ANALYZING THE IMPACT OF BROKERED SERVICES ON THE CLOUD COMPUTING MARKET

Richard Shang and Yinping Yang
Institute of High Performance Computing
Agency for Science, Technology and Research (A*STAR), Singapore

Jianhui Huang and Robert J. Kauffman
School of Information Systems
Singapore Management University
Agenda

1) Introduction
2) Model
3) Analysis
4) Numerical Simulation
5) Conclusion
1. Introduction

Provisions of Cloud Computing Services
1. Introduction

Provisions of Cloud Computing Services

- **Spot**
- **Reserved**

Risk of Interruption vs. Average Price

Logos: Amazon Web Services, Google, Microsoft

Institute of High Performance Computing

Singapore Management University
1. Introduction

Provisions of Cloud Computing Services

- Spot
- Brokered
- Reserved

Risk of Interruption vs. Average Price
Research Question

How do brokered cloud computing services affect the cloud computing market?
1. Introduction

![Diagram showing risk preference with Spot and Reserved categories, and an arrow indicating a shift to include a Brokered category.]
1. Introduction

Reserved Resource Usage and Risk Mapping Function

- Broker's Profit after Price Change
- Vendor's Gain after Price Change
- Broker's Profit
- Vendor's Gain

Profit/Gain vs. Reserved Resource Usage

Uniform
Skewed
## 2. Model

<table>
<thead>
<tr>
<th>Provision</th>
<th>Charge to Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor</td>
<td>( JobCost_{\text{Reserved}} )</td>
</tr>
<tr>
<td>Spot</td>
<td>( JobCost_{\text{Spot}} )</td>
</tr>
<tr>
<td>Broker</td>
<td>[ JobCost_{\text{Broker}} = (1 + \text{PricePremium}) \cdot (a \cdot JobCost_{\text{Reserved}} + (1 - a) \cdot JobCost_{\text{Spot}}) ]</td>
</tr>
</tbody>
</table>
2. Model

\[ \text{TotalCost} = \text{JobCost} + \text{InterruptCost} \cdot [\text{Mean#Interrupts} + (\text{RiskPref} \cdot \text{SD#Interrupts})] \]

<table>
<thead>
<tr>
<th>Provision</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserved</td>
<td>( \text{JobCost}_{\text{Reserved}} )</td>
</tr>
<tr>
<td>Spot</td>
<td>( \text{JobCost}<em>{\text{Spot}} + \text{InterruptCost} \cdot [\text{Mean#Interrupts}</em>{\text{Spot}} + (\text{RiskPref} \cdot \text{SD#Interrupts}_{\text{Spot}})] )</td>
</tr>
</tbody>
</table>
| Brokered    | \( \text{Mean#Interrupts}_{\text{Broker}} = \text{BrokerInterruptRisk}(a) \cdot \text{Mean#Interrupts}_{\text{Spot}} \)  
\( \text{SD#Interrupts}_{\text{Broker}} = \text{BrokerInterruptRisk}(a) \cdot \text{SD#Interrupts}_{\text{Spot}} \)  
\( \text{BrokerInterruptRisk}(a) < 1 - a \) |
3. Analysis

Risk preference-based stratification of client segments.

\[ \theta \]

\[ \text{Spot} \quad \text{Reserved} \]

\[ \text{RiskPref}_{\text{Spot, Reserved}} \quad \text{Without the Broker} \]

\[ \text{Spot} \quad \text{Brokered} \quad \text{Reserved} \]

\[ \text{RiskPref}_{\text{Spot, Broker}} \quad \text{RiskPref}_{\text{Broker, Reserved}} \quad \text{With a Broker} \]
3. Analysis

\[
\Delta \text{Revenue} = \text{JobCost}_{\text{Reserved}} \cdot (F(RiskPref_{\text{Spot, Reserved}}) \\
- (1 - a) \cdot F(RiskPref_{\text{Broker, Reserved}}) - a \cdot F(RiskPref_{\text{Spot, Broker}})) \\
+ \text{JobCost}_{\text{Spot}} \cdot (a \cdot F(RiskPref_{\text{Spot, Broker}}) \\
+ (1 - a) \cdot F(RiskPref_{\text{Broker, Reserved}}) - F(RiskPref_{\text{Spot, Reserved}}))
\]

\[F(RiskPref_{\text{Spot, Reserved}}) --- \text{cumulative distribution function of risk preference}\]

\[a --- \text{percentage of reserved services used by the broker}\]
3. Analysis

Broker's Profit = \textbf{PricePremium} \cdot \left[ a \cdot \text{JobCost}_{\text{Reserved}} + (1 - a) \cdot \text{JobCost}_{\text{Spot}} \right] \\
\cdot \left[ F(\text{RiskPref}_{\text{Broker, Reserved}}) - F(\text{RiskPref}_{\text{Spot, Broker}}) \right]

subject to:

