# SPSE: A Flexible QoS-based Service Scheduling Algorithm for Service-Oriented Grid

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# 1. Introduction

Motivation:

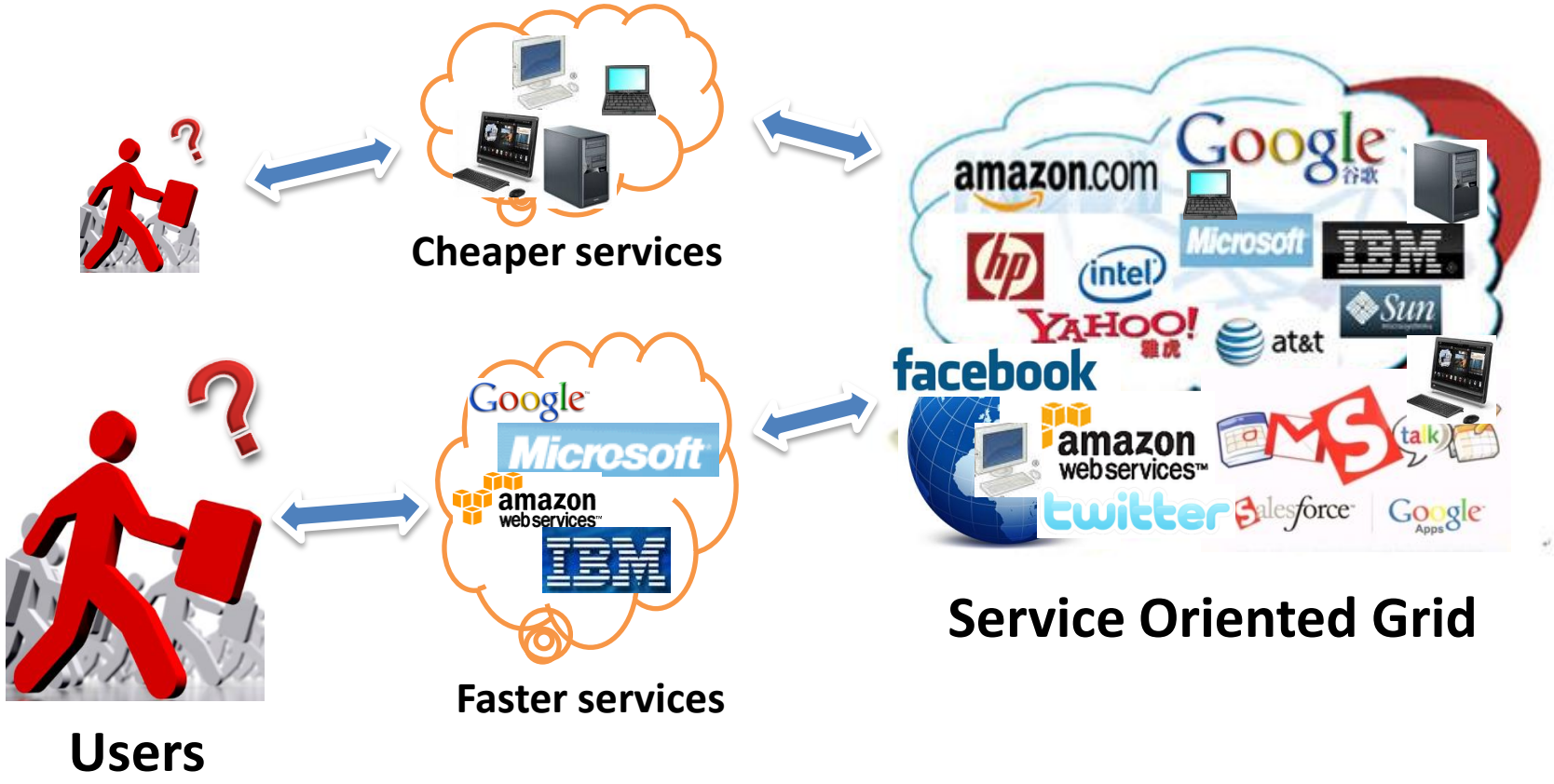

Which service is the most appropriate?

# 1. Introduction

- Problem:
  - Multi-objective supported?
    - Price? Time? Reliability? Trust?...
  - User personalization?
    - Different people have different preferences.
- We seek a *QoS-based service schedule algorithm*, which supports multi-objective and user personalization.

