CS528

Workload Prediction in Cloud System

A Sahu

Dept of CSE, IIT Guwahati

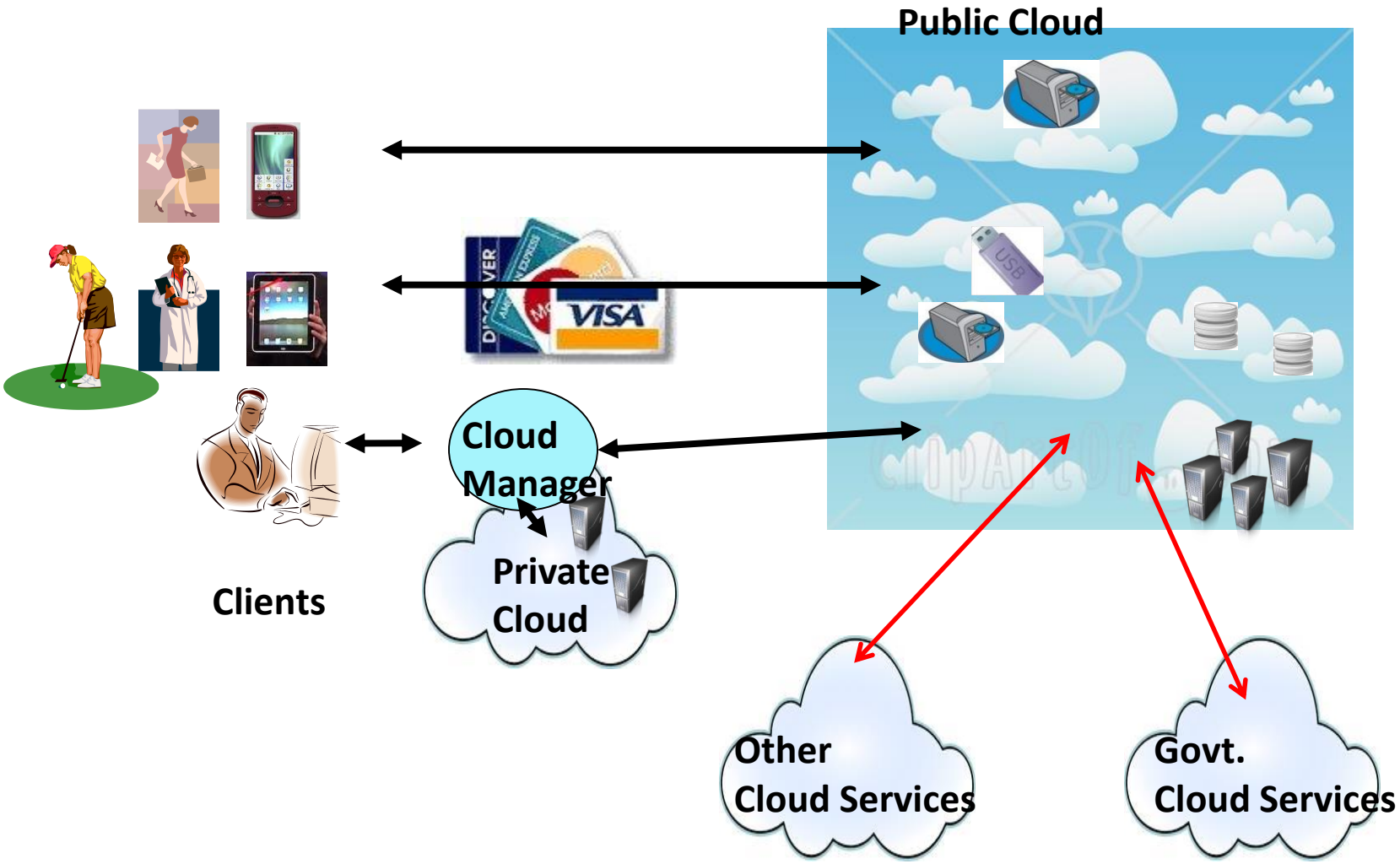
Outline

- Work load Prediction
  - EWMA, FUSD
- Dynamic Resource Management
  - Scale up and Scale Down
- SLAV

