Cloud Scale Resource Management: Challenges & Techniques

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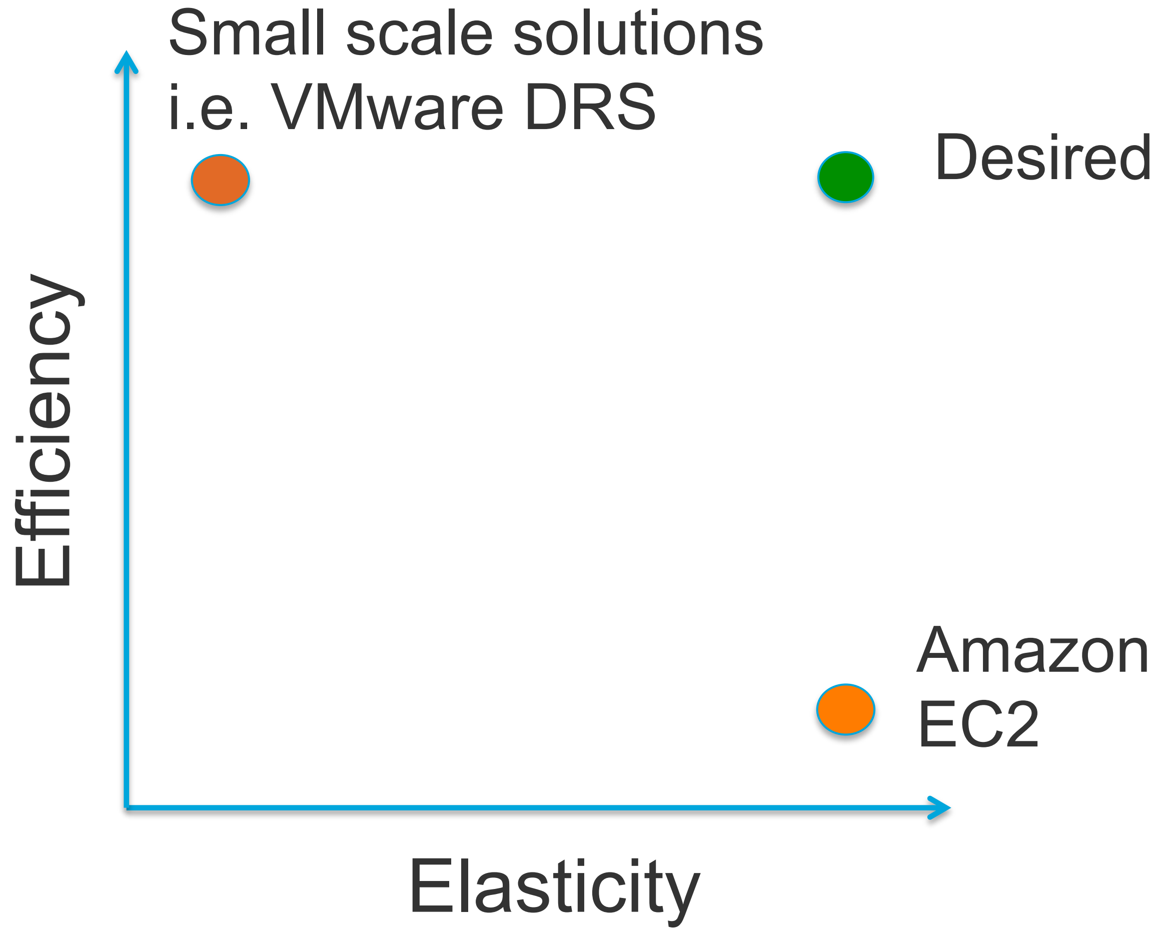
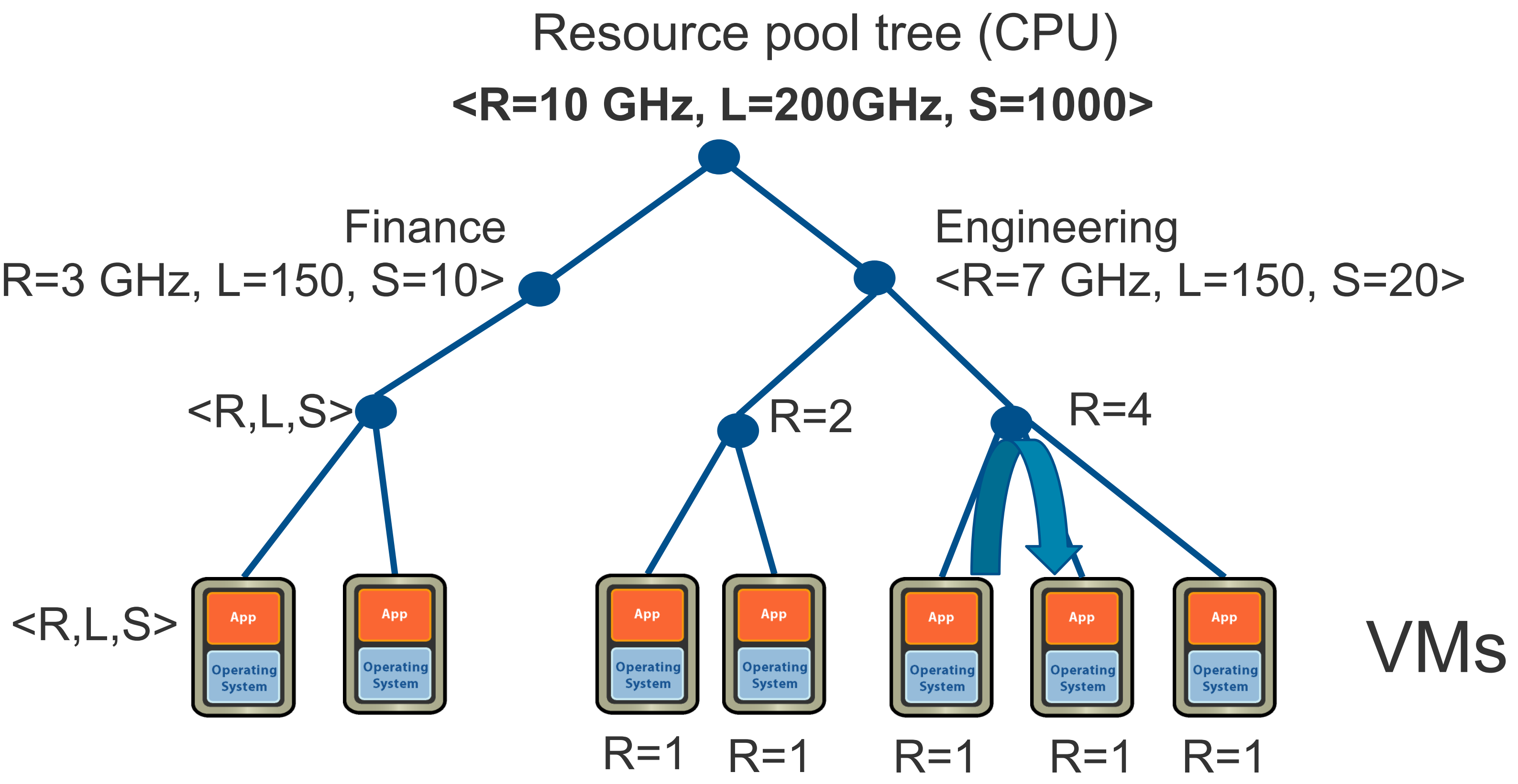
Existing Solutions