# 2. SPSE algorithm

- Service provider search engine (SPSE)



# 2. SPSE algorithm

- Job model:

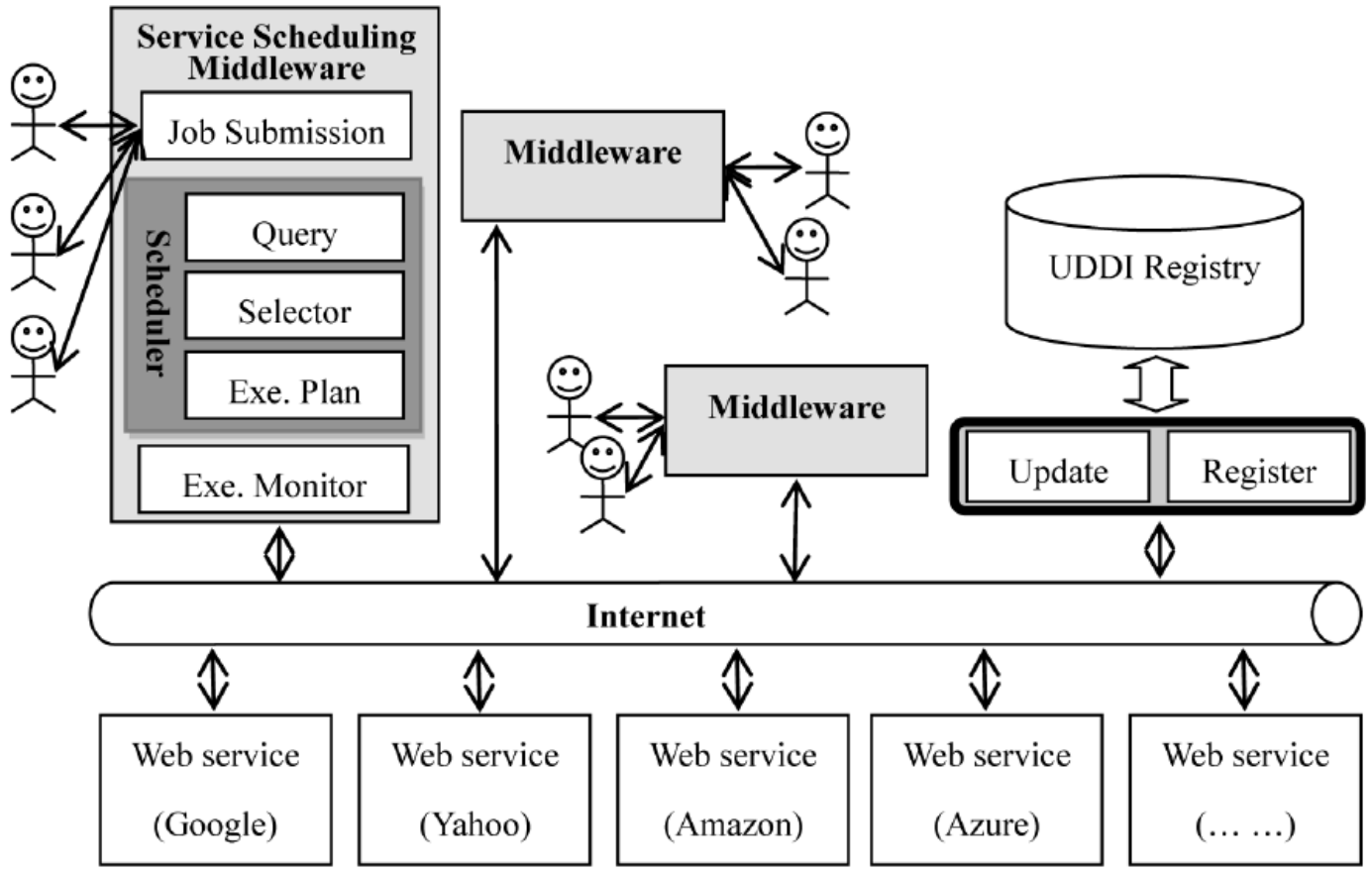
$$job = \{user\_id, job\_id, instructions, service\_type\}$$

- Service model:

$$resource = \{resource\_id, service\_type, cpu, price, trust, \ldots, (other\ criteria)\}$$

  - *cpu*, *price*, *trust*, *reliability* are the criteria.
- Service-oriented Grid environment:
  - There are many different kinds of services on the Internet. (The *service_type* indicates this.)
  - For each service, there are many service providers.
  - Web services from different organizations providing the same type of service come with the unified same interfaces.

