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:

$$payments = price + incentives$$

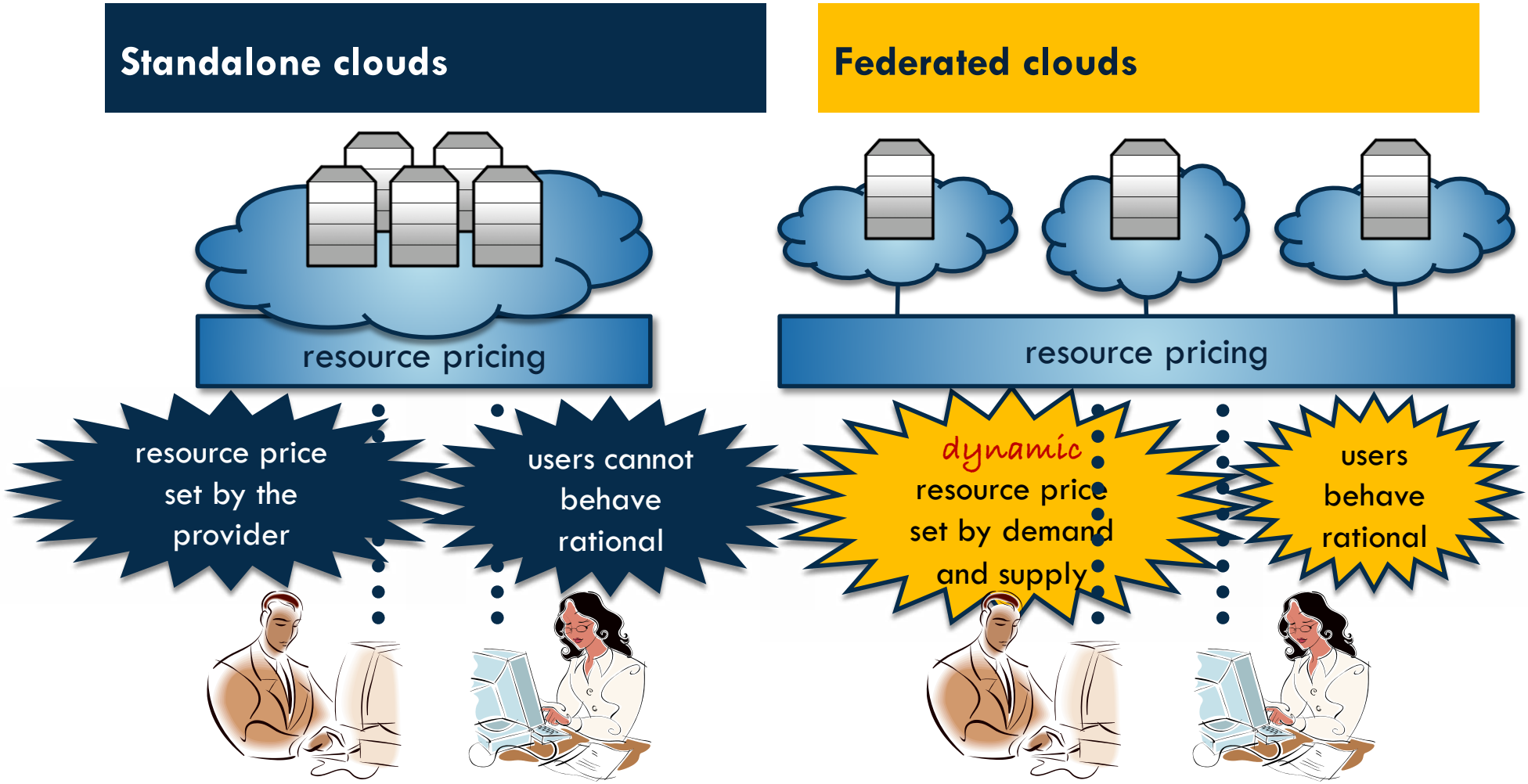
- Challenges in resource pricing
  - Computational
    - Efficient algorithms are NP-complete, not scalable
  - Economic
    - Myerson-Satterthwaite theorem: *No mechanism is efficient, budget-balance and incentive-compatible at the same time*