Goal: EC2's ***Elasticity* + DRS' *Resource management***

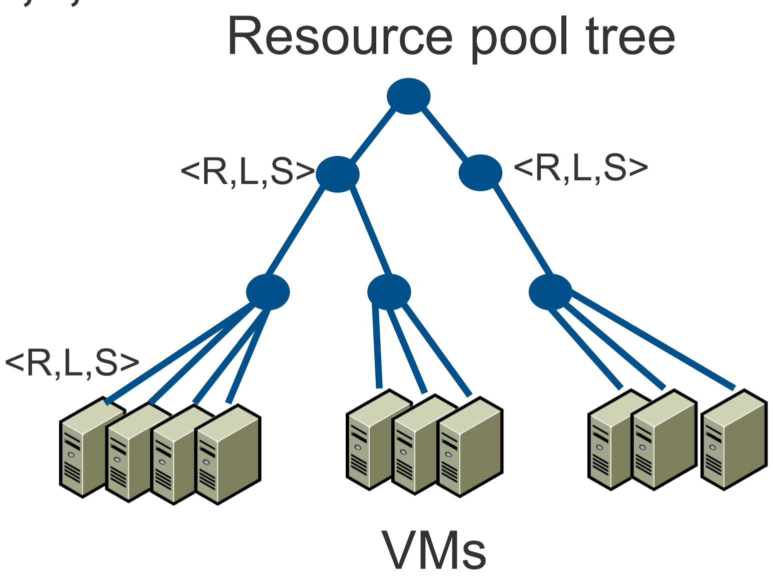
DRS Resource Controls

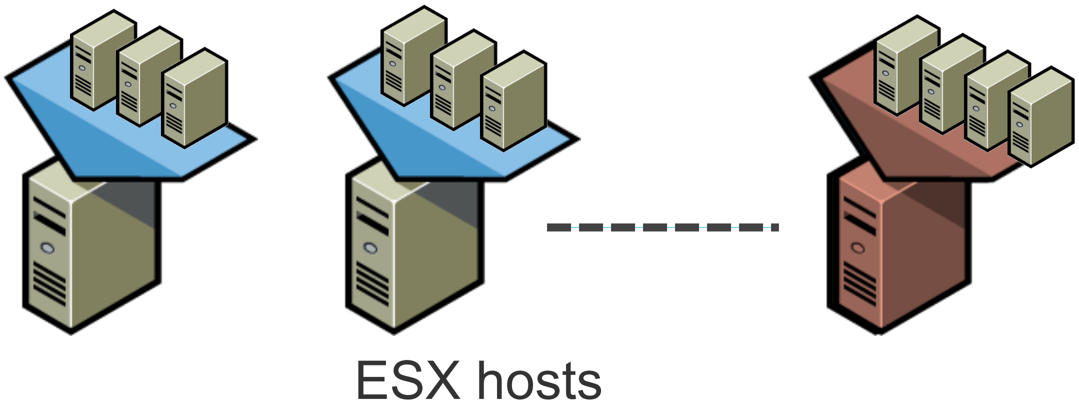
- **Resource pools: hierarchical resource allocation**
- **Reservation(R), Limit(L), Shares(S) per VM and RP node**
- **Allows statistical multiplexing, fair over-commitment of resources**
- **Very useful for Cloud, each org can own a resource pool**



DRS Primer

- **Computes VM entitlement based on R,L,S**
- **Maps resource pools to hosts**
- **Initial placement of VMs**
- **Load balancing across hosts**
  - Invoked every 5 mins





R: reservation
L: limit
S: share

How DRS works

- **Uses *dynamic entitlement* as load metric for each resource**

$$E_{VM} = F(R, L, S, demand)$$

$$R \le E_{VM} \le L$$

- **Computes host normalized entitlement**
  - C_H is host capacity

$$N_H = \frac{\Sigma E_{VM}}{C_H}$$

- **Reduces stddev N_H using Greedy-hill climbing**
- **Multi-dimensional balancing problem**
- **Does cost-benefit analysis for each move**
- **Finds incremental improvements, complete re-shuffle is not an option**