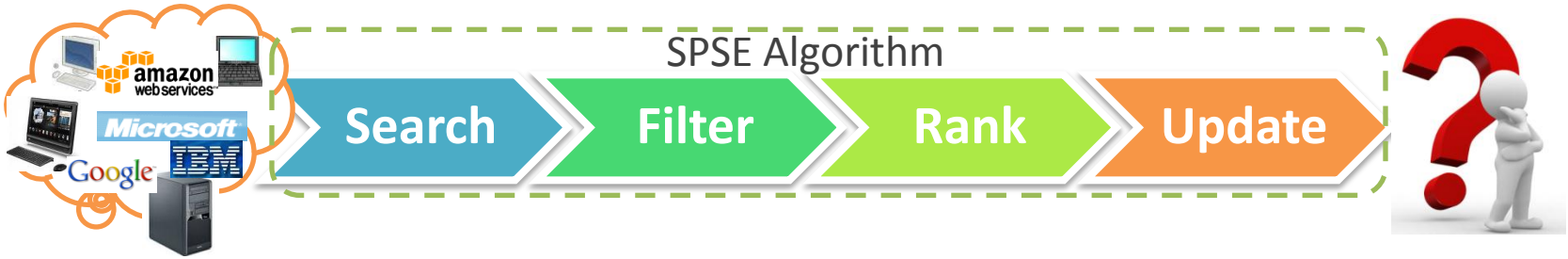
# 2. SPSE algorithm




The service scheduling middleware

# 2. SPSE algorithm

- The Service Provider Search Engine (SPSE).



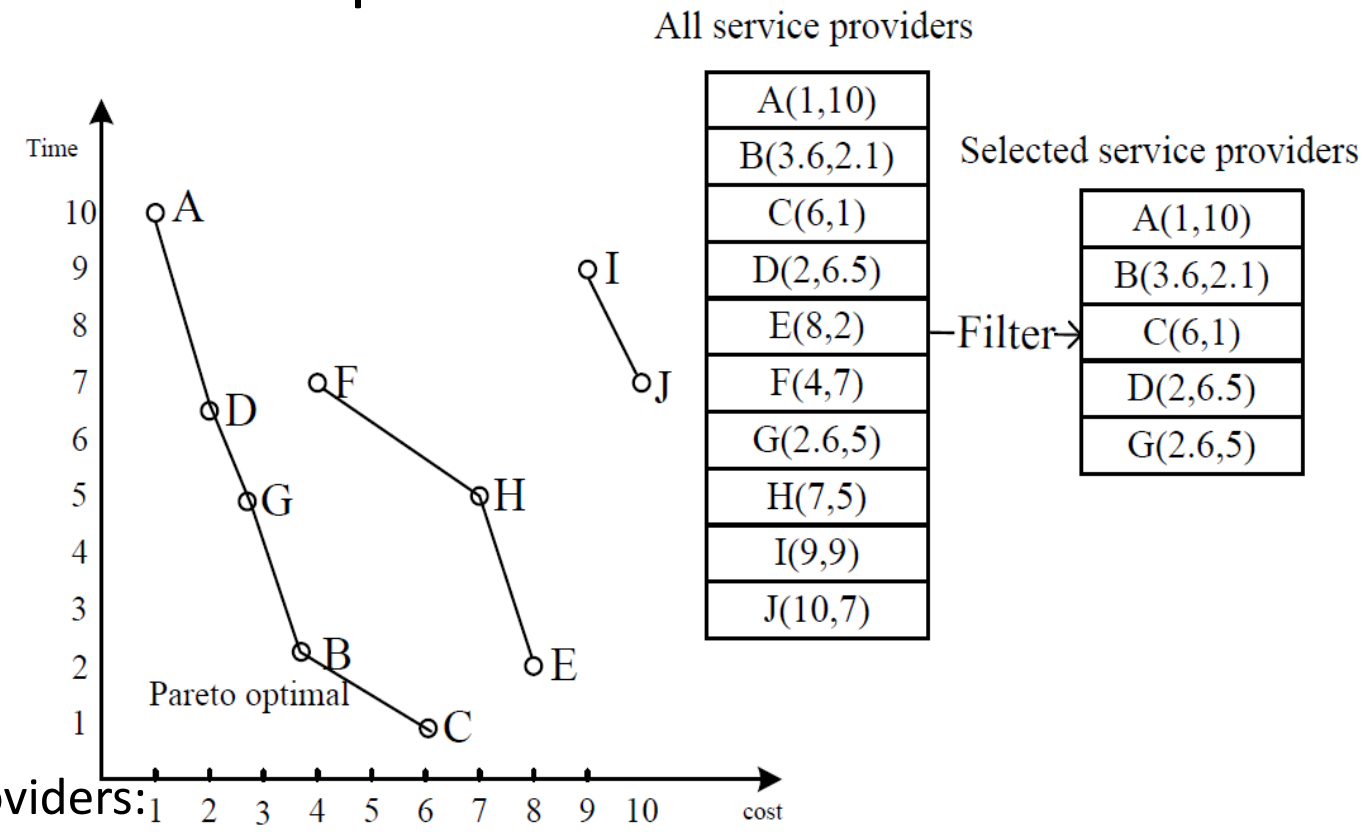
# 2. SPSE algorithm

- Operations in the algorithm:
  - *Search*:
    - Searches service providers from Grid information services (GIS) according to the *service_type*.
  - *Filter*
    - Deletes the poor service providers from all candidates.
  - *Rank*
    - Let better candidates rank higher than poorer candidates.
  - *Update*
    - User selects one candidate as the final choice, the user's choice will be used to update user's preferences.

