Quality Driven Web Services Composition

Liangzhao Zeng

- Liangzhao Zeng, Boualem Benatallah, et.al: **Quality driven web services composition** (gs: 359). WWW 2003
- Liangzhao Zeng, Boualem Benatallah, Anne H. H. Ngu et.al: **QoS-Aware Middleware for Web Services Composition**.(gs: 496) IEEE Trans. Software Eng. 30(5): 311-327 (2004)
- Yutu Liu, Anne H. H. Ngu, Liangzhao Zeng: **QoS computation and policing in dynamic web service selection.** (gs: 224) WWW 2004

Problem

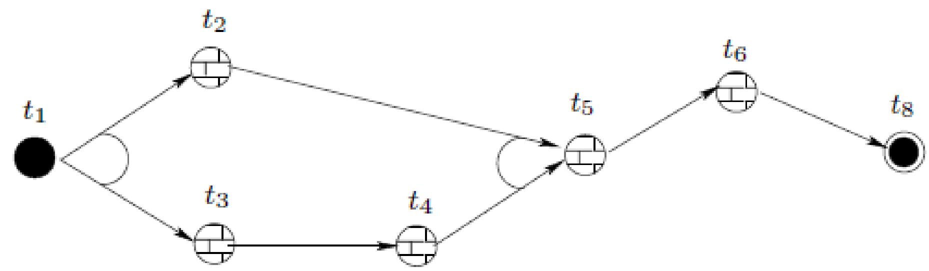
- 美好的愿望：整合企业资源，组合web服务
- QoS-based web service selection(related with web service composition)
  - Web service具多属性
  - Web services具多种组合结构
  - 不同的QoS属性及计算方法
  - Local optimal vs global optimal
  - 执行过程中进行选择

Component service → Composite service

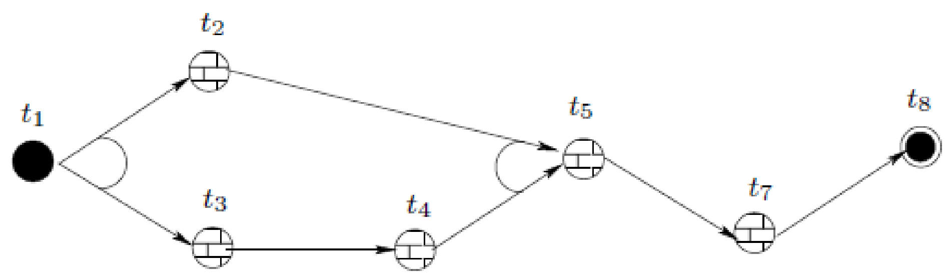
- Travel Planner:
  - Itinerary planning
  - Flight Ticket booking
  - Travel insurance
  - Accommodation booking
  - Car rental/Bike rental

Representation

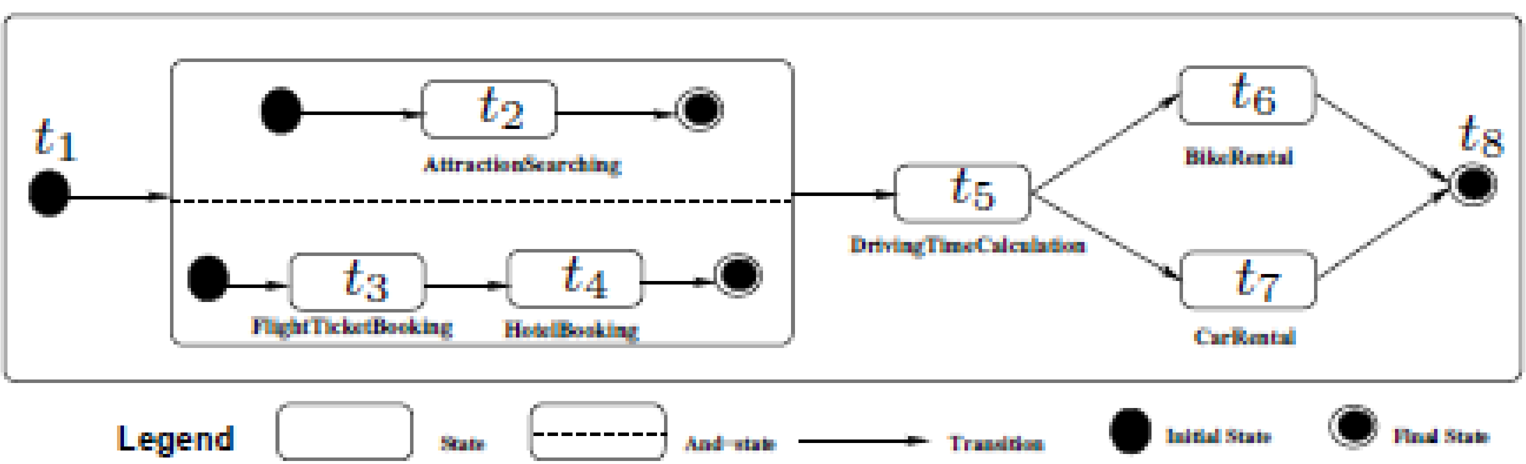
- Statechart
- DAG
- Execution path
- Execution plan



