Trust in Multiagent Systems

Pınar Yolum
p.yolum@uu.nl

Utrecht University

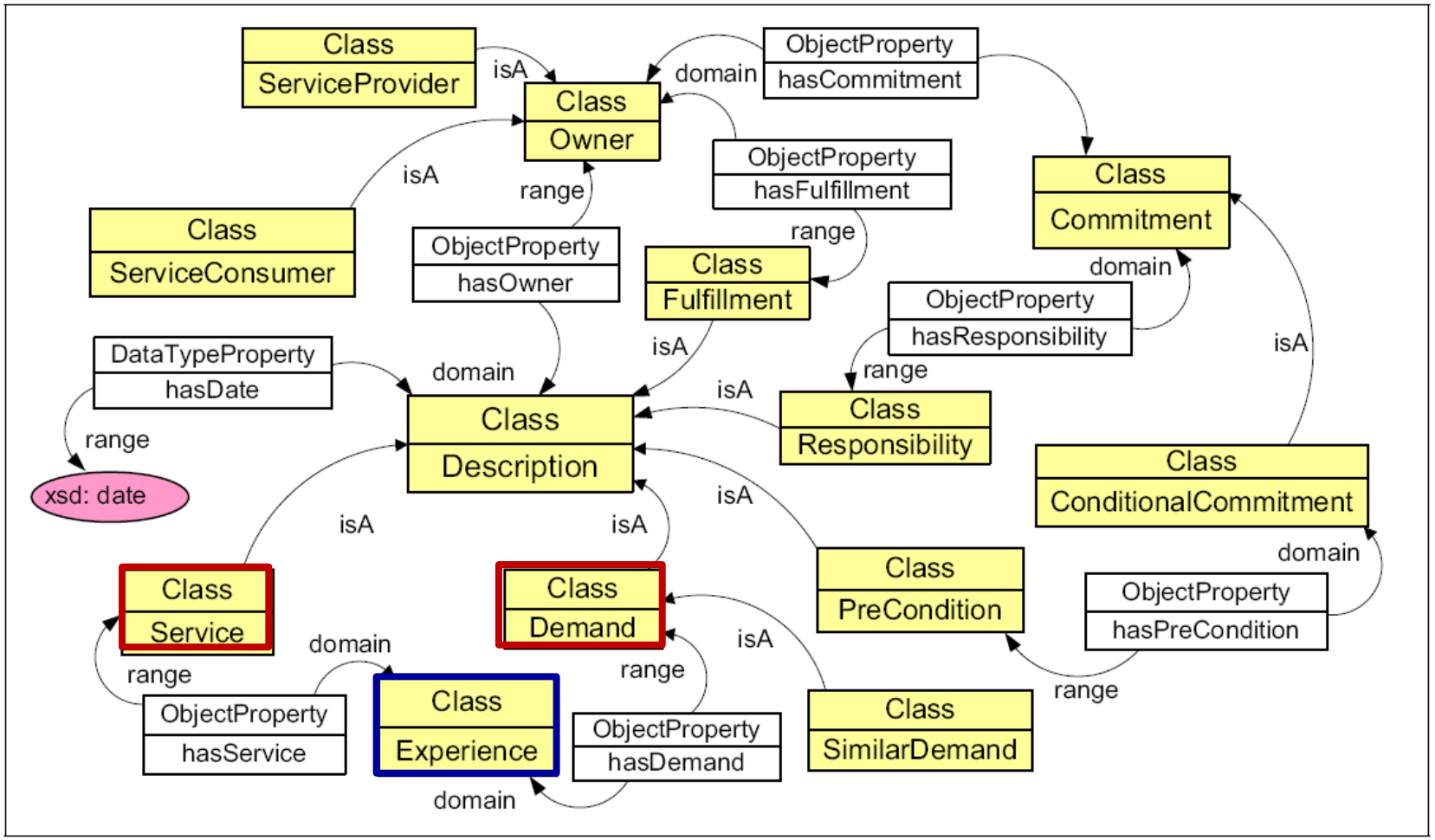
Ontology-Based Service Representation

Alternative: Replace Ratings with Experiences, which are the semantic descriptions of consumers' past dealings with the providers (Sensoy and Yolum, TKDE 2007).