# 2.1 Filter operation

**Goal**:

Delete the poor service providers from all candidates.




**Example 1**:

There exists 10 providers:

A,B,C,D,E,F,G,H,I,J have different performance on time and economic cost.

After the Pareto optimization based selection: A,D,G,B,C are left.

# 2.1 Filter operation

- The *time minimization service provider* (*cost minimization service provider, trust maximization service provider*) is not deleted by the filter operation.
  - (*Proof*)
- Therefore, SPSE can be used for *single objective scheduling*.

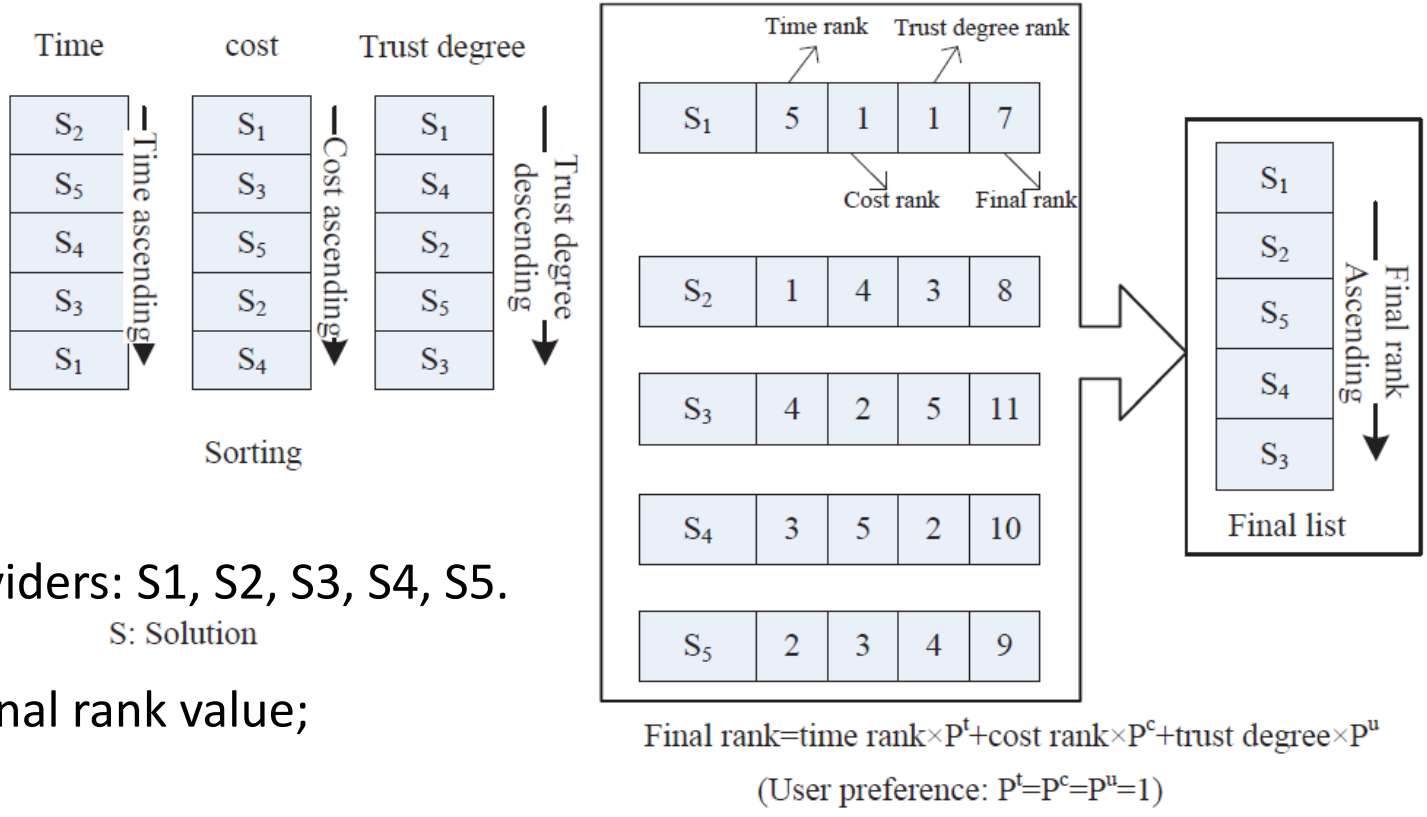
# 2.2 Rank operation

- User preference:
  - A set of parameters: $\{p_1, p_2, p_3, \ldots, p_m\}$
    - m is the number of criteria.
  - Each parameter reflects how highly user values the corresponding criteria.
- Attributes of user preferences:
  - Every user has a parameter set.
  - Initialization: $p_1^x = p_2^x = p_3^x = \ldots = p_m^x = 1$
  - The values are updated every time after one scheduling.