Execution Path 1 (W_{e1})

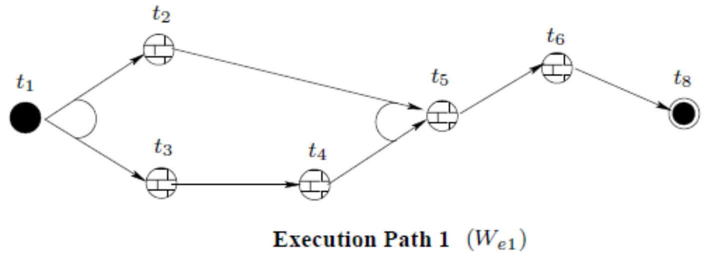


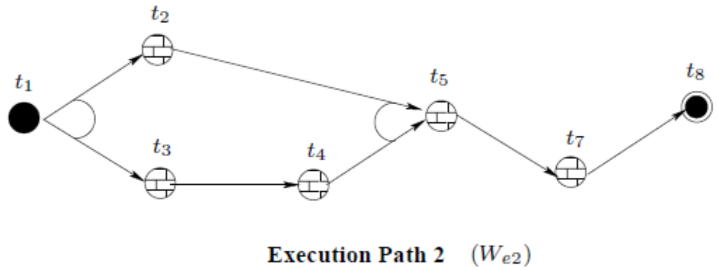
Execution Path 2 (W_{e2})

