DYNAMIC RESOURCE PRICING ON FEDERATED CLOUDS

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Overview

- Introduction
- Resource pricing and cloud computing
- Impact of dynamic pricing
  - Proposed dynamic scheme
  - User welfare and allocation efficiency with dynamic pricing
- Conclusions and remarks
Introduction

- Large-scale sharing of computing resources
  - Peer-to-peer, grid, cloud computing
- Users are rational
  - Self-interested parties, which can devise strategies and manipulate the system to maximize their benefit
- Market-based models used for resource allocation
  - Efficiency is user-centric: Pareto efficiency
  - Strategy-proof: users are incentivized for being truthful
Resource pricing

- **Pricing is the process of computing the exchange value of resources using a common form of currency**
  - Pricing enables financial incentives for rational users:
    
    $\text{payments} = \text{price} + \text{incentives}$

- **Challenges in resource pricing**
  - **Computational**
    - Efficient algorithms are NP-complete, not scalable
  - **Economic**
    - Myerson-Satterthwaite theorem: No mechanism is efficient, budget-balance and incentive-compatible at the same time
Example: pricing on Amazon EC2

- **On-demand instances**
  - Hourly flat rate (e.g. small instance = $0.085/h)

- **Reserved instances**
  - Hourly flat rate + one-time-fee
    (e.g. small instance = $0.03 + $0.013* = $0.043/h)

- **Spot instances (dec 2009)**
  - Load-based *dynamic* rate
    (e.g. small instance = $0.028 - $0.095 dec09 – may10)
  - Spot pricing is **not** market-based pricing

*) 3 years reservation
Motivation

Standalone clouds

- Resource price set by the provider
- Users cannot behave rational

Federated clouds

- Dynamic resource price set by demand and supply
- Users behave rational

Resource pricing
Motivation (cont.)

- Fixed pricing limits provider (seller) welfare

![Graph showing fixed and dynamic pricing]

- Provide financial incentives for rational users

load-based pricing is not sufficient without a market mechanism
Performance study

- Economic efficiency measures the aggregate buyer and seller welfare
- Metrics
  - average buyer and seller welfare
  - number of successful buyer requests
  - number of allocated seller resources
- Truthful users
  - prices generated from a uniform distribution
Proposed dynamic pricing scheme [ICPP09]

- **Payment functions**

  \[ p_s = \begin{cases} 
  0, & \text{if seller } s \text{ does not contribute with resources to satisfy the request} \\
  c_{M|s=\infty} - c_{M|s=0} & \text{if seller } s \text{ contributes with resources to satisfy the request} 
  \end{cases} \]

  \[ p_b = - \sum_{s \in S} p_s \]

- **Properties**
  - **Economic**
    - Strategy-proof
    - Budget balance
    - Multiple resource type allocations
  - **Computational**
    - Low algorithm complexity
Proposed dynamic pricing scheme (cont.)

reverse auction-based pricing mechanism

- 10 VM instances
- 200 GB disk space

market-maker
Experimental setup

- Pricing schemes implemented on top of FreePastry, open-source DHT overlay (simulator)
  - 10,000 nodes
  - 600,000 events, 1s inter-arrival rate
- Nodes act as providers (sellers) and users (buyers)
  - Requests of multiple resource types
- One node acts as (centralized) market-maker
Impact of dynamic pricing

Average buyer welfare

- Balanced market (demand = supply)
- Price variation 10%, 20%, 50%
- avg. 10% increase
Impact of dynamic pricing

Average buyer welfare

- Up to 25% increase when demand is low
- Up to 10% increase for a balanced market
- User welfare decreases slower when the number of resource types increases
Impact of dynamic pricing

- Successful buyer requests
  - Up to 90% increase when demand is low
  - Up to 20% increase in a balanced market
  - Number of successful buyer requests is increased when the number of resource types in a request grows
Impact of dynamic pricing

Allocated seller resources

- More than 20% increase when demand is low
- Up to 20% increase in a balanced market
- Number of allocated seller resources is increased when the number of resource types in a request grows
Conclusions and remarks

- Dynamic pricing is more suitable than fixed pricing for federated clouds
  - Dynamic pricing offer incentives to users and providers
  - User and provider welfare is increased
  - Successful number of requests and number of allocated resources are increased
- Scalability of pricing algorithms can still be improved
  - Distributed pricing mechanisms
Thank you!

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