# 2.2 Rank operation

**Goal**:

Sort the service providers set into order.




**Example 2**:

There exists 5 providers: S1, S2, S3, S4, S5.

S: Solution

(1) Sort;

(2) Calculate the final rank value;

(3) Sort again.

Final rank=time rank×$P^t$+cost rank×$P^c$+trust degree×$P^u$

(User preference: $P^t=P^c=P^u=1$)

$$final\_rank = time\_rank \times p_1^x + cost\_rank \times p_2^x + trust\_rank \times p_3^x + (reserved \times p_i^x)$$

# 2.2 Rank operation

- Using the struct:

| Solution ID | Time rank | Cost rank | Trust rank | (Reserved) | Final rank |
|---|---|---|---|---|---|

- We get:

$$final\ rank_{s_1} = 5 \times 1 + 1 \times 1 + 1 \times 1 = 7$$

$$final\ rank_{s_2} = 1 \times 1 + 4 \times 1 + 3 \times 1 = 8$$

$$final\ rank_{s_3} = 4 \times 1 + 2 \times 1 + 5 \times 1 = 11$$

$$final\ rank_{s_4} = 3 \times 1 + 5 \times 1 + 2 \times 1 = 10$$

$$final\ rank_{s_5} = 2 \times 1 + 3 \times 1 + 4 \times 1 = 9$$

- Therefore, we get: S1 > S2 > S5 > S4 > S3

# 2.3 Update the preferences

- User select one provider from final set.
- Update the preference value on **time**:

$$p_1^{'} = p_1 \times (1 + \frac{\overline{t_{top}} - t_{user}}{\overline{t_{top}}})$$

Where $t_{user}$ is the execution time of user selected solution; $t_{top}$ is the is execution time of NO.1 solution; $p_1$ is the original preference value on time.

**Economic cost:** $$p_2^{'} = p_2 \times (1 + \frac{\overline{c_{top}} - c_{user}}{\overline{c_{top}}})$$

**Trust:** $$p_3^{'} = p_3 \times (1 + \frac{r_{user} - \overline{r_{top}}}{\overline{r_{top}}})$$

**Other criteria:** $$p_m^{'} = p_m \times (1 + \frac{\mp e_{user} \pm \overline{e_{top}}}{\overline{e_{top}}})$$

# 2.3 Update the preferences

- Update operation follows two rules:
  - If $p_i^{'} < 0$, then set $p_i^{'} = 0$
  - Reward principle:

$$\text{If}(\ p_1 < \delta\ \&\&\ \frac{\overline{t_{top}} - t_{user}}{\overline{t_{top}}} > \delta)\ \text{then set}\ p_1^{'} = 1.$$

$$\text{If}(\ p_2 < \delta\ \&\&\ \frac{\overline{c_{top}} - c_{user}}{\overline{c_{top}}} > \delta)\ \text{then set}\ p_2^{'} = 1.$$

$$\text{If}(\ p_3 < \delta\ \&\&\ \frac{r_{user} - \overline{r_{top}}}{\overline{r_{top}}} > \delta)\ \text{then set}\ p_3^{'} = 1.$$

$$\text{If}(\ p_m < \delta\ \&\&\ \frac{\mp e_{user} \pm \overline{e_{top}}}{\overline{e_{top}}} > \delta)\ \text{then set}\ p_m^{'} = 1$$