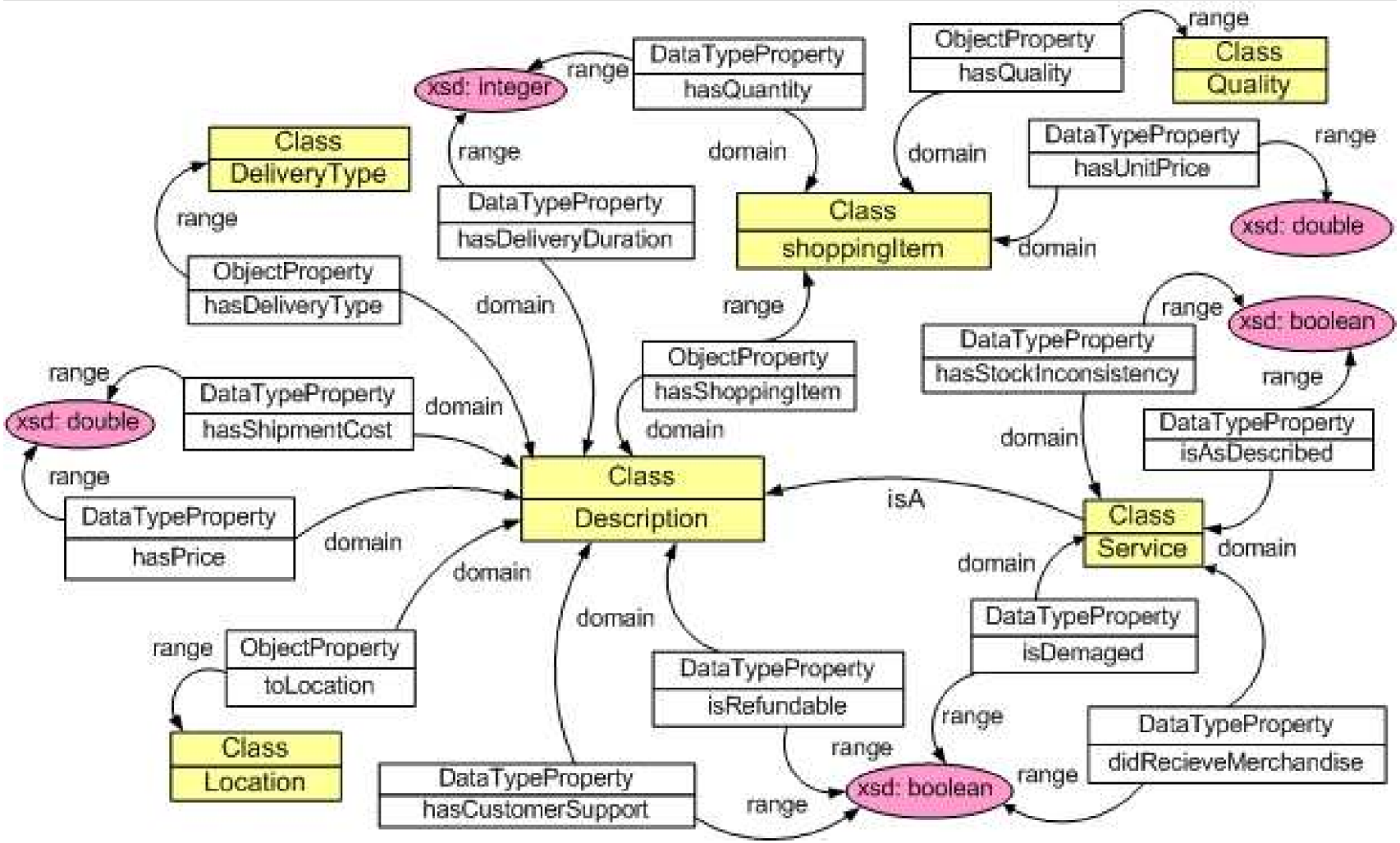
An Experience is …

- A combination of what a consumer requests from a service provider and what the consumer receives at the end.
- Expresses the story between the consumer and the provider regarding a specific service demand.
- Used to evaluate service providers according to consumers' own criteria.

