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Dynamic Resource Allocation for Spot Markets in Clouds

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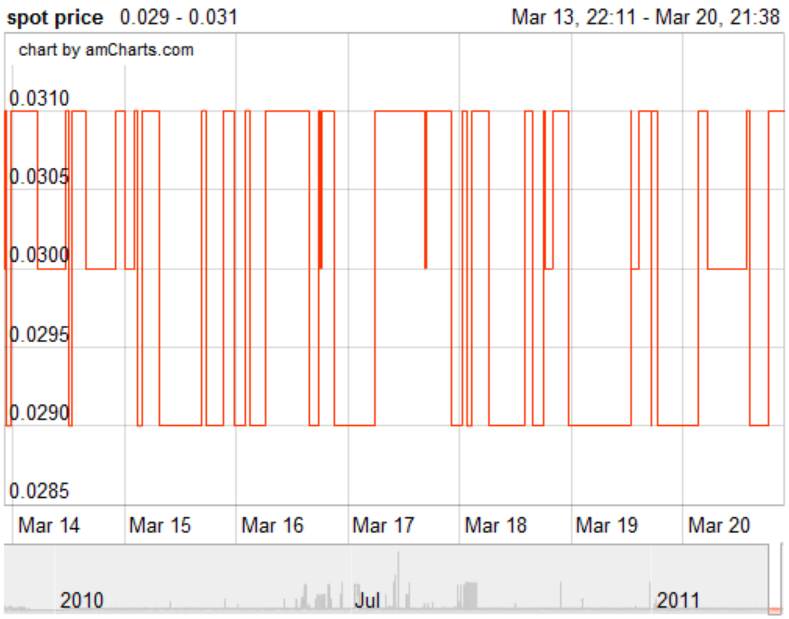
Introduction

- Cloud computing aims at providing resources to customers in an on-demand manner
  - A customer can purchase resources dynamically based on the current needs
- Typically, cloud providers employ usage-based pricing
  - A fixed unit price is specified for each type of VM offerings
- However, fixed pricing schemes lack incentives to encourage desirable customer behavior
  - Low demand results in poor resource utilization
  - high demand leads to revenue loss and customer dissatisfaction
- Market-based resource allocation is gaining popularity
  - Let the price fluctuates with supply and demand

Amazon EC2 Spot Instance Service

- Launched on Dec. 15, 2009
- Multiple VM types per availability zone
- Customers submit requests with bidding prices
- Spot price fluctuates with supply and demand
- Instances may be terminated with prior notice



Price of a single m1.small linux instance in US-East-1 between Mar. 14- Mar. 20, 2011

Motivation

- Multiple spot markets sharing the same resource pool
- As request arrival can be highly volatile, sometimes certain markets may be "hotter" than others
- A static allocation strategy can lead to situations where markets are over-supplied or under-supplied
  - Over-supplying a market causes poor resource utilization
  - Under-supplying a market leads to low income and customer dissatisfaction
- How to dynamically allocate resources to spot markets?

