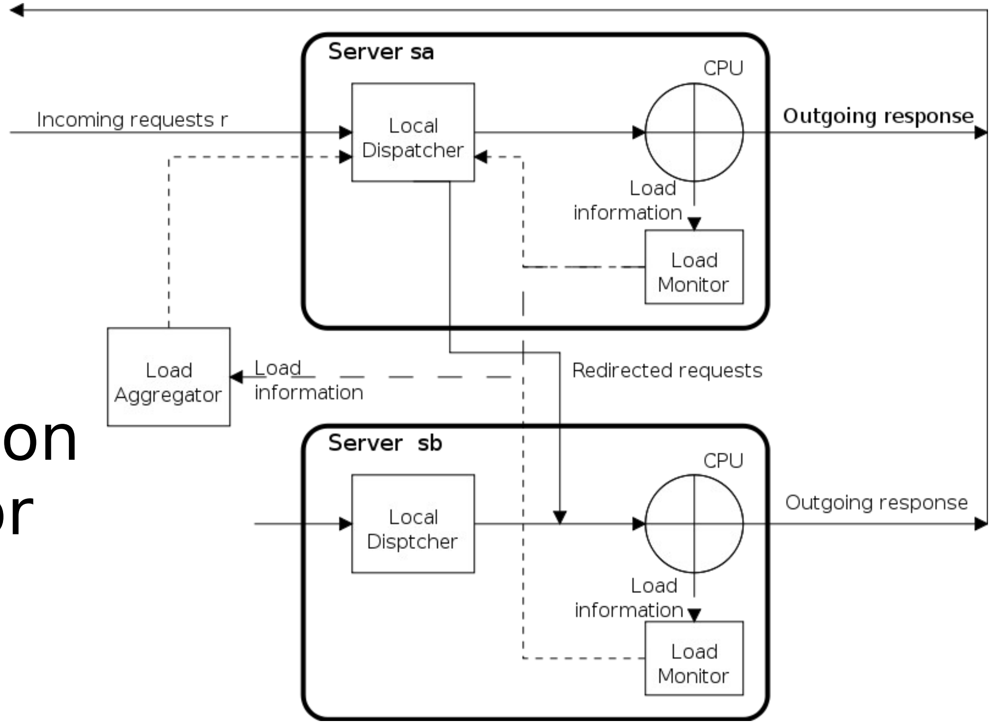
- **Existing solutions:**
  - Threshold-based algorithms
    → lack of adaptivity, oversimplified model
  - Analytical models (M/M/1, M/G/1)
    → oversimplified performance model (mean time), high computational cost (off-line)

- **Our proposal: performance gain prediction algorithm that forecasts the expected performance in case of redirection**

VM request redirection model

- **Time shared Virtual CPU with monitoring facility and a local dispatcher (for redirection)**
- **Storage space shared among multiple VM (e.g., NAS)**
- **Redirection can occur between VMs sharing storage (and hosting the same apps)**

- **Redirection:**
  - Migration of user sessions
  - Trade-off: load sharing *vs.* migration overhead
  - Can exploit load information about local and neighbor servers



Performance Gain Prediction algorithm

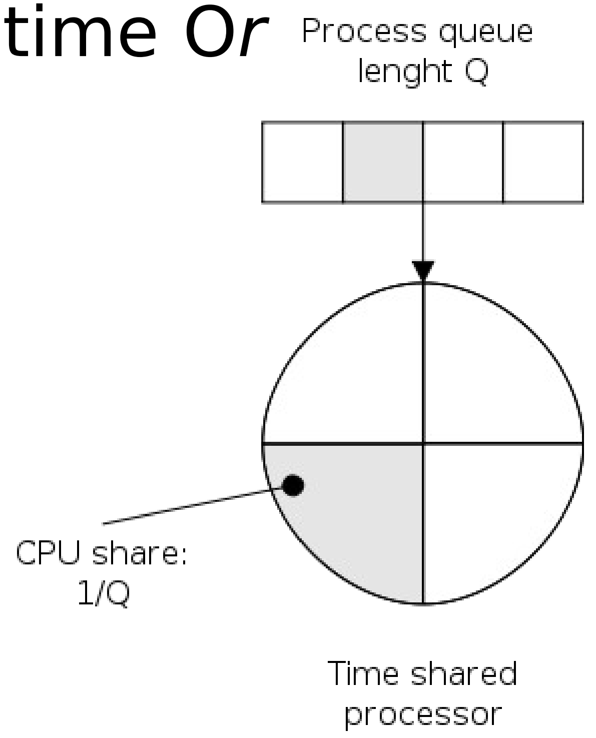
- **Redirection decisions take into account:**
  - Delay *d* for redirection (migration overhead)
  - Characteristics of request *r* (computational cost Or)
  - Load on server *sa* at time *t*
  - Load on server *sb* at time *t*