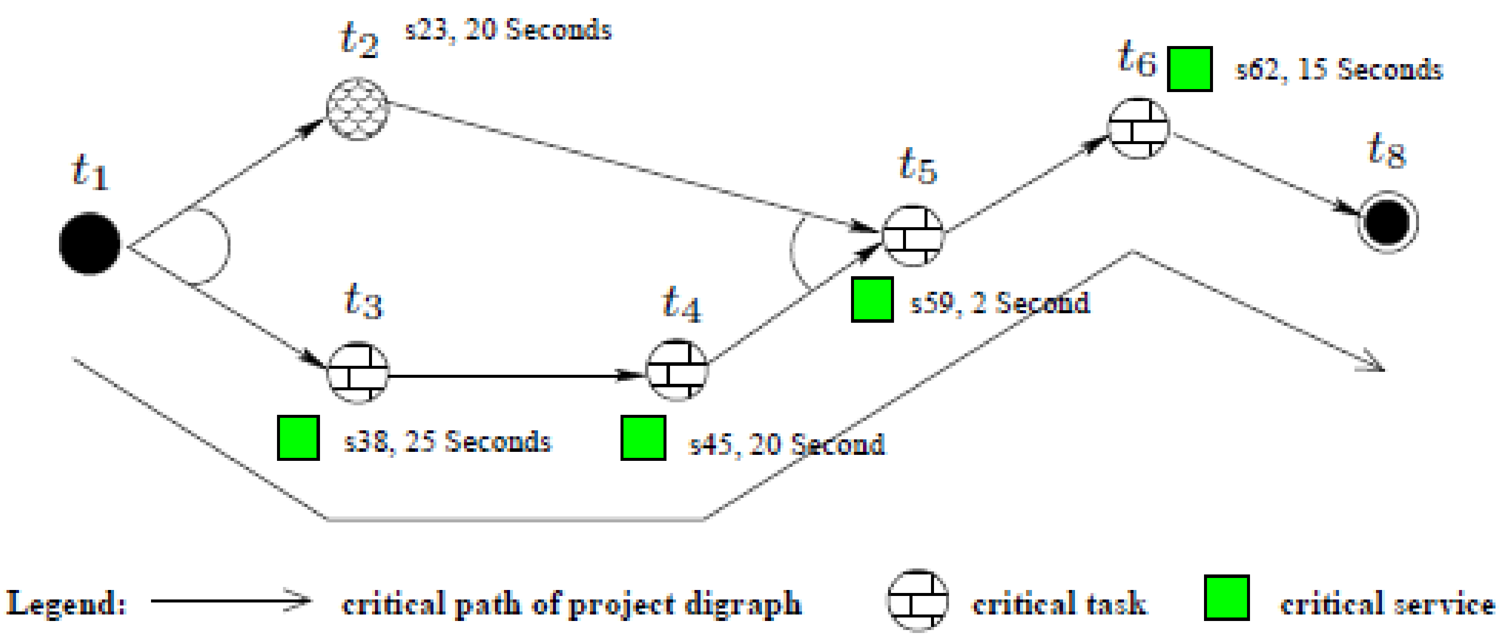


Representation

- DAG
- Project path
- Critical path
- Critical task
- Critical service







QoS criteria for Service

- Execution price
- Execution duration: $q_{du}(s, op) = T_{process}(s, op) + T_{trans}(s, op)$
  $T_{trans}(s, op) = \frac{\sum_{i=1}^{n} T_i(s,op)}{n}$
- Reliability: $q_{rel}(s) = N_c(s)/K$
- Availability： $q_{av}(s) = T_a(s)/\theta$
- Reputation: a measure of trustworthiness $q_{rep} = \frac{\sum_{i=1}^{n} R_i}{n}$
- Quality vector： $q(s) = (q_{price}(s), q_{du}(s), q_{av}(s), q_{re}(s), q_{rep}(s))$

QoS criteria for Composite Services

Table 1: Aggregation functions for computing the QoS of execution plans

Criteria	Aggregation function
Price	$Q_{price}(p) = \sum_{i=1}^{N} q_{price}(s_i, op_i)$
Duration	$Q_{du}(p) = CPA(q_{du}(s_1, op_1), ..., q_{du}(s_N, op_N))$
Reputation	$Q_{rep}(p) = \frac{1}{N} \sum_{i=1}^{N} q_{rep}(s_i)$
Reliability	$Q_{rel}(p) = \Pi_{i=1}^{N}(e^{q_{rel}(s_i)*z_i})$
Availability	$Q_{av}(p) = \Pi_{i=1}^{N}(e^{q_{av}(s_i)*z_i})$

$$Q(p) = (Q_{price}(p), Q_{du}(p), Q_{av}(p), Q_{re}(p), Q_{rep}(p))$$

Method 1—one execution path

- Select all possible execution plans $P = \{p_1, p_2, ..., p_n\}$
- Derived the quality vector for each execution plan

$$\mathbb{Q} = \begin{pmatrix} Q_{1,1} & Q_{1,2} & \dots & Q_{1,5} \\ Q_{2,1} & Q_{2,2} & \dots & Q_{2,5} \\ \vdots & \vdots & \vdots & \vdots \\ Q_{n,1} & Q_{n,2} & \dots & Q_{n,5} \end{pmatrix}$$

