Optimal Bidding in Spot Instance Market

Presenter: Jian Zhao

April 12, 2012

Background

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  - Amazon introduced spot instance market on Dec. 2009 to utilize the idle resources of Amazon EC2 efficiently.
  - Price changes dynamically according to the supply and demand of cloud resources.
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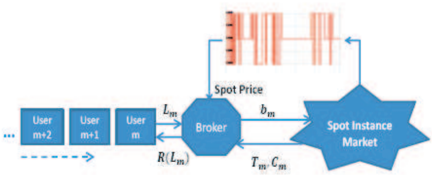
- **Cloud User**
  - Spot instances are suitable for compute-oriented, delay-tolerant job requests, e.g., Big Data analytics such as Hadoop, biological data processing, scientific batch computing.

How could cloud service broker maximize the time average profit?



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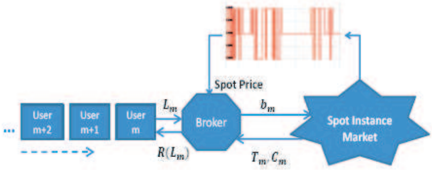

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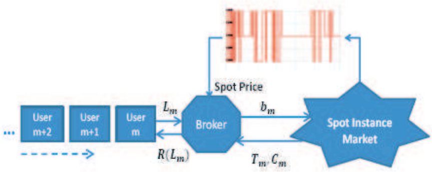

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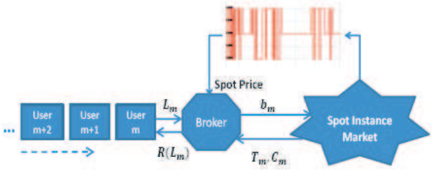

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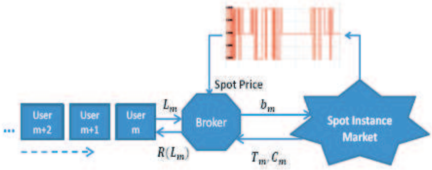

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  - The cloud provider charges C_m for T_m time length of a job.
  - The profit per unit time in serving job m for cloud service broker is $(R(L_m) - C_m)/T_m$.

Profit Maximization Problem

CSB optimizes the time average profit

- The time average profit maximization problem:

$$\max \lim_{M\to\infty} \frac{\sum_{m=1}^{M}(R(L_m) - C_m)}{\sum_{m=1}^{M} T_m}$$

s.t. (average cost requirement.)

$$\lim_{M\to\infty} \frac{\sum_{m=1}^{M} C_m}{\sum_{m=1}^{M} T_m} \leq \alpha$$

and (average job computation rate requirement.)

$$\lim_{M\to\infty} \frac{\sum_{m=1}^{M} L_m}{\sum_{m=1}^{M} T_m} \geq \beta$$

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Construct two virtual queues for the two constraints respectively:

- virtual queue $Y(m)$ for cost requirement:

$$Y(m+1) = [Y(m) - \alpha T_m]^+ + C_m \qquad \lim_{M\to\infty} \frac{\sum_{m=1}^{M} C_m}{\sum_{m=1}^{M} T_m} \leq \alpha$$

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Define a counter for the time average profit before serving the m-th job.

$$\rho'(m) = \frac{\sum_{r=1}^{m-1}(R(L_r) - C_r)}{\sum_{r=1}^{m-1} T_r}, m = 2, 3, \ldots$$

Profit Aware Dynamic Bidding Algorithm

- **Algorithm:**
  For each job m, the CSB observes $(L_m, S_m, Y(m), Z(m))$, selects the bid $b_m^\star$ which maximize:

$$VR(L_m) + Z(m)L_m - (V + Y(m)) \cdot E(C_m(S_m, b_l, L_m)) - \\ (V\rho'(m) - \alpha Y(m) + \beta Z(m)) \cdot E(T_m(S_m, b_l, L_m))$$

  The intuition is to minimally upper-bound $\Delta - V\bar{P_m}$, Δ is the Lyapunov drift to measure the change of total queue backlogs.

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  (a) Both the virtual queues are stable, hence, the two constraints are satisfied.

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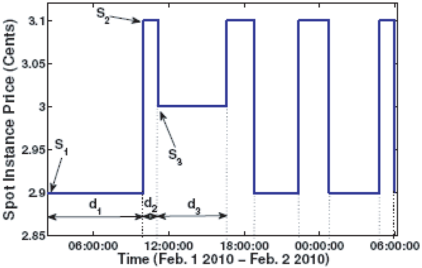
- **Performance of Algorithm**
  (a) Both the virtual queues are stable, hence, the two constraints are satisfied.
  (b) $\rho' \geq \rho^\star - \frac{B}{VT^{MIN}}$, ρ' is the solution from PADB algorithm. $\rho^\star$ is the optimum solution.

Random Event Distribution: Spot Price and Job Size

Spot Price Model:



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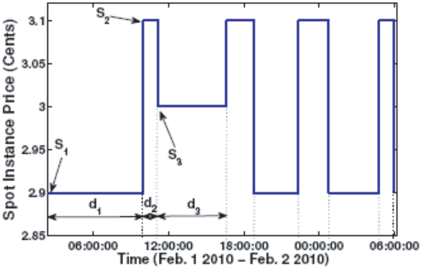

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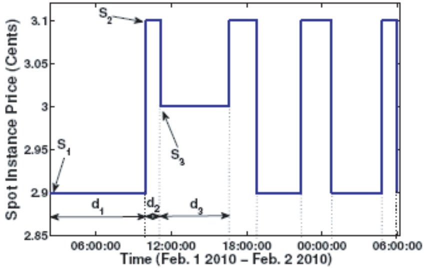

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- Empirical Estimator for $q_{i,j,k}$: N_i is the number of occurrences of price $s_i \in \mathcal{S}$; $N_{i,j}^k$ is the number of transitions from price $s_i \in \mathcal{S}$ to $s_j \in \mathcal{S}$ with sojourn time of $k \in \mathcal{T}$.

$$\hat{q_{i,j,k}} = \frac{N_{i,j}^k}{N_i}.$$

Random Event Distribution: Spot Price and Job Size

Job Size: A bounded-pareto distribution: $L^{MIN} < L < L^{MAX}$. The probability density function:

$$f(x) = \frac{\sigma(L^{MIN})^{\sigma} x^{-\sigma-1}}{1 - (\frac{L^{MIN}}{L^{MAX}})^{\sigma}}.$$

Conclusions

- How the spot instance is priced is not discussed. It uses a semi-markovian model to capture the spot price characterization.