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

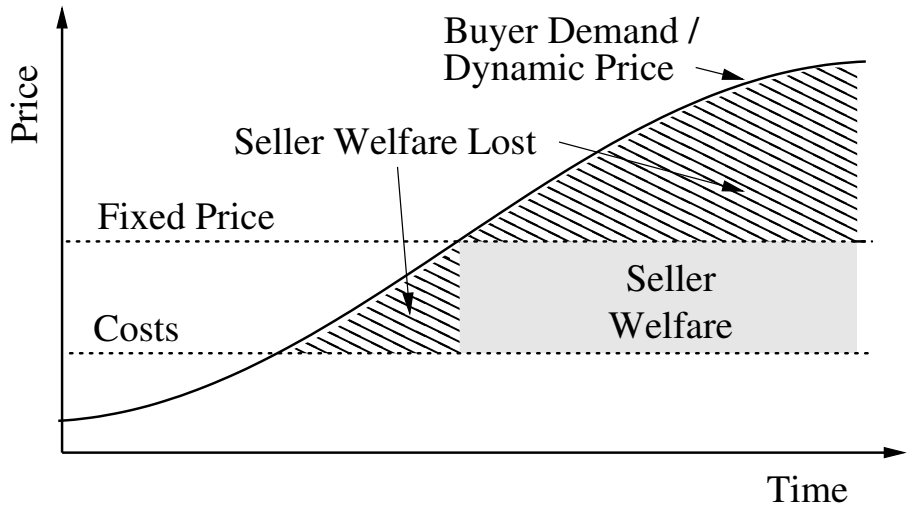
*) 3 years reservation

Motivation


Standalone clouds
Federated clouds
resource pricing
resource pricing
resource price set by the provider
users cannot behave rational
dynamic resource price set by demand and supply
users behave rational

Motivation (cont.)

- Fixed pricing limits provider (seller) welfare



load-based pricing is not sufficient without a market mechanism

- Provide financial incentives for rational users

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]