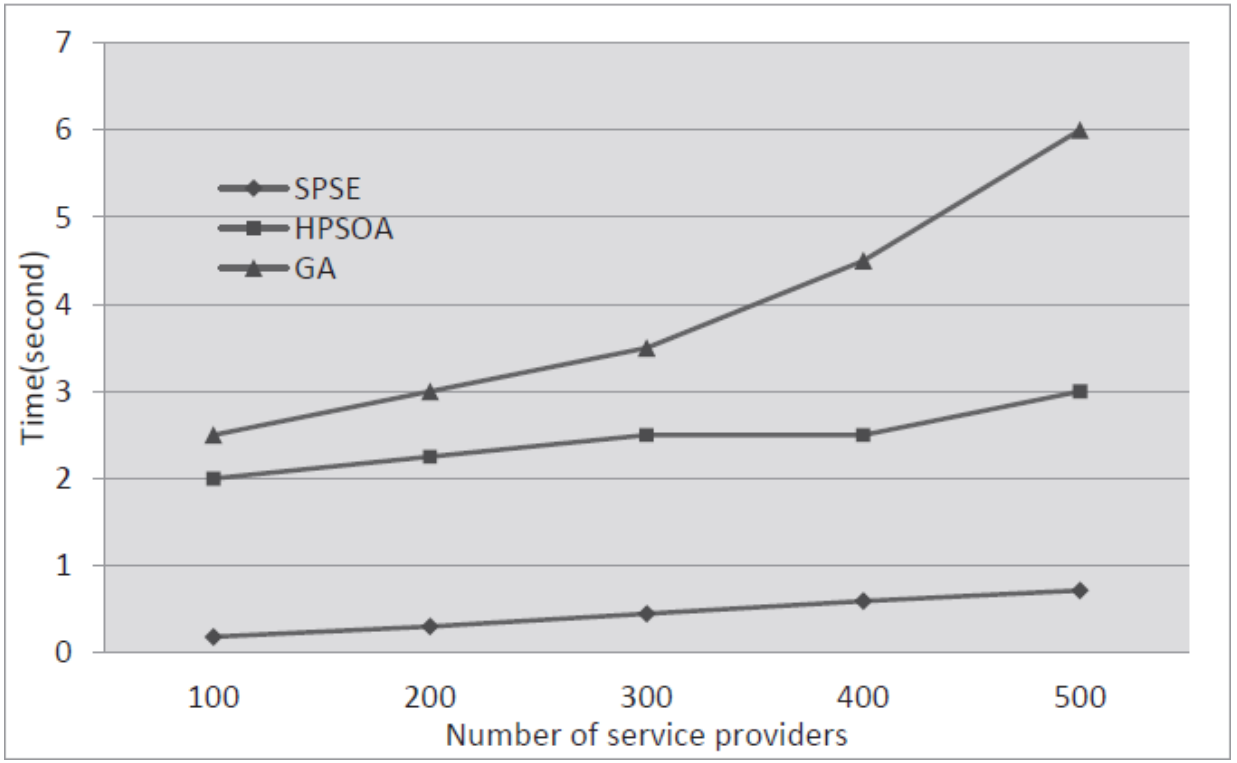
  - Where $\delta$ is a threshold value, indicating how big changes to the user's preferences.

# 3. Analysis & Experiments

**Time complexity**:

$$O(MN^2)$$

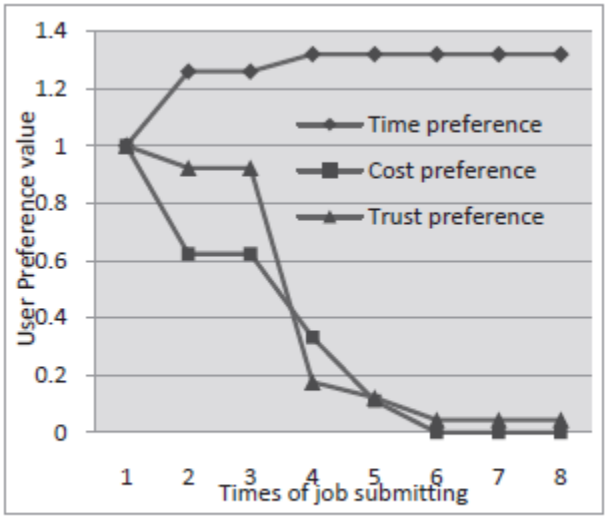
Where M is the number of criteria, N is the number of service provider candidates.



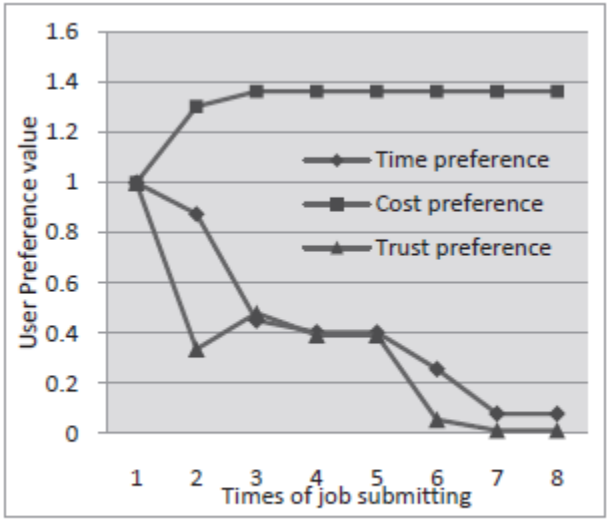

The scheduling time of SPSE with respect to different number of service providers