- SAW(Simple Additive Weighting)
  - Scaling phase

$$V_{i,j} = \begin{cases} \frac{Q_j^{max} - Q_{i,j}}{Q_j^{max} - Q_j^{min}} & \text{if } Q_j^{max} - Q_j^{min} \neq 0 \\ 1 & \text{if } Q_j^{max} - Q_j^{min} = 0 \end{cases} \quad j = 1, 2$$

$$V_{i,j} = \begin{cases} \frac{Q_{i,j} - Q_j^{min}}{Q_j^{max} - Q_j^{min}} & \text{if } Q_j^{max} - Q_j^{min} \neq 0 \\ 1 & \text{if } Q_j^{max} - Q_j^{min} = 0 \end{cases} \quad j = 3, 4, 5$$

$$\mathbb{Q}' = \begin{pmatrix} V_{1,1} & V_{1,2} & \dots & V_{1,5} \\ V_{2,1} & V_{2,2} & \dots & V_{2,5} \\ \vdots & \vdots & \vdots & \vdots \\ V_{n,1} & V_{n,2} & \dots & V_{n,5} \end{pmatrix}$$

  - Weighting phase

$$Score(p_i) = \sum_{j=1}^{5} (V_{i,j} * W_j)$$

$W_j \in [0, 1]$ and $\sum_{j=1}^{5} W_j = 1.$

Method 1—multiple execution path

- How to select execution plans to cover all tasks, all services?
  - Task ti blongs to one execution path:
  - Task ti blongs to multiple execution path: execute in hot path

- Computing cost is too high : O(M^N)—So ,method 2

Method 2—LP

$$\text{var}\, iables: y_{ij}, st: y_{ij} = 0 or 1, \sum_{i \in S_j} y_{ij} = 1, \forall j \in A$$

$$Objectivefunction: \max\{\sum_{l=1}^{2} (\frac{Q_l^{\max} - Q_{i,l}}{Q_l^{\max} - Q_l^{\min}} * W_l) + \sum_{l=3}^{5} (\frac{Q_{i,l} - Q_l^{\min}}{Q_l^{\max} - Q_l^{\min}} * W_l)\}$$

$$Constra\,\text{int}\, s:$$

$$Q_{price} = \sum_{j \in All} \sum_{i \in S_j} \cos t_{ij} * y_{ij} \le Budget$$

$$Q_{duration} = \sum_{j \in critical\_path} \sum_{i \in S_j} duration_{ij} * y_{ij} \le Time\_\lim it$$

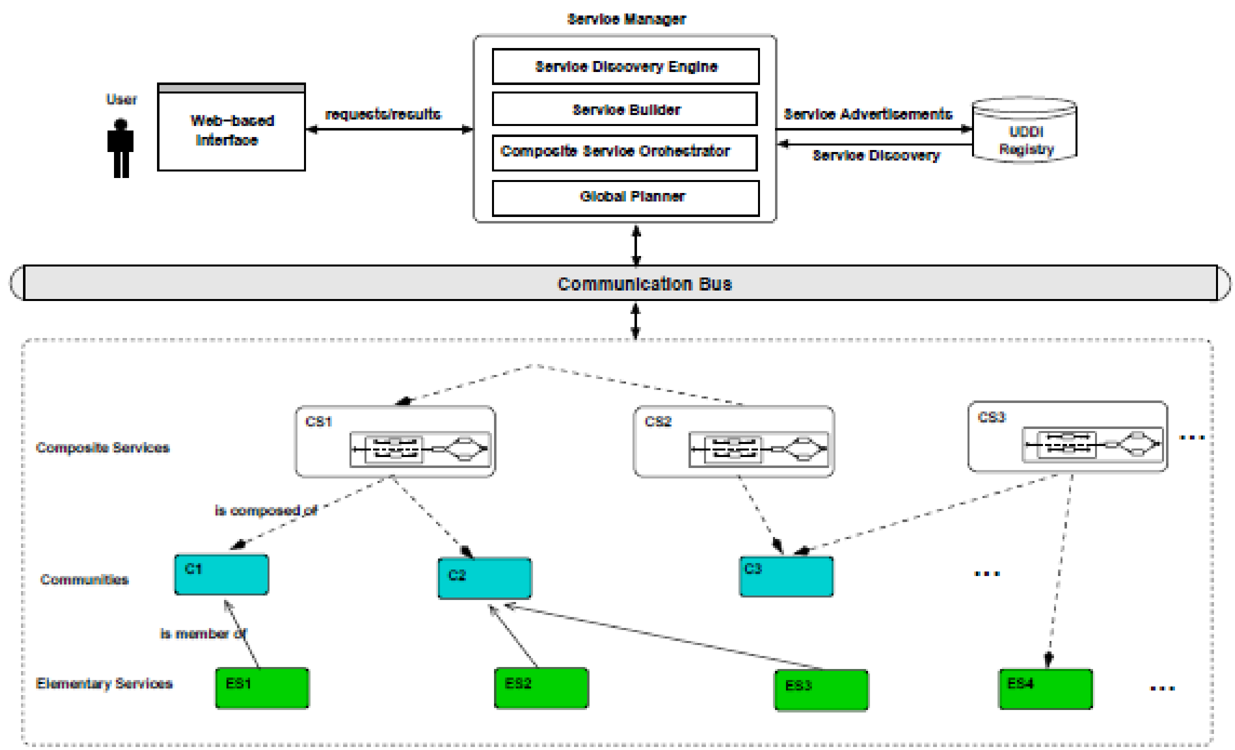
$$Q_{reputation} = \frac{\sum_{j \in All} \sum_{i \in S_j} reputation_{ij} * y_{ij}}{N} \ge reputation\_\exp ect$$