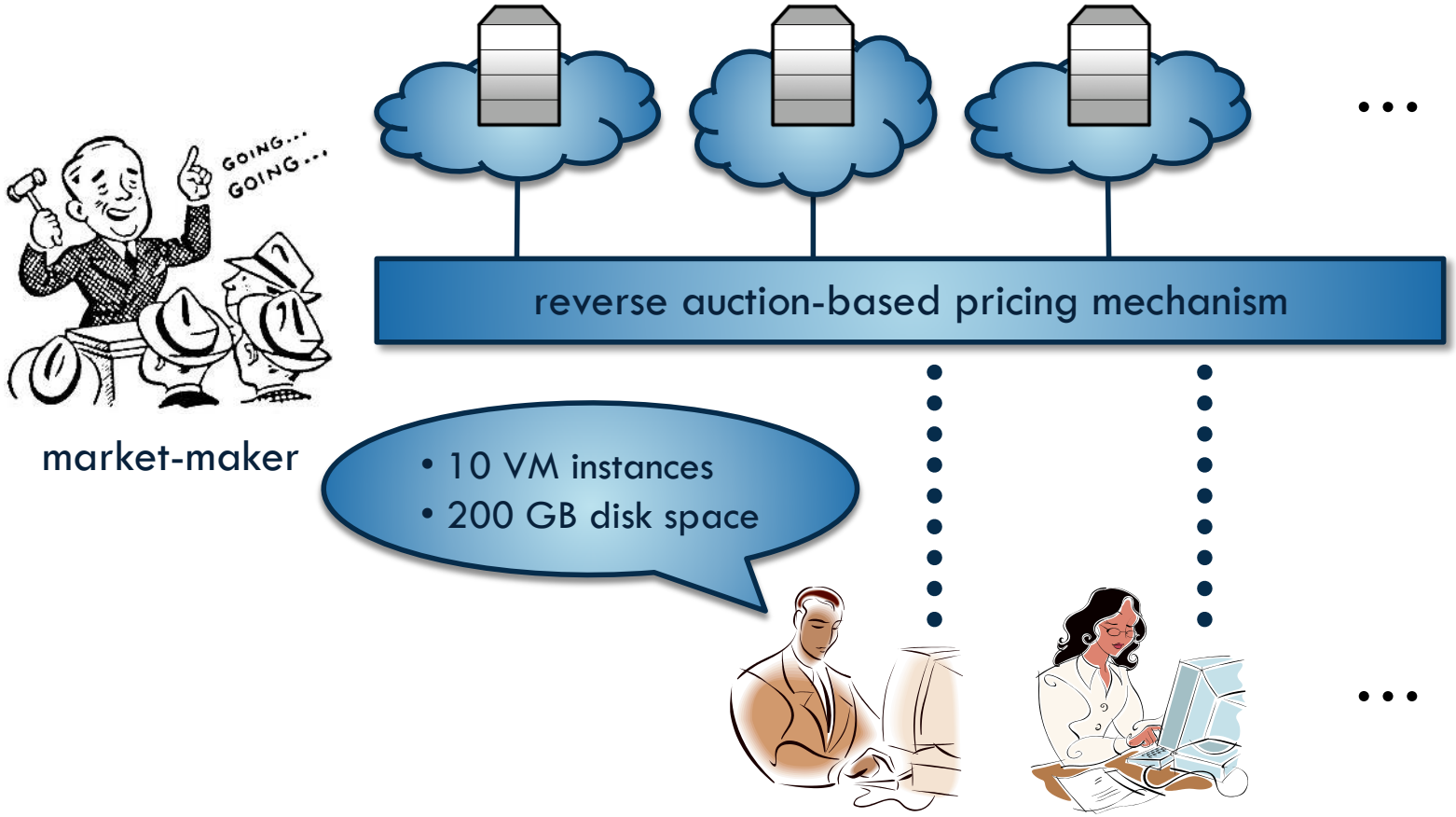
- Payment functions

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

$$p_b = -\sum_{s \in S} p_s$$

- Properties
  - **Economic**
    - Strategy-proof
    - Budget balance
    - Multiple resource type allocations
  - **Computational**
    - Low algorithm complexity

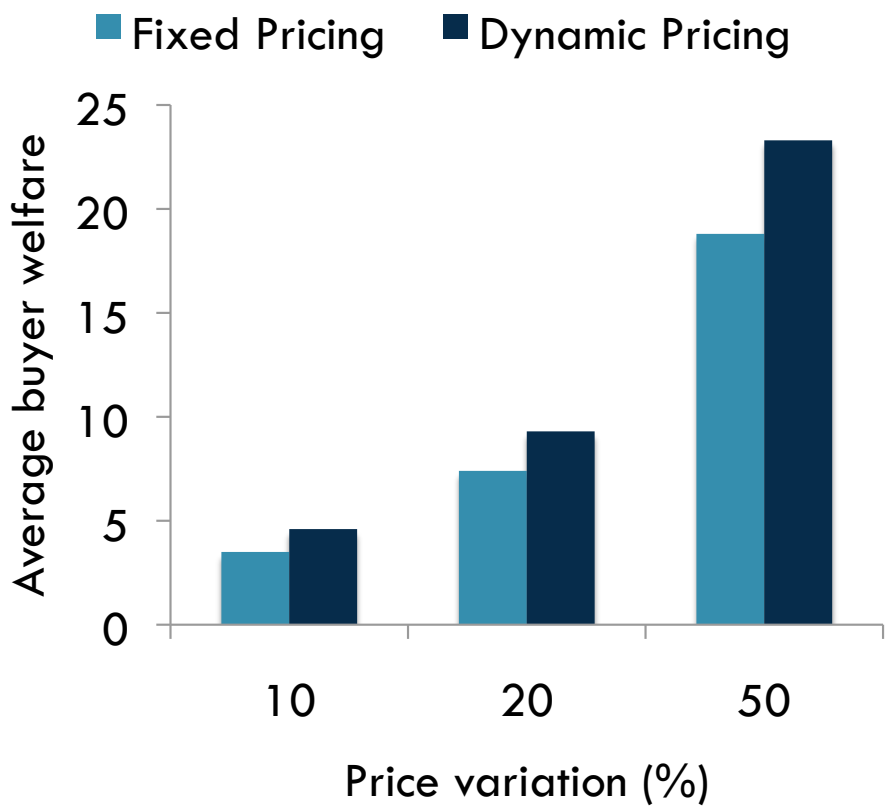
Proposed dynamic pricing scheme (cont.)