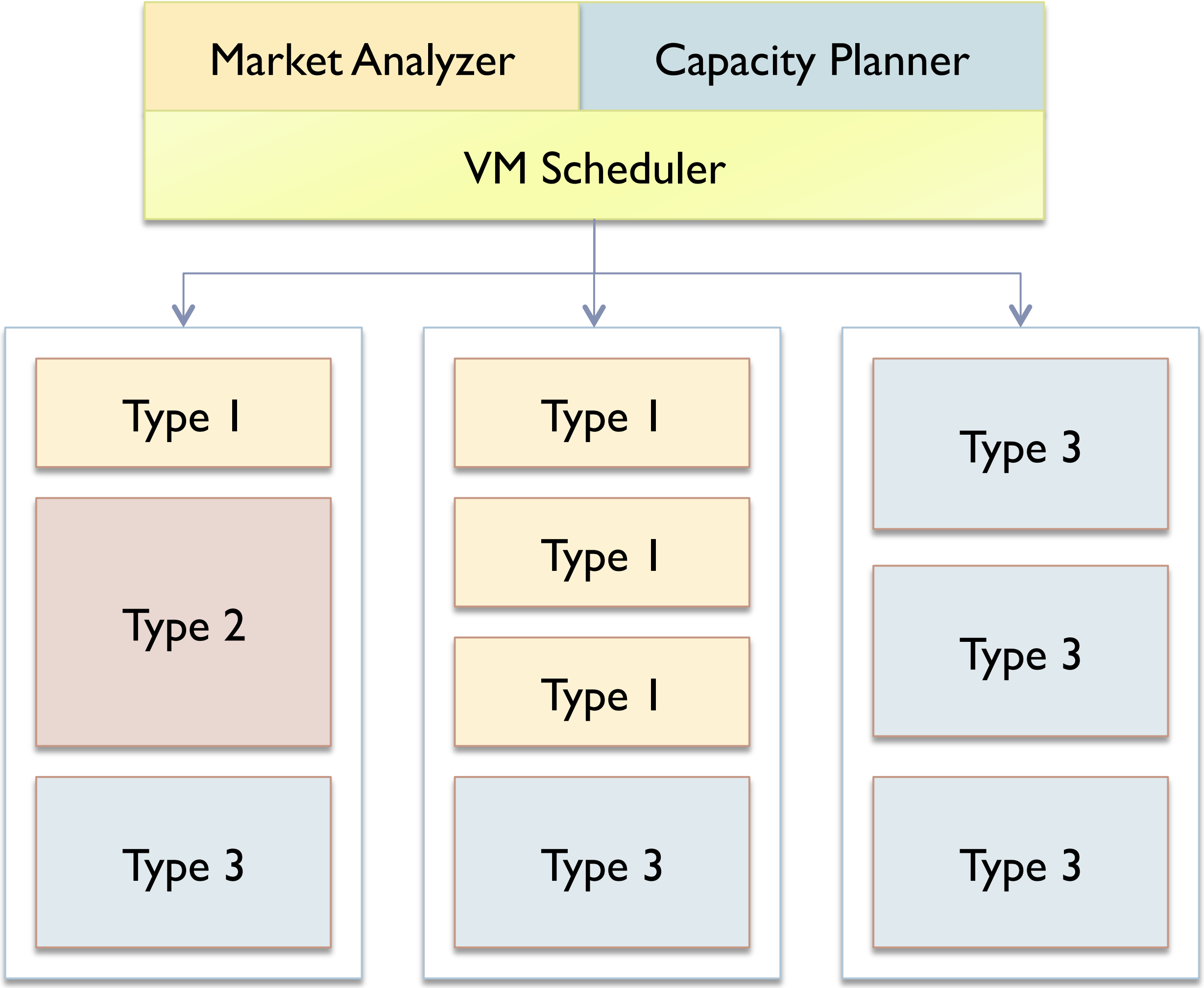
Contribution

- We propose a framework that dynamically adjust supply of spot markets to maximize total revenue

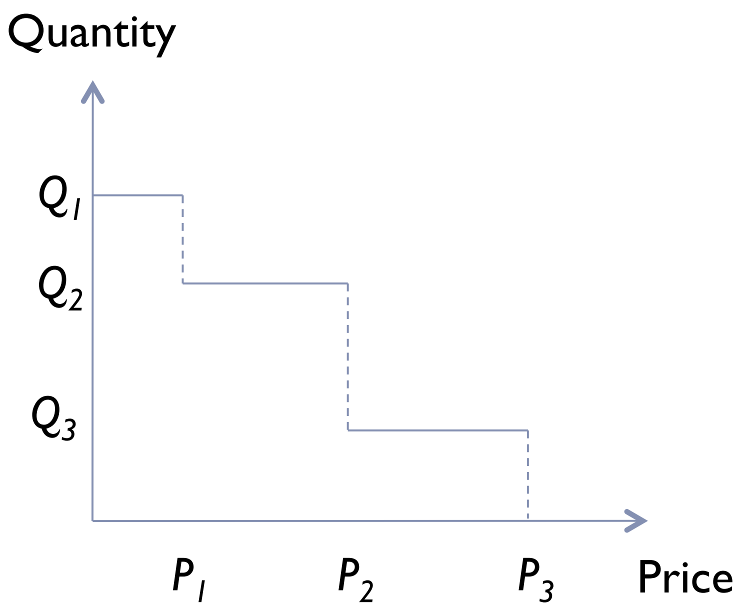
- Challenges
  - Need to predict future demand for every spot market
  - Need to determine the allocation strategy that optimizes revenue

- Our solution
  - Predicting future demand using an autoregressive (AR) model
  - Compute expected spot price and allocation for each market to maximize total revenue
  - Schedule VMs according to expected price