Reference

Zhen Xiao, Weijia Song, and Qi Chen "**Dynamic Resource Allocation Using Virtual Machines for Cloud Computing Environment",** IEEE Trans. on Parallel & Dist. Computing., JUNE 2013

Clouds offer Subscription-Oriented IT Services: {compute, apps, data,..} as a Service (..aaS)



Basic Approaches

- Cloud computing allows business customers
  - To scale up and scale down
  - Their resource usage based on needs
- Allocate data center resources dynamically
  - based on application demands
- Supporting green computing
  - by optimizing the number of servers in use
- “skewness” to measure
  - unevenness in the multidimensional resource utilization of a server

Service Level Agreement

- Service Level Agreement
  - Agreement between user and provider
  - Cost, resources, QoS, timely manner
- Agreement in Cloud User and Provider
  - Want to execute a task with time deadline D for E time and require C cpu, M memory unit
  - Cost Payable to Cloud provider by User
  - If Violate, provider needs to penalty

Service Level Agreement

- Real life Example : SLA is every where
- Giving Party Food contract to Caterer
  - Caterer A is good one, what ever he say he do
  - Caterer B is not good: he say some thing but do not provide what he says, always he provide less.
- Transport service : Taking pickup/drop/tour service from Travel agent/Airlines
  - Travel agent TA1: Gives proper services, always service in times, no late, all service are excellent
  - Travel agent TA2: Don’t gives proper services, always service in, late, service are bellow expectation based on price.

Resource Allocation Approaches

- **Service Level Agreement**
  - Agreement between user and provider
  - Cost, resources, QoS, timely manner
- **Overload Avoidance**
  - Capacity of a PM should be sufficient
  - to satisfy the resource needs of all VMs running on it.
  - Otherwise, the PM is overloaded and can lead to degraded performance of its VMs.
  - Hot threshold: Utilization of a host $\mathbf{U_h < U_{hotthrehold}}$

Resource Allocation Approaches

- Green Computing
  - Number of PMs used should be minimized
  - as long as they can still satisfy the needs of all VMs.
  - Idle PMs can be turned off to save energy.
- Term used to do
  - **Cold Threshold**: Under utilized Server
  - **Green Computing Threshold** : Average Utilization of all active PM is bellow this ➔ Some server are under utilized

Resource Allocation Approaches

- Assume 10 servers are there
- Average utilization is 40%
- Can we say some server are underutilized U_h< 25%
  - Yes, may be some server have
- If a server **H** have U_h<25%
  - Migrate VMs of **H** to other servers
  - Switch off **H** to save power
- Migrate to VMs of H to other server S
  - where Us < 90% after migration
  - Should not be overloaded

Resource Prediction

- Given Catering to Caterer A :100 Plates of food
  - Caterer will estimates 80% of guest will come
  - Average amount food (F_{avg}) per person consumes A knows in general
  - He (A) will prepare : 80*F_{avg} food for the party.
- Train services
  - During holiday period people go for travels
  - During Holi/Diwali/Dushehara require special train
- Customer at shop
  - Night time customer will be less
  - Evening time is peak time ==>prepare for that

Resource Prediction

- General prediction of online series
- May be more complex
- Most people use based on history, last one/n time slots
- Re Call : CPU burst time prediction by OS for an application
  - Application have series Compute and I/O requests

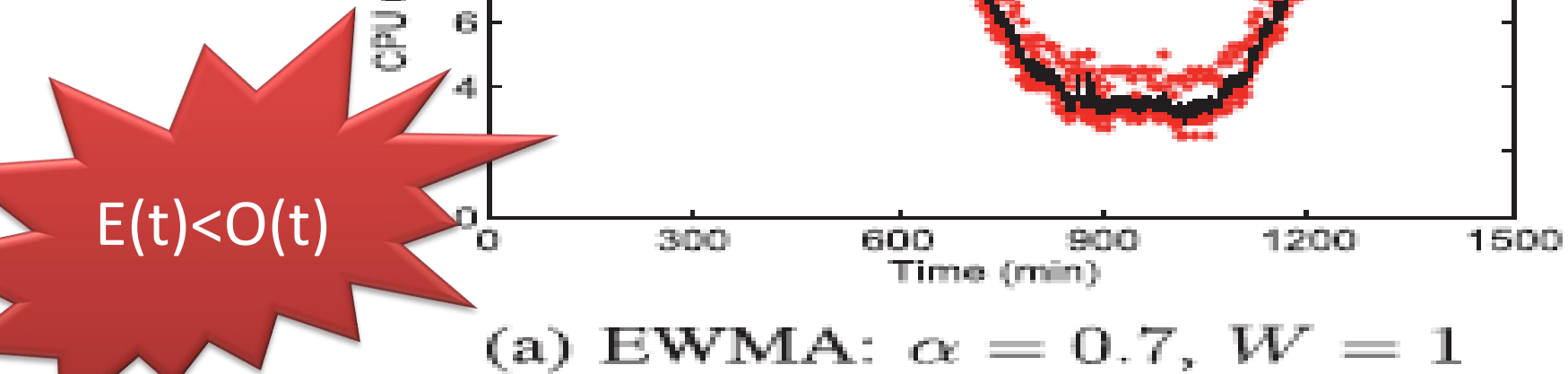
  - OS schedule task on processor by estimating the CPU time of task for next CPU burst