\text{PricePremium} < UB[\text{PricePremium}]
4. Numerical Simulation

![Graph showing profit/gain vs reserved resource usage for Uniform and Skewed distributions. The graph illustrates a decrease in profit/gain as the reserved resource usage increases, with a lower curve for the Skewed distribution compared to the Uniform distribution.]
4. Numerical Simulation

Reserved Resource Usage and Risk Mapping Function

- Broker's Profit
- Vendor's Gain
4. Numerical Simulation

- Vendor’s Gain after Price Change
- Broker’s Profit after Price Change

Reserved Resource Usage and Risk Mapping Function

Profit/Gain
4. Numerical Simulation

The Impact of Distribution of Risk References on Broker Profit

Reserved Resource Usage and Risk Mapping Function
4. Numerical Simulation

\[ \Delta \text{Revenue} = \text{JobCost}_{\text{Reserved}} \cdot (F(RiskPref_{\text{Spot, Reserved}}) \\
- (1 - a) \cdot F(RiskPref_{\text{Broker, Reserved}}) - a \cdot F(RiskPref_{\text{Spot, Broker}})) \\
+ \text{JobCost}_{\text{Spot}} \cdot (a \cdot F(RiskPref_{\text{Spot, Broker}}) \\
+ (1 - a) \cdot F(RiskPref_{\text{Broker, Reserved}}) - F(RiskPref_{\text{Spot, Reserved}})) \]

\[ a > \frac{F(RiskPref_{\text{Broker, Reserved}}) - F(RiskPref_{\text{Spot, Reserved}})}{F(RiskPref_{\text{Broker, Reserved}}) - F(RiskPref_{\text{Spot, Broker}})} \]
5. Conclusion

The cloud brokers have a room to promote the use of cloud services by customizing them for cost and risk-conscious clients.

Cloud service brokers need to assess its business feasibility based on the risk mitigation capability, vendor’s pricing, and client related parameters.

Broker’s profit does not align with the vendor’s gain in a saturated market.
3. Analysis

$$\theta$$

Spot  Reserved  Without the Broker

$$\text{RiskPref}_{\text{Spot}, \text{Reserved}}$$  $$\text{RiskPref}$$

$$\text{RiskPref}_{\text{Spot}, \text{Reserved}} = \frac{\text{JobCost}_{\text{Reserved}} - \text{JobCost}_{\text{Spot}}}{\text{SD} \# \text{Interrupts}_{\text{Spot}} \cdot \text{InterruptCost}} - \frac{\text{Mean} \# \text{Interrupts}_{\text{Spot}}}{\text{SD} \# \text{Interrupts}_{\text{Spot}}}$$
3. Analysis

\[ \text{RiskPref}_{\text{Spot, Broker}} \]

\[ \text{RiskPref}_{\text{Broker, Reserved}} \]

\[ \text{RiskPref}_{\text{Reserved}} \]

\[ \text{With a Broker} \]

\[ \theta \]

\[ \text{RiskPref}_{\text{Spot, Broker}} = \frac{\text{JobCost}_{\text{Reserved}} - \text{JobCost}_{\text{Broker}}}{\text{SD} \# \text{Interrupts}_{\text{Broker}} \cdot \text{InterruptCost}} - \frac{\text{Mean} \# \text{Interrupts}_{\text{Broker}}}{\text{SD} \# \text{Interrupts}_{\text{Broker}}} \]

\[ \text{RiskPref}_{\text{Spot, Broker}} = \frac{\text{JobCost}_{\text{Broker}} - \text{JobCost}_{\text{Spot}}}{(\text{SD} \# \text{Interrupts}_{\text{Spot}} - \text{SD} \# \text{Interrupts}_{\text{Broker}}) \cdot \text{InterruptCost}} - \frac{\text{Mean} \# \text{Interrupts}_{\text{Spot}} - \text{Mean} \# \text{Interrupts}_{\text{Broker}}}{\text{SD} \# \text{Interrupts}_{\text{Spot}} - \text{SD} \# \text{Interrupts}_{\text{Broker}}} \]