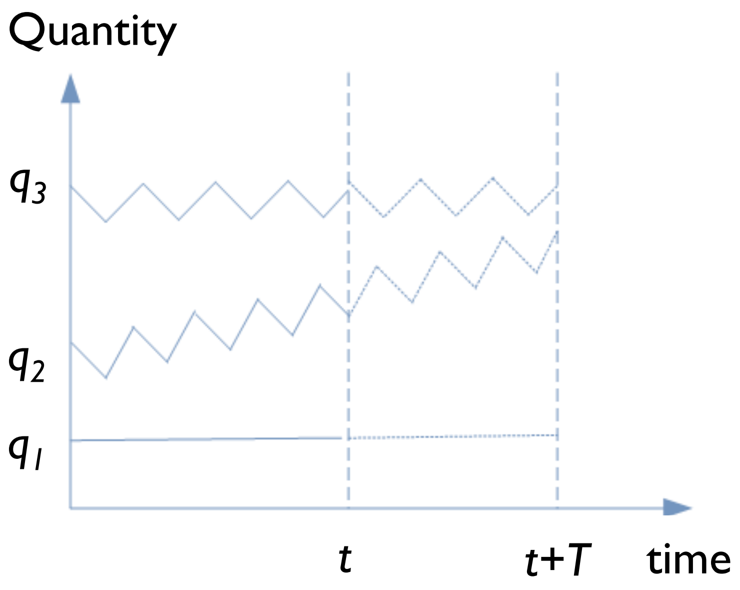
System Architecture



Demand Prediction



Demand curve



Predicting future demand curve

- Demand curve can be modeled as a non-increasing, piecewise-linear function
- Predicting future demand curve using autoregressive (AR) functions

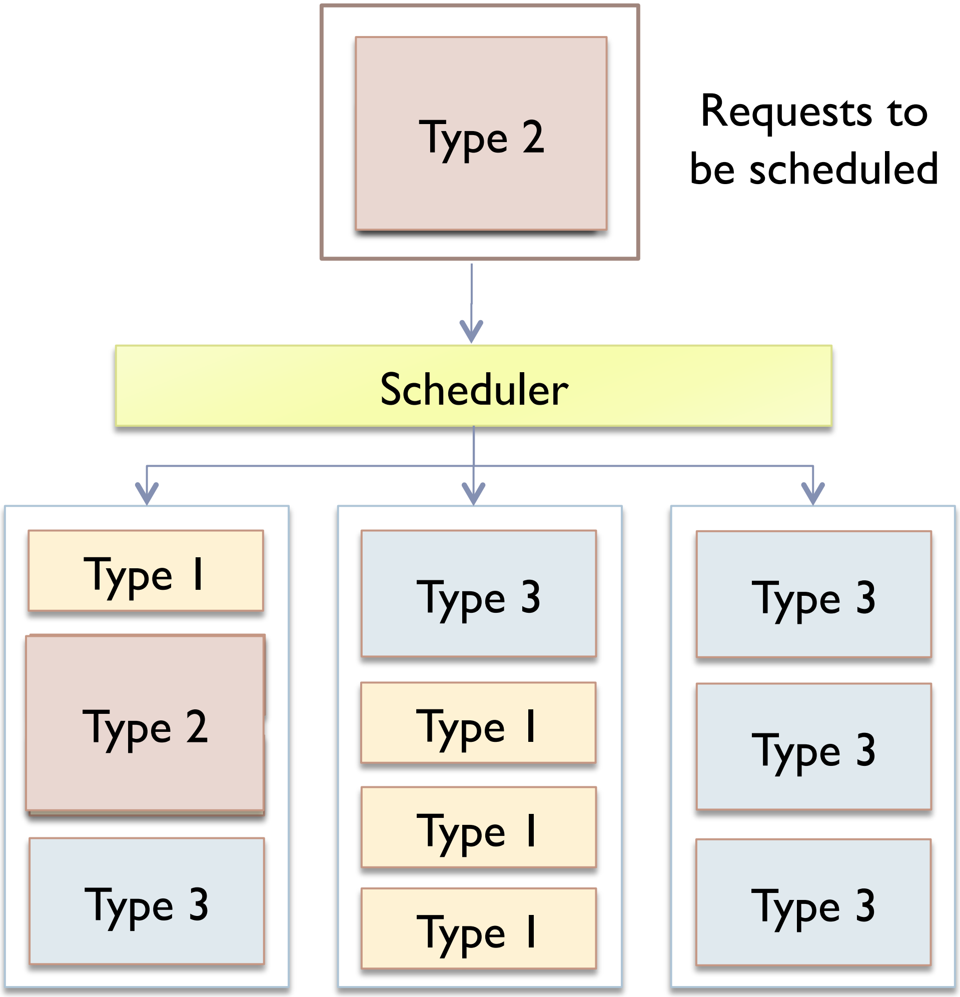
Computing Expected Allocation

- Goal: determine the expected price and allocation of resources to spot markets to maximize total revenue

- Simple case: Prices are fixed
  - This problem is a variant of the NP-hard multiple knapsack problem (MKP)

- Real case: Prices are not fixed
  - Much harder than MKP, as objective function is non-linear
  - By approximating the revenue using a concave function, the problem can be reduced to a MKP