# 3. Analysis & Experiments

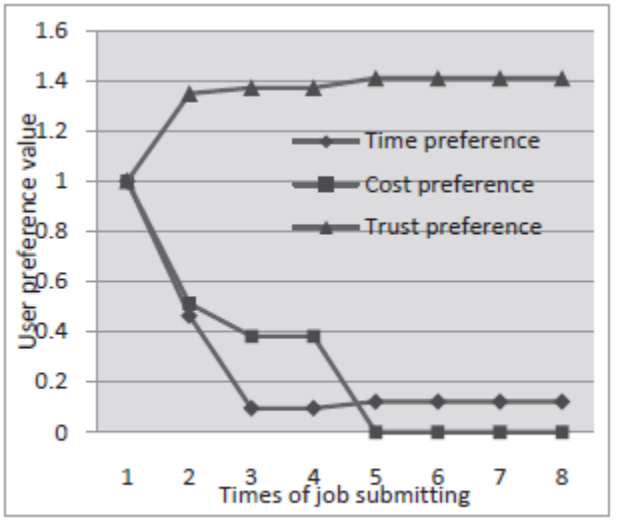
- Precision of preference values




(a)




(b)

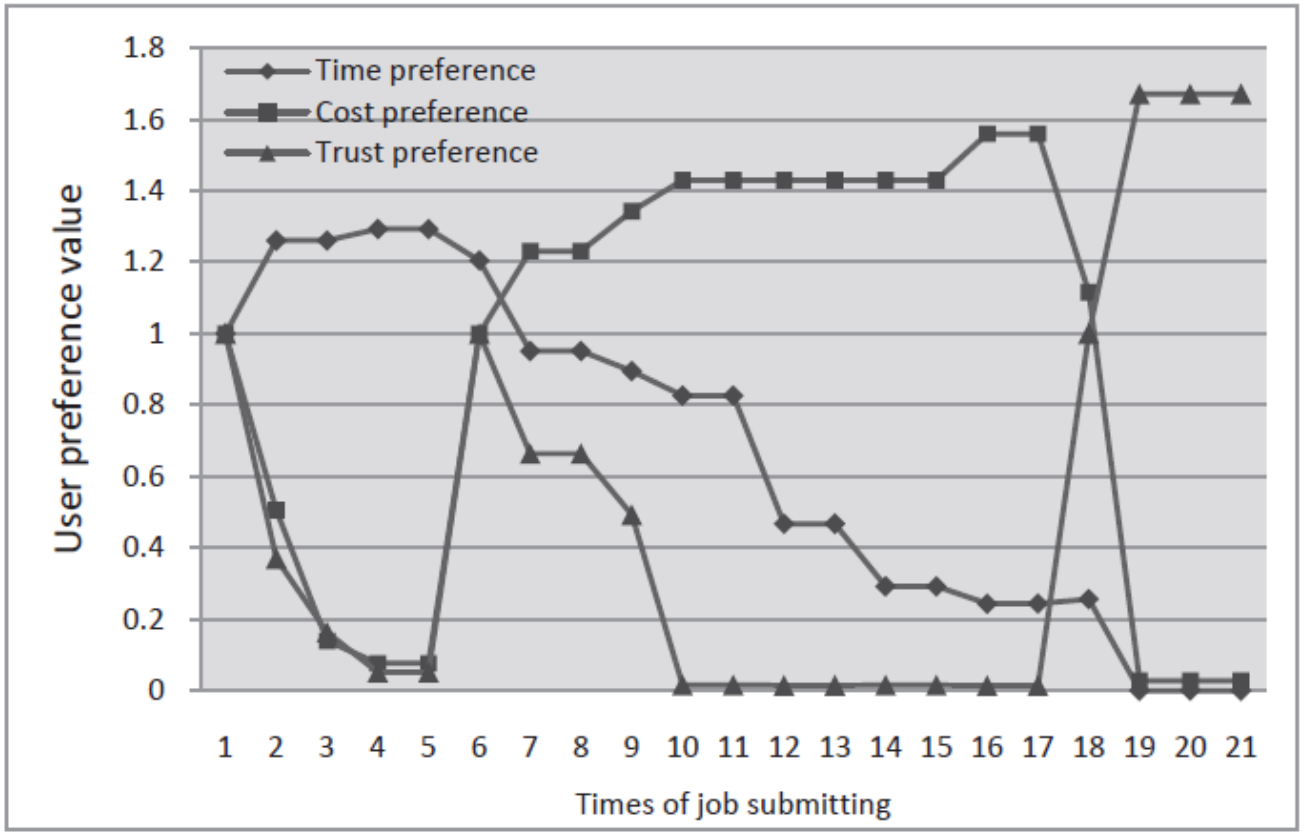



(c)

a: One person who prefers shorter time.
b: One person who prefers less economic cost.
c: One person who prefers higher provider's trust.