Base-Level Ontology



Domain-Level Ontology



Example

Alice states that she ordered an **IBM ThinkPad T60** notebook from a seller named ***TechnoShop*** *on* ***15 October 2007****. She requested* the merchandise to be delivered to **New York within 14 days**.

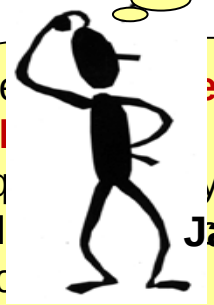
```
    <owlx:Individual owlx:name="servic
  </owlx:ObjectPropertyValue>
</owlx:Individual>

<owlx:Individual owlx:name="demandInstance">
  <owlx:type owlx:name="Demand" />
  <owlx:ObjectPropertyValue owlx:property="hasOwner">
    <owlx:Individual owlx:name="MuratSensoy" />
  </owlx:ObjectPropertyValue>
  <owlx:DataPropertyValue owlx:property="hasDate">
    <owlx:DataValue owlx:datatype="&xsd;Date">2007-10-15</owlx:DataValue>
  </owlx:DataPropertyValue>
  <owlx:ObjectPropertyValue owlx:property="hasShoppingItem">
    <owlx:Individual owlx:name="#IBM_ThinkPad_T60" />
  </owlx:ObjectPropertyValue>
  <owlx:ObjectPropertyValue owlx:property="toLocation">
    <owlx:Individual owlx:name="New
  </owlx:ObjectPropertyVa
  <owlx:DataPropertyValue
    <owlx:DataValue o                    Value>
  </owlx:DataProperty
</owlx:Individual>
```

```
<owlx:Individual owlx:name="serviceInstance">
  <owlx:type owlx:name="Service" />
  <owlx:ObjectPropertyValue owlx:property="hasOwner">
    <owlx:Individual owlx:name="TechnoShop" />
  </owlx:ObjectPropertyValue>
  <owlx:ObjectPropertyValue owlx:property="hasShoppingItem">
    <owlx:Individual owlx:name="#IBM_ThinkPad_T60" />
  </owlx:ObjectPropertyValue>
  <owlx:DataPropertyValue owlx:property="hasDeliveryDuration">
    <owlx:DataValue owlx:datatype="&xsd;Integer">7</owlx:DataValue>
  </owlx:DataPropertyValue>
  <owlx:DataPropertyValue owlx:property="recivedMerchandise">
    <owlx:DataValue owlx:datatype="&xsd;boolean">true</owlx:DataValue>
  </owlx:DataPropertyValue>
  <owlx:DataPropertyValue owlx:property="isRefundable">
    <owlx:DataValue owlx:datatype="&xsd;boolean">false</owlx:DataValue>
  </owlx:DataPropertyValue>
  <owlx:DataPropertyValue owlx:property="h
    <owlx:DataValue owlx:datatype="
  </owlx:DataPropertyValue>
  <owlx:DataPropertyValue o
    <owlx:DataValue owlx:da
  </owlx:DataPropertyVal
  <owlx:DataPropertyVal
    <owlx:DataValue owl
  </owlx:DataPropertyVal
</owlx:Individual>
```

I would give a positive rating

For me, customer support is crucial. I would give a negative rating.



Jack

The **received $700** for the product and the **del** merchandise **within 7 days without** req **extra money for shipping**. But, the del duct was **not refundable**, and Tec did **not** provide any **customer support**.

Ontologies enable consumers to evaluate the experience according to their own satisfaction criteria.

Jennifer

Exchanging Experiences (1)

Service Consumers need others' experiences to decide.