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

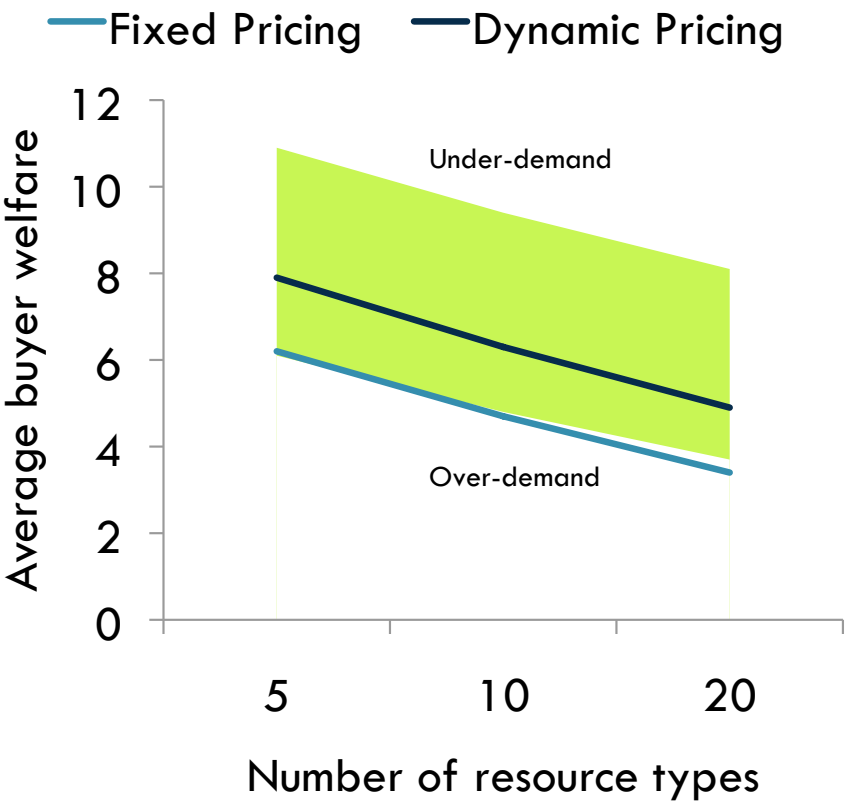


Average buyer welfare

- Balanced market (demand = supply)
- Price variation 10%, 20%, 50%

- avg. 10% increase

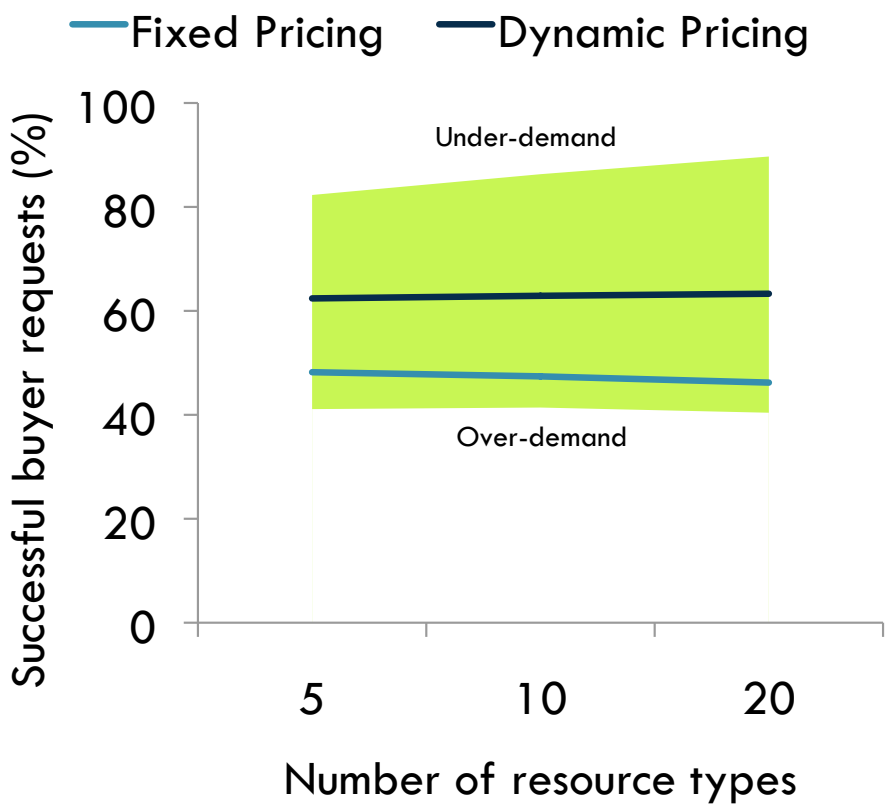