Efficient Cloud Scale Resource Management Challenges

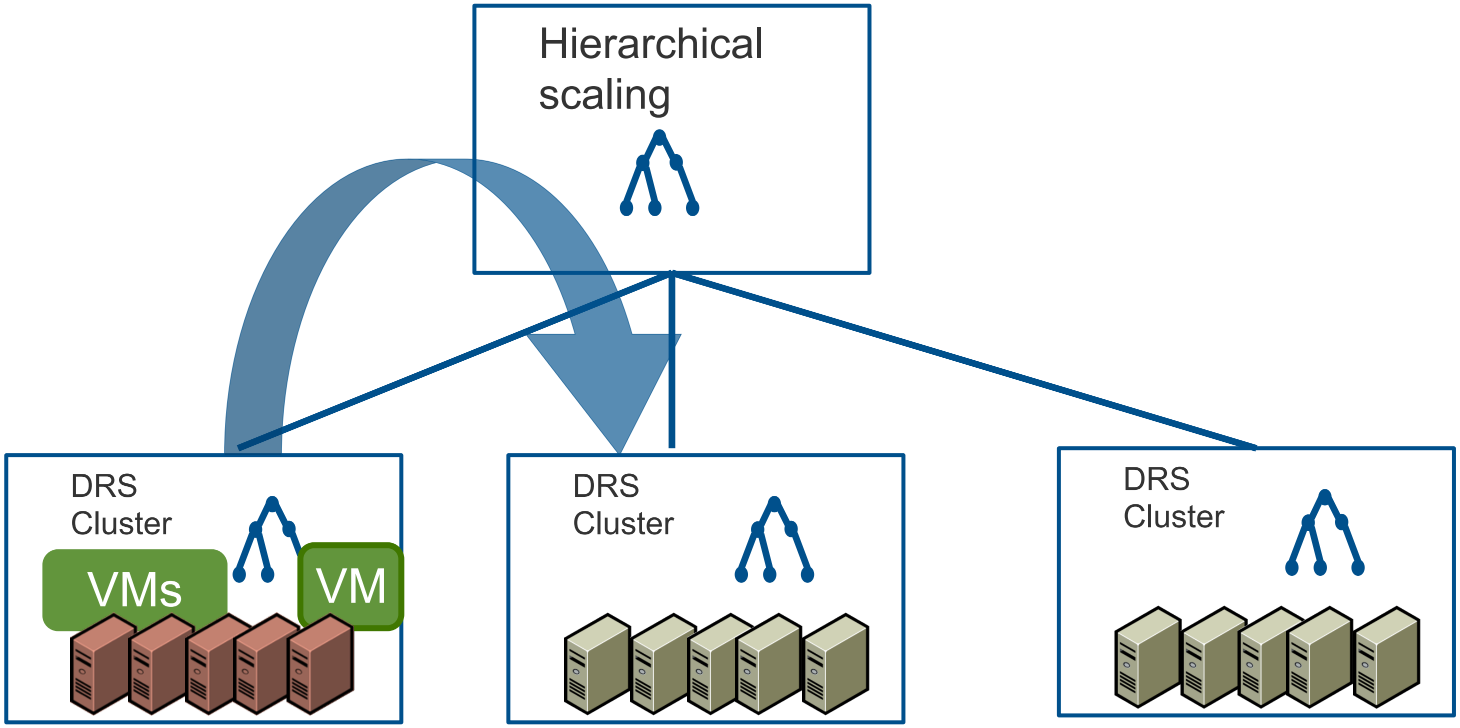
- **Heterogeneity of resources**
  - VM/Host compatibility matrix needs to be maintained
  - Islands formed due to storage and network connectivity
  - Multiple versions of hardware co-exist
- **High frequency of operations**
  - Centralized scheme may have high latency due to lock serialization
  - Distributed scheme may have stale inventory snapshot
  - Update host & VM stats/states periodically
- **Failure tolerance**
  - Failures are common at cloud scale
  - Need to handle/retry failed operations

Techniques

- **Three proposals**
  - Hierarchical Scaling
  - Flat Scaling
  - Statistical Scaling

Hierarchical Scaling

- Build a load balancer on top of clusters
- Cluster level metrics don’t aggregate well
- Scale of certain operations may be limited to a cluster