- **Predict response time *T(r, sa, t)* and *T(r, sb, t)***
  - Redirect *iif T(r, sa, t)>T(r, sb, t)*
  - where *T(r, sb, t)* includes delay for redirection

- **Must predict expected response time *T(r, s, t)***

Prediction of response time

- **Exploit time shared model of CPU**
  - Time shared processor with *Q* processes
    → each process receives *1/Q* of processor resources
  - Based on URL we can infer computational cost of request *r* → estimation of service time O*r*



- **Prediction of response time**
  - *T(r, sa, t)=Or (Qsa(t)+1)*
  - *T(r, sb, t)=Or (Qsb(t)+1) + d*
- **Redirection condition becomes**
  - Redirect *iif Or (Qsa(t)-Qsb(t)) > d*

Coping with data variability

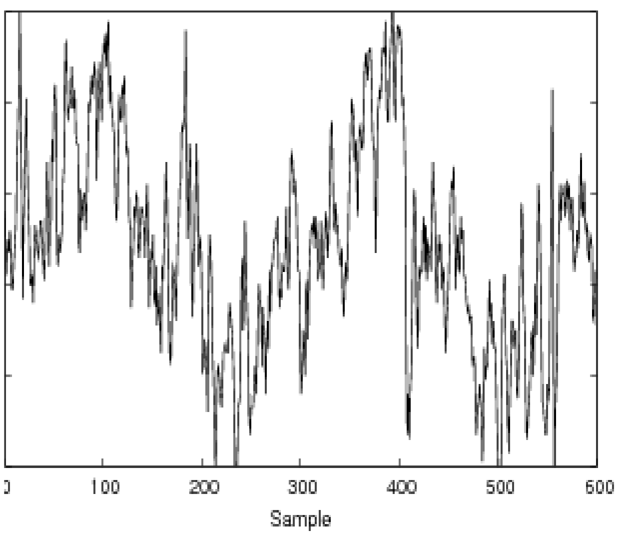
- **High variability in the raw samples of *Q***
- **Assumption: Q not changing (too much) during request service**

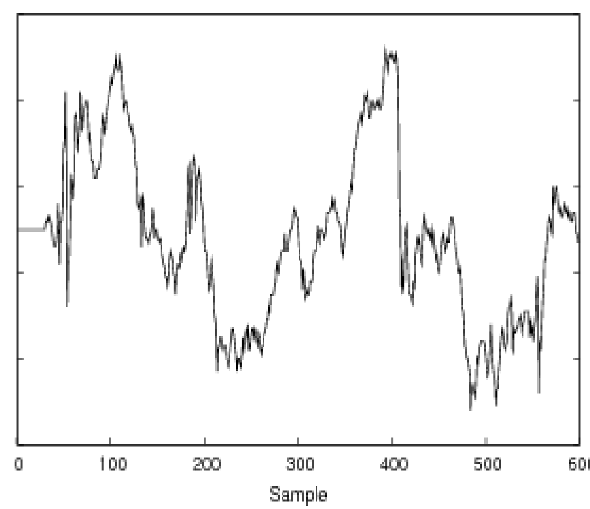
  → Use of smoothing techniques

- **Double Exponential Smoothing (DES)**

  $$Qs'(t)=\gamma Qs(t)+(1-\gamma)(Qs(t-t)+b_Q(t-\Delta t))$$

  where: $b_Q(t)=\alpha(Qs(t)-Qs(t-\Delta t))+(1-\alpha)b_Q(t-\Delta t)$





Alternative algorithms

- **Threshold-based**
  → Evaluation of CPU utilization
  - Redirects *iif* $\rho_{sa} > Thr$
  - $Thr = 0.7$ (commonly used value)
- **High variability in the samples**
  - Use of smoothing techniques
  - Fair comparison with Performance Gain Prediction algorithm
- **Baseline comparison →**
  Local processing *(No redirection)*