$$Q_{reliability} = \prod_{j \in critical\_path} \sum_{i \in S_j} e^{reliability_{ij} * y_{ij}} \ge reliability\_\exp ect$$

$$Q_{availability} = \prod_{j \in critical\_path} \sum_{i \in S_j} e^{availability_{ij} * y_{ij}} \ge availability\_\exp ect$$

Experimental Implementation

- SELF-SERV:
  - Service manager:
    - Service discovery engine:WSTK2.4
    - Global planner: OSL

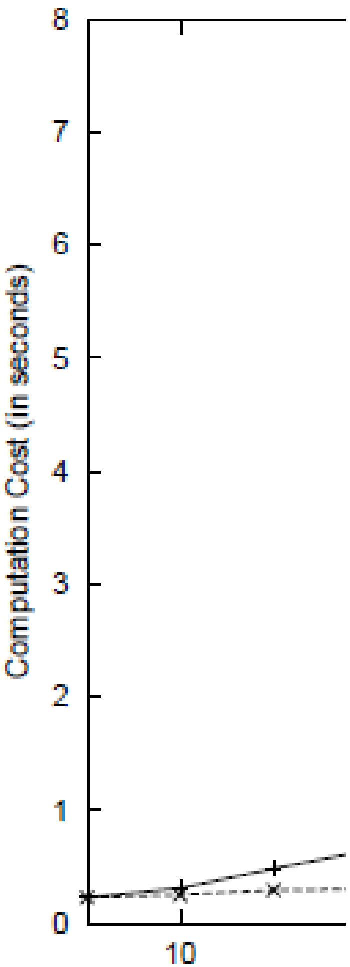


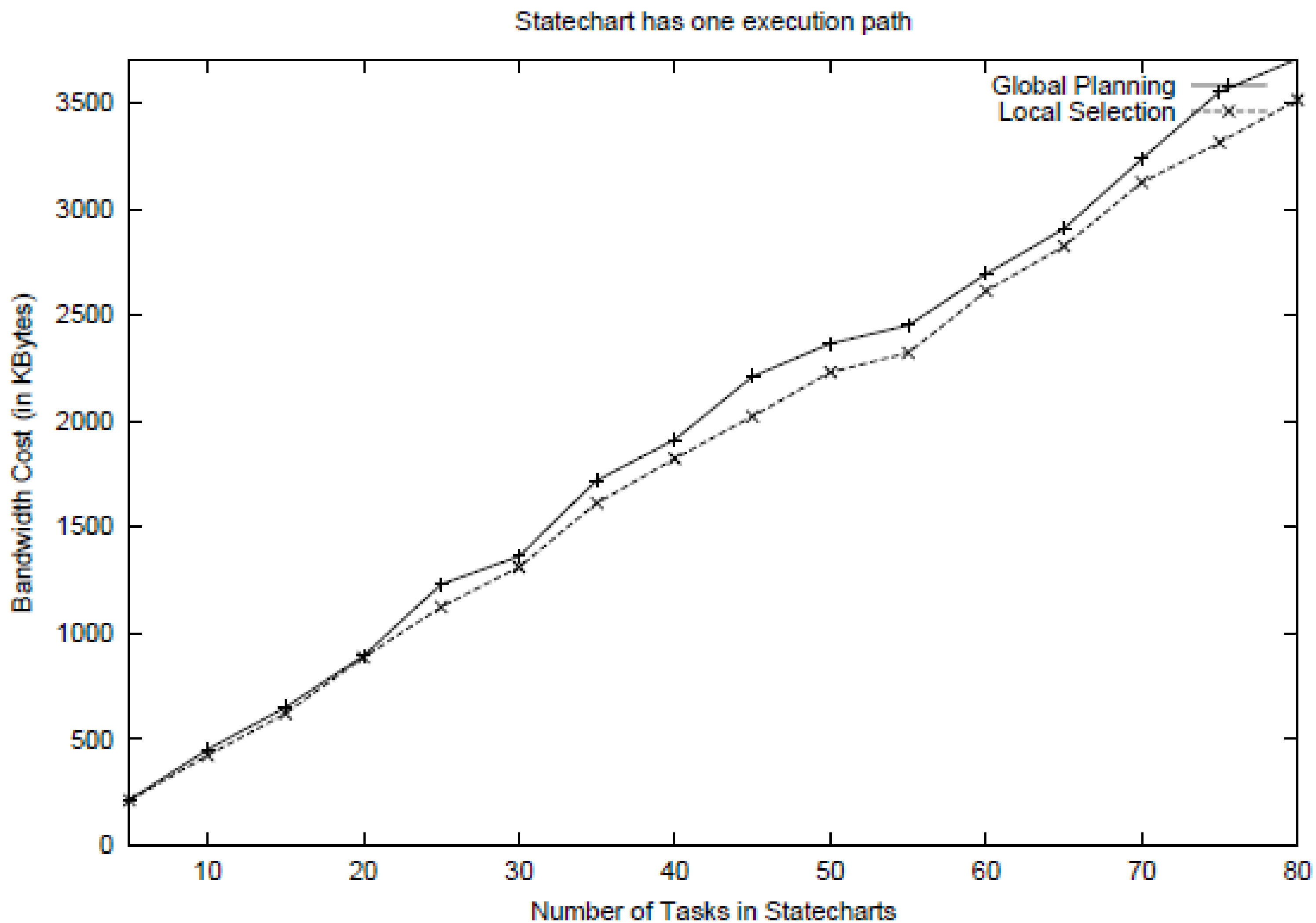
QoS

Instance No	$Q_{time}(W)$ (second)		$Q_{price}(W)$ (dollar)	
	Global	Local	Global	Local
1	6523.2	8322.4	1023	1642
2	6634.4	9123.9	1117	1728
3	6843.2	9234.5	1123	1825
4	6432.5	9292.2	1132	1824
5	6347.3	8943.3	1121	1723
6	6512.3	9902.8	1185	1888
7	6451.2	9480.4	1231	1789
8	6440.5	9470.5	1275	1787
9	6970.4	9920.4	1324	1625
10	6890.3	9628.3	1235	1759
11	6590.3	9520.3	1267	1852
12	6890.3	8920.5	1250	1599
Average:	6627.2	9305.9	1191	1753

System costs

- Computation&bandwidth





problems

- Execution duration: transmission time varies with network factors
- Reliability: how can I get the composite service's reliability? What is the meaning of critical path for reliability?
- Constraints on Uncertainty of Execution Duration: why deviation?