Resource Prediction

- Exponential Weighted Moving Average (EWMA)

$$E(t)=\alpha*E(t-1)+(1-\alpha)*O(t)$$

E(t) and ***O(t)*** : Estimated and Observed load at time **t**



(a) EWMA: $\alpha = 0.7$, $W = 1$

Resource Prediction Approaches

- If E(t) < O(t), estimated is less than observed
  - Party meals: Estimated 80 but came 90: 10 will not get any thing
  - **Safe side: Estimate should be a bit higher to maintain the agreement (SLA)**
- **When observed usage is going down**
  - **be conservative in reducing our estimation**
- Solution to Problem of EWMA

$$E(t) = -|\alpha|\ E(t-1) + (1+|\alpha|)O(t)$$

$$= O(t) + |\alpha|(\ O(t) - E(t-1))$$

- When O(t) > E(t) use α^u
- When O(t) < E(t) use α^d

Resource prediction Approaches

- FUSD: Fast Up-Slow Down
  - Up direction resource increment aggressive
  - Down direction : be conservative

if (O(t-1) > E(t-1)) // FU $\alpha^u = -0.2$

$E(t)=\alpha^u * E(t-1)+(1-\alpha^u)*O(t)$

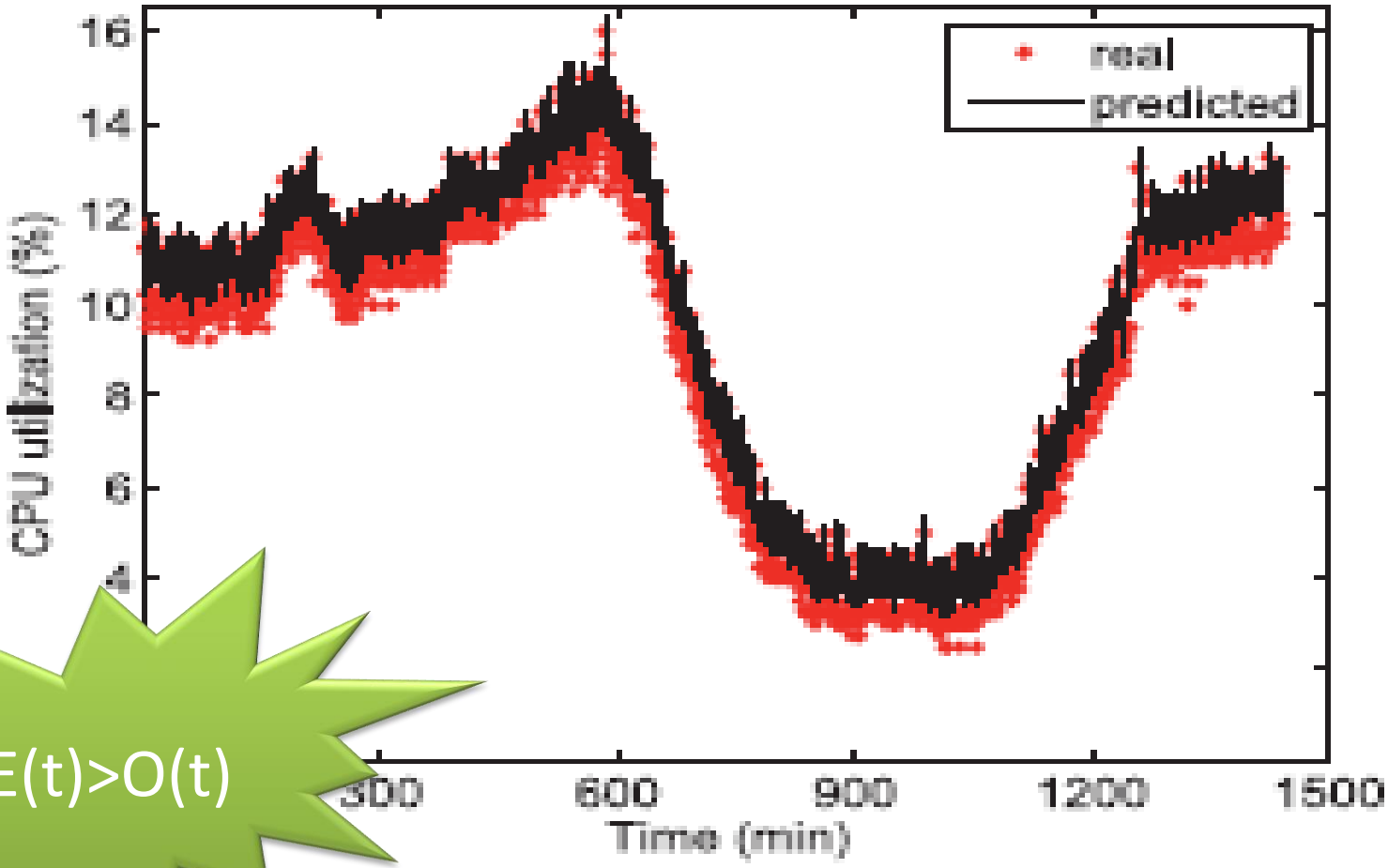