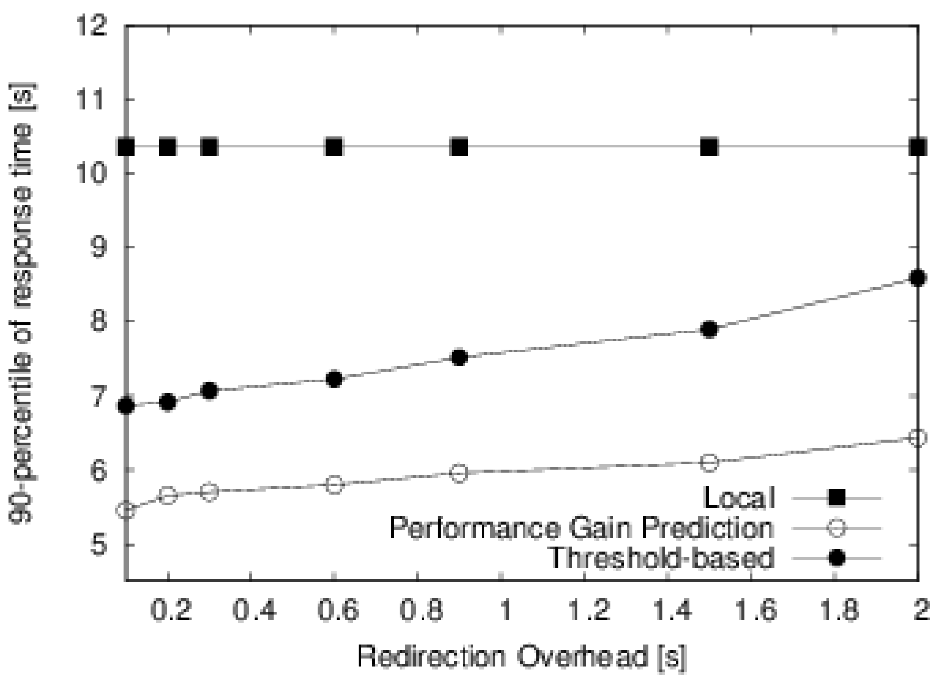
Experimental setup

- **Discrete simulator based on Omnet++ framework**
- **Virtualized infrastructure:**
  - 50 server supporting the same Web-based application
- **Workload characteristics:**
  - Overload on 50% of the servers
- **Different migration delays:**
  - From 0.1 to 2 seconds

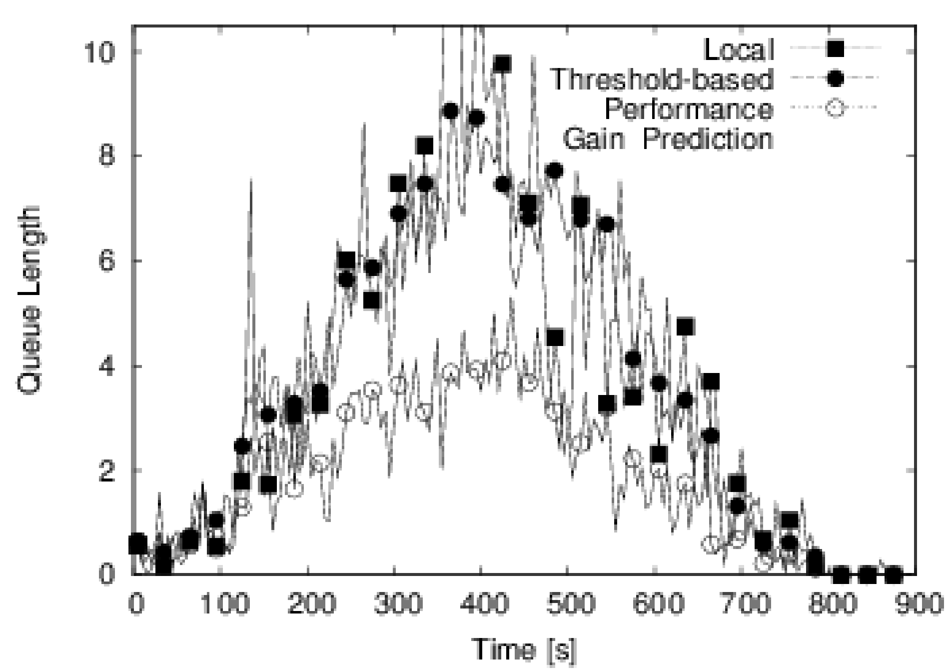
Performance evaluation

- **For both scenarios predictive algorithm outperforms the alternatives. Performance gain:**
  - Nearly 20% w.r.t. Threshold-based algorithm
  - Up to 60% w.r.t. No redirection (Local)