Hierarchical scaling

DRS Cluster

VMs

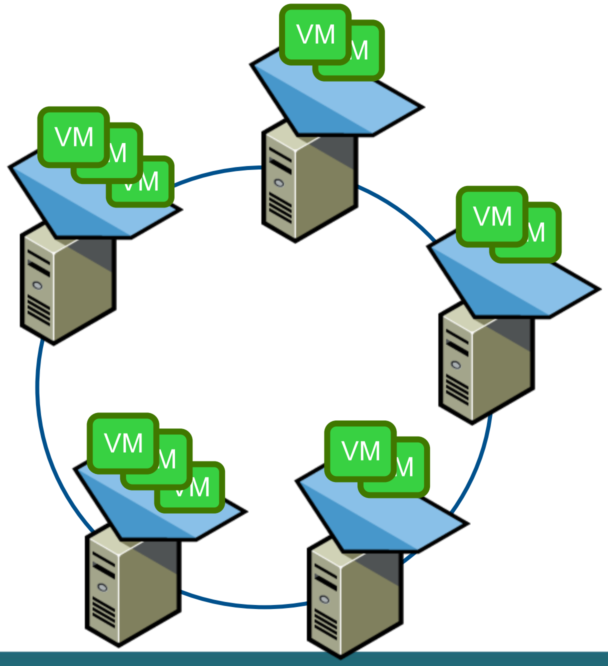
VM

DRS Cluster

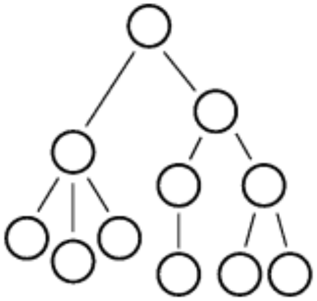
DRS Cluster

Flat Scaling

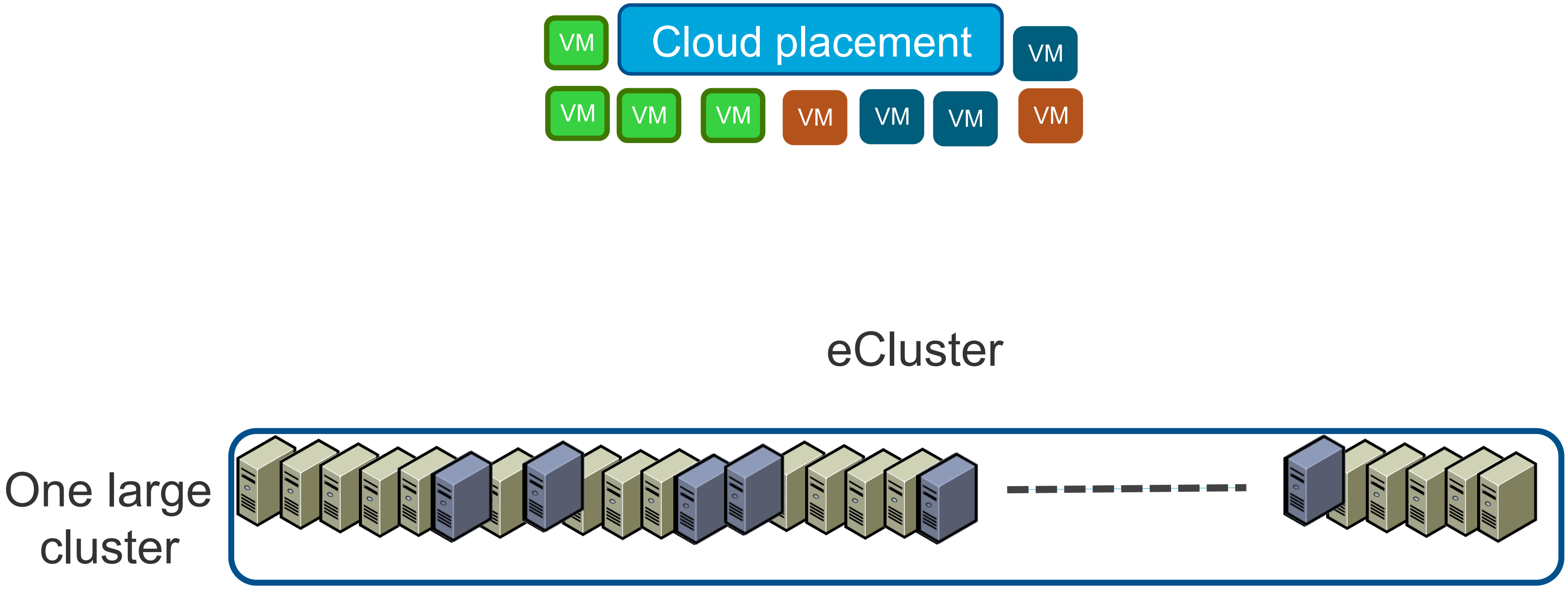
- Build a overlay of virtualized hosts
- Do initial placement and load balancing using
  - Distributed aggregation of stats (SDMIS, Sigcomm’04)
  - Queries on the overlay (SAAR, NSDI’07)
- **Hard and challenging to build, debug**
- **No consistent views**



Trees for stats aggregation and queries



Statistical Scaling



- Create small clusters dynamically
- Run DRS on this small cluster
- Key idea: Obtain large scale resource management by doing small scale optimizations
- Well known result: Power-of-two choices

Conclusions

A cloud solution needs to provide

Elasticity + Efficient resource management

- **Challenges: scale, heterogeneity, rate of operations and failure handling**
- **Techniques:**
  - Can we break the problem hierarchically?
  - Can we use completely decentralized approach?
  - Can we use local optimizations for global efficiency?