else //SD $\alpha^d = 0.7$

$E(t)=\alpha^d * E(t-1)+(1-\alpha^d)*O(t)$

- FU : E(t)= 0.2E(t-1)+1.2 O(t) ➔
  - high weigh to O(t) ➔ increase aggressively
- SD : E(t)= 0.7E(t-1)+0.3 O(t) ➔
  - high weight to E(t) ➔ decrease conservatively

Resource Allocation Approaches

- FUSD Example α^u =-0.2 α^d =0.7
- E(t) > O(t) : No SLA Violation



E(t)>O(t)

Skewness

- Quantify unevenness in the utilization of multiple resources on a server
- **Skewness (p) = $\sqrt{\sum_{i=1}^{n}(\frac{r_i}{\bar{r}} - 1)^2}$**
  - $\bar{r}$ is AVG utilization of the resources for server p
  - r_i is utilization of i_{th} resource
  - Resources are CPU, memory, disk BW, net BW
  - Skewed : CPU Util 90%, memory Util 10%

Hot and Cold Spots

- **Hot spot** : Utilization of **any** of the resources of a server **above** hot threshold
  - Hot threshold say 90% and CPU/mem of server is >90% utilized
- **Cold Spot**: Utilization of **all** of the resources of a server **bellow** cold threshold
- The term Temp of a server