Response time



Queue length



Amount of redirection

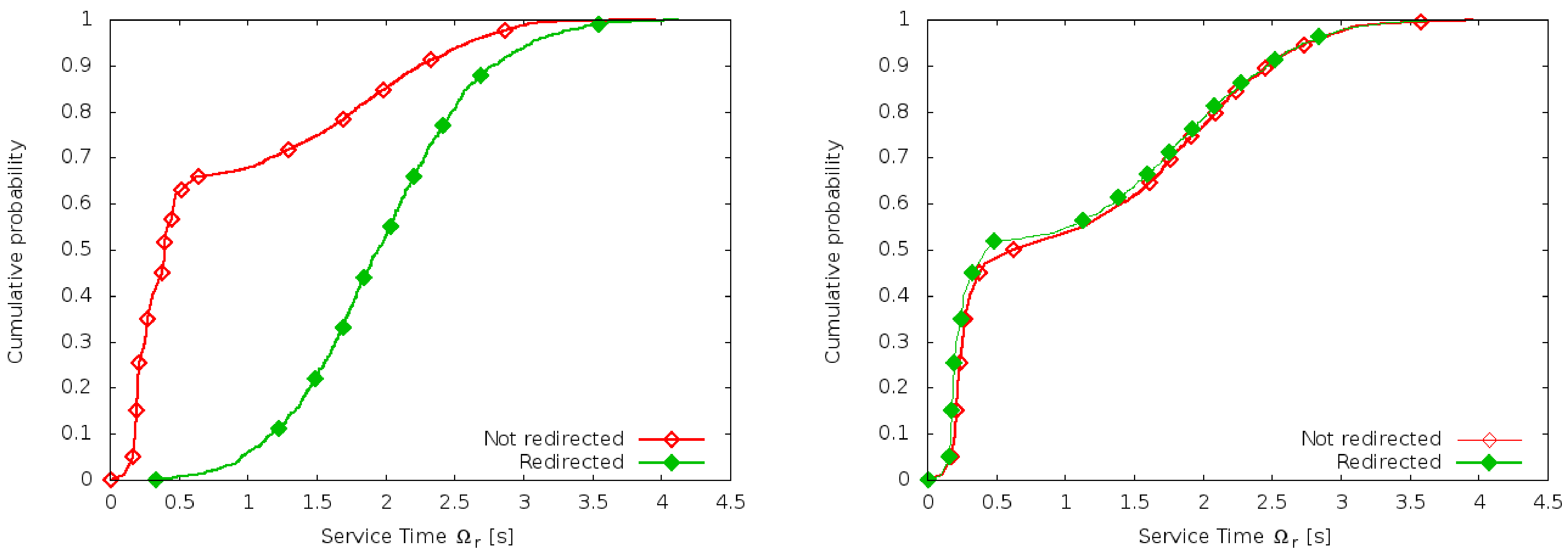
- **Threshold-based algorithm**
  - Large amount of redirection
  - Redirection decisions non adaptive to migration delay
- **Performance Gain Prediction algorithm**
  - Redirects only when needed
  - Takes into account migration delay

Redirection overhead	Performance gain prediction	Threshold-based
d=0.1s	12%	67%
d=2 s	21%	67%

Performance evaluation

- **Performance gain prediction algorithm redirects mainly the resources with high computational costs**
  - Redirection only when we identify a significant performance gain

Performance gain prediction **Threshold-based**



Conclusions

- **Proposal of redirection algorithms to face request surges in large data centers**
  - Exploits information on process queue length
  - Use of predictive techniques to quantify the performance gain from redirection
- **Comparison with threshold-based existing algorithms**
  - Response time → reduction close to 20% (90-percentile)
  - Number of redirected requests → reduction up to 5 times
  - Performance Gain Prediction algorithm redirects only the “right” resources

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