CHALLENGE:

Many people are on the social network. Whom to trust for that particular service need?

PROPOSED SOLUTION:

Model others' expertise. When looking for a dentist, you might want to get referrals from a doctor (rather than your high school friend).

Exchanging Experiences (2)

Service Consumers collect experiences related to *semantically similar service demands*. Then, they use these experiences for the service selection.

CHALLENGE:

Similarity is a subjective concept and may differ for each consumer.

PROPOSED SOLUTION:

Model others' familiarity. Allow consumers to express their description of similar demand using *SimilarDemand* concept and *Semantic Web Rule Language* (SWRL).

A demand is a *Similar Demand* only if the demand is related to buying a notebook and

```
<ruleml:imp>
 <ruleml:_head>
    <swrlx:classAtom>
      <owlx:Class owlx:name="#SimilarDemand"/><ruleml:var> DEMAND </ruleml:var>
    </swrlx:classAtom>
 </ruleml:_head>
 <ruleml:_body>
    <swrlx:DataPropertyValue swrlx:property="#hasDeliveryDuration">
    <ruleml:var>DEMAND</ruleml:var><ruleml:var>DURATION </ruleml:var>
    </swrlx:DataPropertyValue>
      <swrlx:individualPropertyAtom  swrlx:property="#hasShoppingItem">
      <ruleml:var>DEMAND</ruleml:var><owlx:Individual owlx:name="#Notebook"/>
    </swrlx:individualPropertyAtom>
    <swrlx:predicateAtom swrlx:predicate="..#ifTrue">
      <owlx:DataValue owlx:datatype="..#string">$1 <= 14 </owlx:DataValue>
      <ruleml:var>DURATION</ruleml:var>
    </swrlx:predicateAtom>
 </ruleml:_body>
</ruleml:imp>
```

requires a delivery duration less than or equal to 14 days.

Decision Making

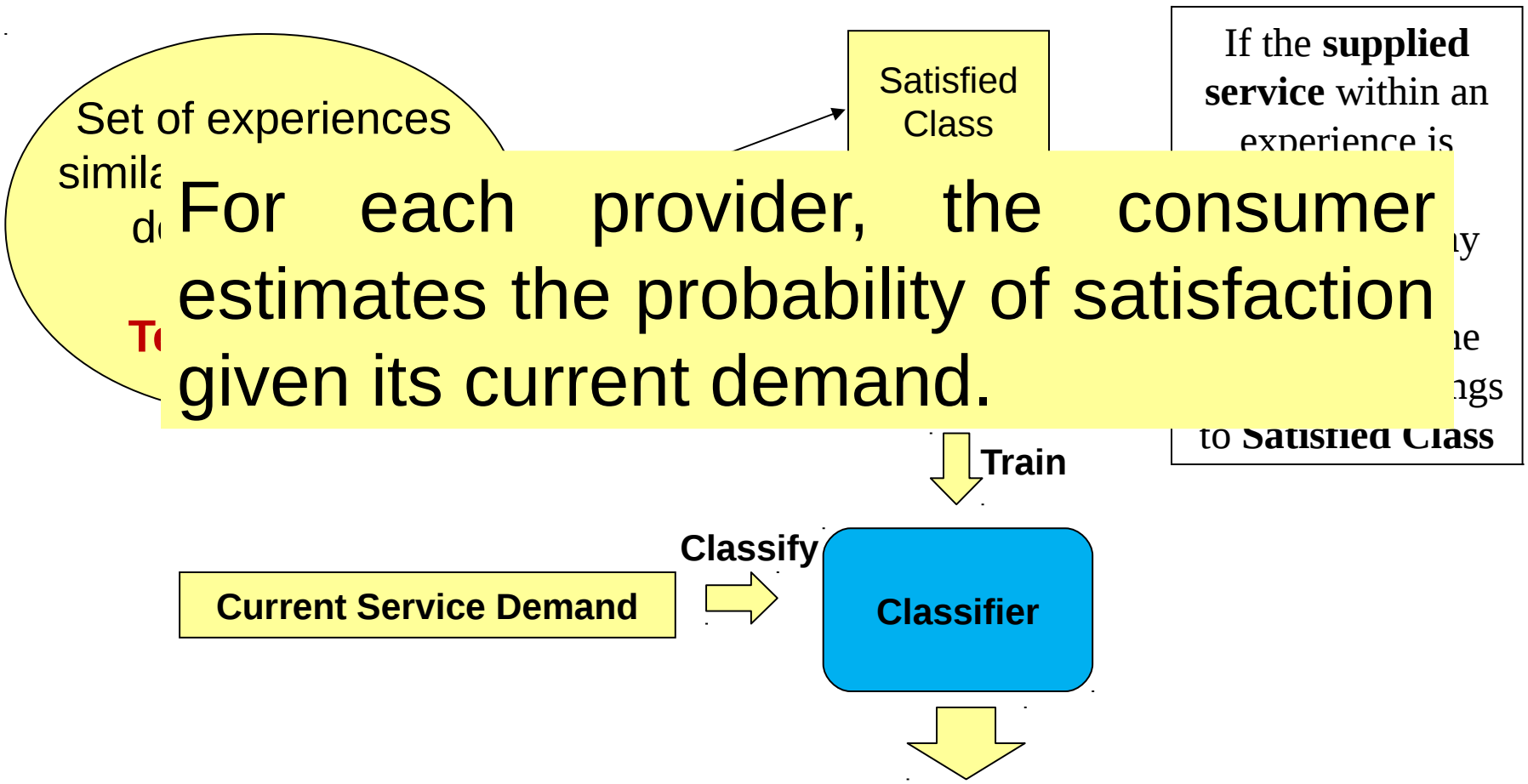
Each experience can be interpreted by an agent. Hence, a satisfaction level is assigned to each experience using the agent's personal satisfaction criteria.