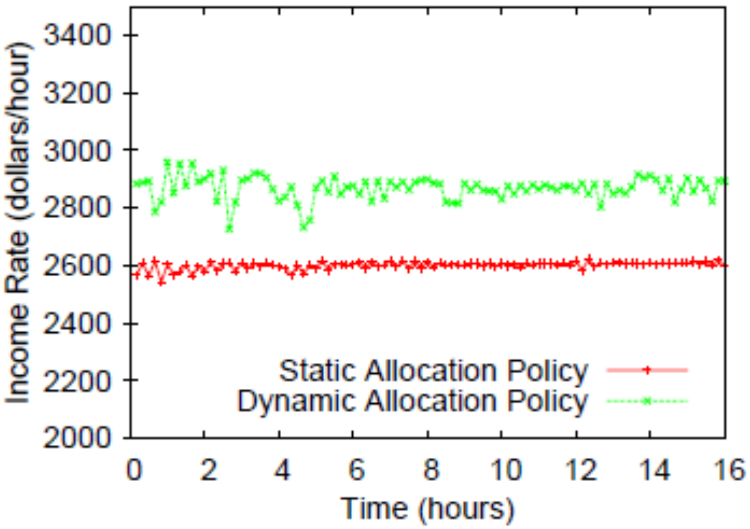
Scheduling Algorithm

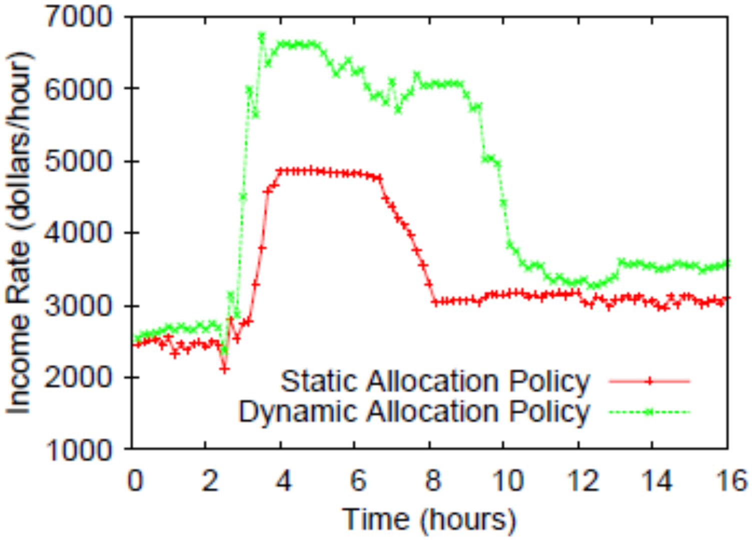


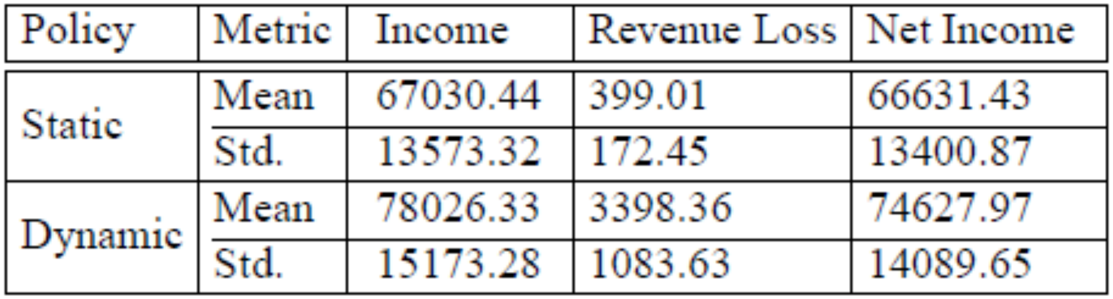
Experiment Setup

- Implemented the scheduler using CloudSim
  - Modified default resource allocation policies
- Workload
  - Non-homogenous poisson process with artificial high and low arrival periods
  - Bidding price and running time are generated from normal distributions
- Scheduling policies
  - Static allocation for each individual market
  - Our dynamic allocation scheme

Experiments







Policy	Metric	Income	Revenue Loss	Net Income
Static	Mean	67030.44	399.01	66631.43
	Std.	13573.32	172.45	13400.87
Dynamic	Mean	78026.33	3398.36	74627.97
	Std.	15173.28	1083.63	14089.65

Conclusion

- Market-based resource allocation mechanisms provide economic incentives to encourage desirable customer behavior

- We have presented a framework that dynamically adjust supply for different spot markets, with the goal of maximizing total revenue
  - Practical and applicable for any market-based cloud environment that uses uniform price scheme

Thanks!

Questions?