# 3. Analysis & Experiments

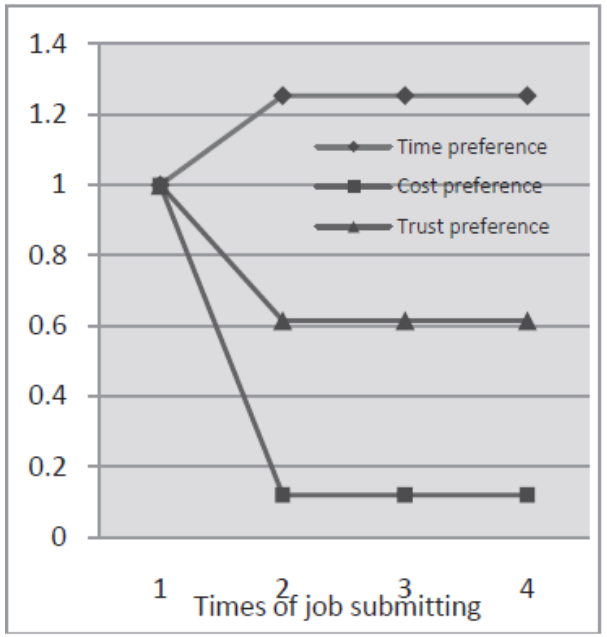
- Precision of preference values



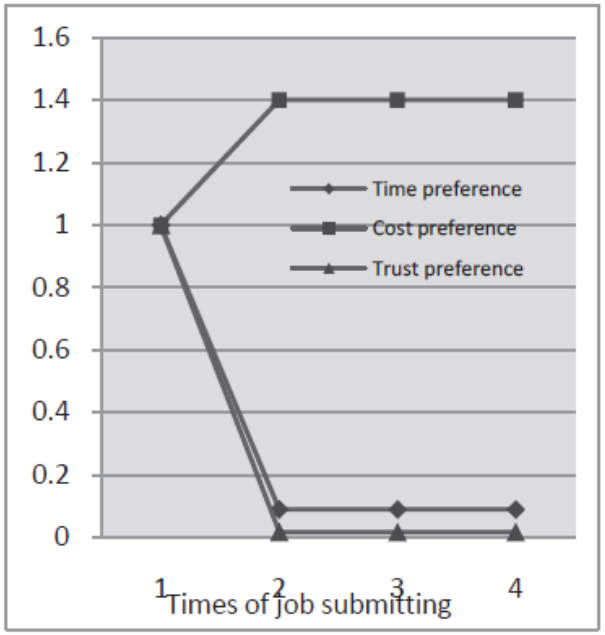

If one person changed his preference: from time to cost, from cost to trust.

# 3. Analysis & Experiments

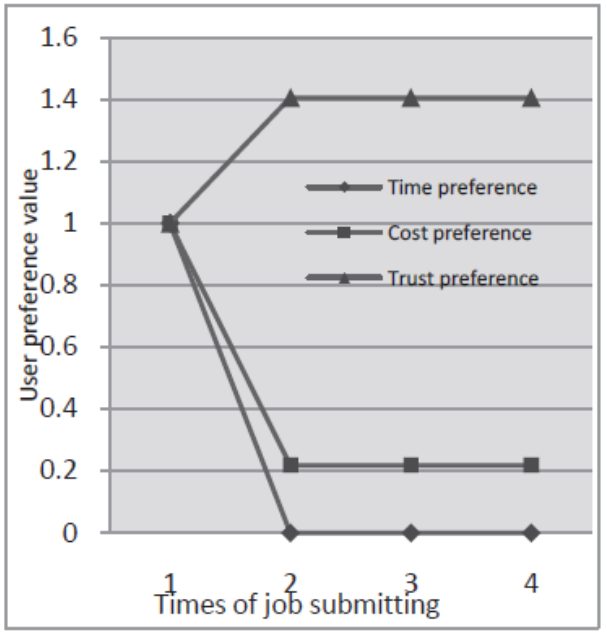
- Precision of solutions:




(a)




(b)




(c)

After the first job submission, users' preference value will be stable, if the job and Grid environment are not changed.

# 4. Conclusion and future works

- SPSE is the first algorithm on service search and scheduling:
  - Support the Multi-objective;
  - Support the User personalization.
- Experiments show that the most preferred service provider by an end-user is captured precisely.
- Future works:
  - The proposed SPSE is still simple, we ignore some issues like: fault tolerance, preemptible, which will be considered in our future work.

- Thank you for your attention.
- Questions?