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

Laiping Zhao, Yizhi Ren, Mingchu Li, Kouichi Sakurai
Information Technology and Security Laboratory
Kyushu University

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1. Introduction

Motivation:

I don’t care much about the price, I need my job completed earlier.

I don’t care much about the time, I like cheaper service.

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:

\[ \text{job} = \{ \text{user\_id, job\_id, instructions, service\_type} \} \]

• Service model:

\[ \text{resource} = \{ \text{resource\_id, service\_type, cpu, price, trust, …, (other criteria)} \} \]

  – 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

- Web service (Google)
- Web service (Yahoo)
- Web service (Amazon)
- Web service (Azure)
- Web service (… …)
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.
(1) Sort;
(2) Calculate the final rank value;
(3) Sort again.

\[
\text{final\_rank} = \text{time\_rank} \times p_i^e + \text{cost\_rank} \times p_i^c + \text{trust\_rank} \times p_i^d + (\text{reserved} \times p_i^f)
\]
2.2 Rank operation

- Using the struct:

<table>
<thead>
<tr>
<th>Solution ID</th>
<th>Time rank</th>
<th>Cost rank</th>
<th>Trust rank</th>
<th>(Reserved)</th>
<th>Final rank</th>
</tr>
</thead>
</table>

- We get:

\[
\text{final rank}_{s_1} = 5 \times 1 + 1 \times 1 + 1 \times 1 = 7 \\
\text{final rank}_{s_2} = 1 \times 1 + 4 \times 1 + 3 \times 1 = 8 \\
\text{final rank}_{s_3} = 4 \times 1 + 2 \times 1 + 5 \times 1 = 11 \\
\text{final rank}_{s_4} = 3 \times 1 + 5 \times 1 + 2 \times 1 = 10 \\
\text{final rank}_{s_5} = 2 \times 1 + 3 \times 1 + 4 \times 1 = 9 \\
\]

- 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:

\[ p'_1 = p_1 \times \left(1 + \frac{t_{top} - t_{user}}{t_{top}} \right) \]

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

Economic cost:

\[ p'_2 = p_2 \times \left(1 + \frac{c_{top} - c_{user}}{c_{top}} \right) \]

Trust:

\[ p'_3 = p_3 \times \left(1 + \frac{r_{user} - r_{top}}{r_{top}} \right) \]

Other criteria:

\[ p'_m = p_m \times \left(1 + \frac{\pm e_{user} \pm e_{top}}{e_{top}} \right) \]
2.3 Update the preferences

• Update operation follows two rules:
  – If $p_i' < 0$, then set $p_i' = 0$
  – Reward principle:
    
    \[
    \text{If}( p_1 < \delta \land \text{and} \quad \frac{t_{top} - t_{user}}{t_{top}} > \delta) \text{ then set } p_1' = 1.
    \]
    \[
    \text{If}( p_2 < \delta \land \text{and} \quad \frac{c_{top} - c_{user}}{c_{top}} > \delta) \text{ then set } p_2' = 1.
    \]
    \[
    \text{If}( p_3 < \delta \land \text{and} \quad \frac{r_{user} - r_{top}}{r_{top}} > \delta) \text{ then set } p_3' = 1.
    \]
    \[
    \text{If}( p_m < \delta \land \text{and} \quad \frac{\pm e_{user} \pm e_{top}}{e_{top}} > \delta) \text{ then set } p_m' = 1.
    \]

• 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) Time preference
(b) Cost preference
(c) Trust preference

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:

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?