Impact of dynamic pricing



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

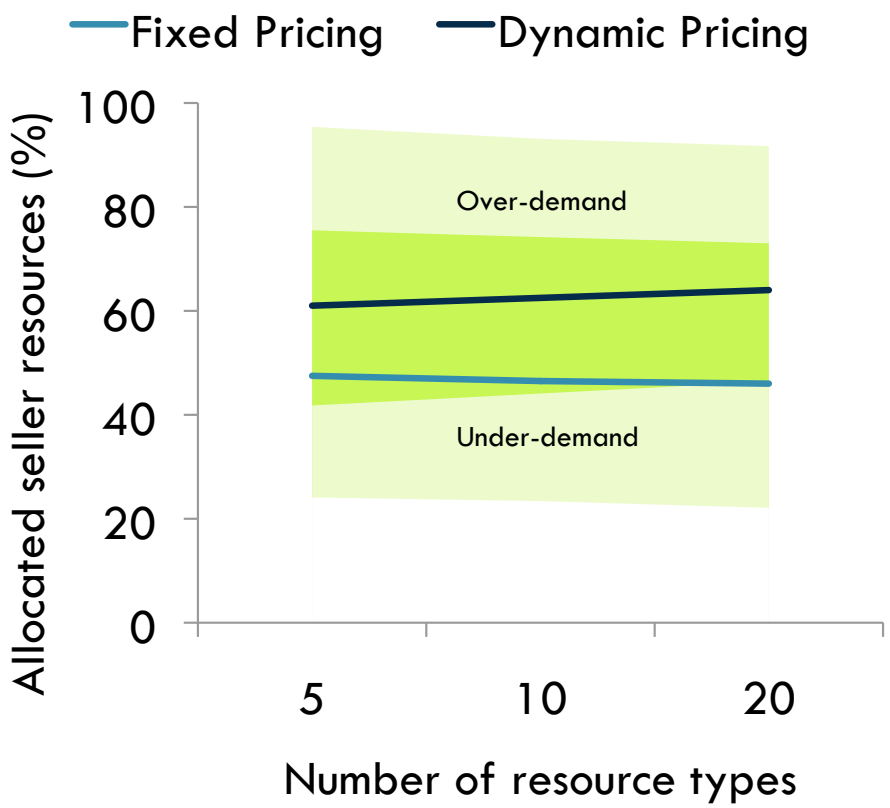
Impact of dynamic pricing



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!

Q & A

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