$$\textbf{Temp (p)} = \sum_{r \in R} (r - r_t)^2$$

  - R is set of overloaded Resources, r_t is hot threshold of r

Hot and Cold Spots

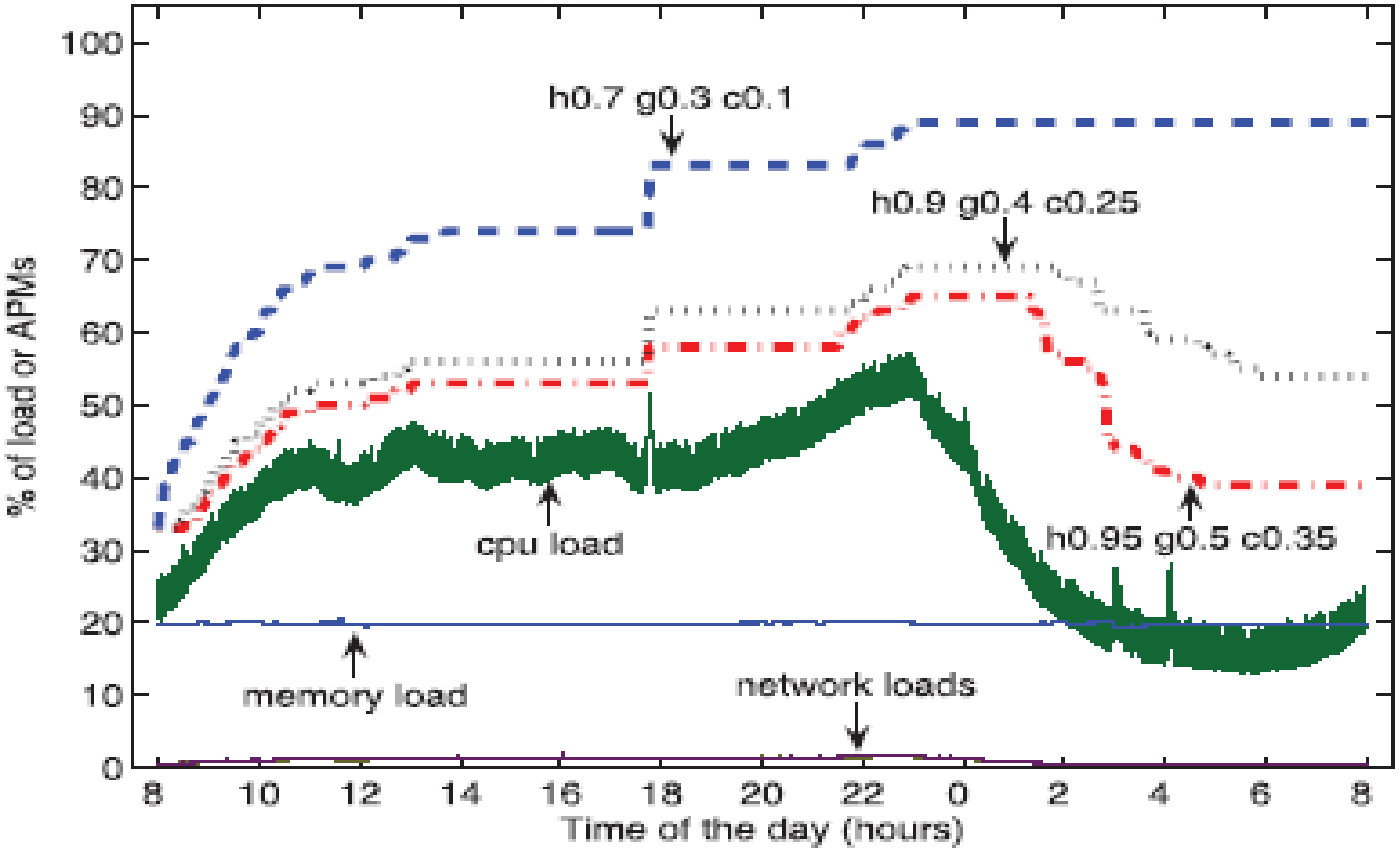
- **Green computing threshold : say 40%**
  - Average Utilization of active server are bellow this
  - Have option is Consolidate
- **Warm threshold : say 65%**
  - Average Utilization above need to start another PM
- **Consolidation limit:** Max Num of cold server can be eliminated in each run **(say 5%)**
  - Consolidation takes time
  - Consolidation reduce the performance a bit

Typical Values

- Number of Active Physical Machine (APM) to server the work load depend on these values
  - The value of h, g, c, w, l
- Hot Threshold h = 0.9
- Cold Threshold c = 0.25
- Warm threshold w =0.65
- Green computing threshold g =0.4
- Consolidation limit l =0.05

Impact of threshold on APM

Lower is better (h0.95, g0.5,c0.35)



Live Migration

- VM live migration technology
  - makes it possible to change the mapping between VMs and PMs
  - while applications are running
- Service of the VM is undisrupted during migration (in case of web/db/file server)
- At the time of migration: service continues at both Source and Target
- Same as Grace full Migration
  - Suppose you want to shift your shop from IITG CORE I to CORE V,
  - First get Space at CORE V, Start Service from CORE V, after some time Stop Service at CORE I