Decision making using:

1. Classification Methods (e.g., Parametric classification with Multivariate Gaussian Model)
2. Case-Based Reasoning

...

Classification Problem (SPSGM)



Select the provider with the highest satisfaction probability

Case-Based Reasoning

The assumption behind CBR approaches is that if two problems look similar, the solutions to these problems will probably be similar too.

Each experience is given a score, depending on:

- **Recency:** The newer experiences, higher the recency
- **Similarity:** Context similarity to the current demand
- **Satisfaction:** How satisfied the current consumer would be, had it lived the examined experience.

Score for Experience i

$$S_i = recency_i \times sim_i \times sat_i$$

Recency factor

Similarity factor

Satisfaction factor

Then, the consumer picks the experience with the highest score and selects the provider supplying the service within this experience.

Evalutaion

- The simulator is implemented in **Java** and **KAON2** is used as OWL-DL reasoner.
- **10** Service **Providers** and **200** Service **Consumers** are simulated.
- **At least one service provider satisfies a service demand. The providers give services in different contexts with varying properties.**
- In the simulations, performance is measured in terms of the ratio of service decisions resulted in satisfaction.

Evalutaion

- The simulator is implemented in **Java** and **KAON2** is used as OWL-DL reasoner.
- **10** Service **Providers** and **200** Service **Consumers** are simulated.
- **At least one service provider satisfies a service demand. The providers give services in different contexts with varying properties.**
- In the simulations, performance is measured in terms of the ratio of service decisions resulted in satisfaction.

Four Approaches Compared

- **Experiences with Gaussian Model (SPS_{GM})**
- **Experiences with CBR (SPS_{CBR})**
- **Ratings from randomly chosen consumers (SPS_{RR})**
- **Selective ratings (SPS_{SR}):** Ratings are taken from those agents who have similar demands with respect to similarity criteria of the agent.

Simulation Factors

Variations in service demand (P_{CD}):

- ✓ Probability of each consumer to change the context of its service demand.
- ✓ Corresponds to variation in context.

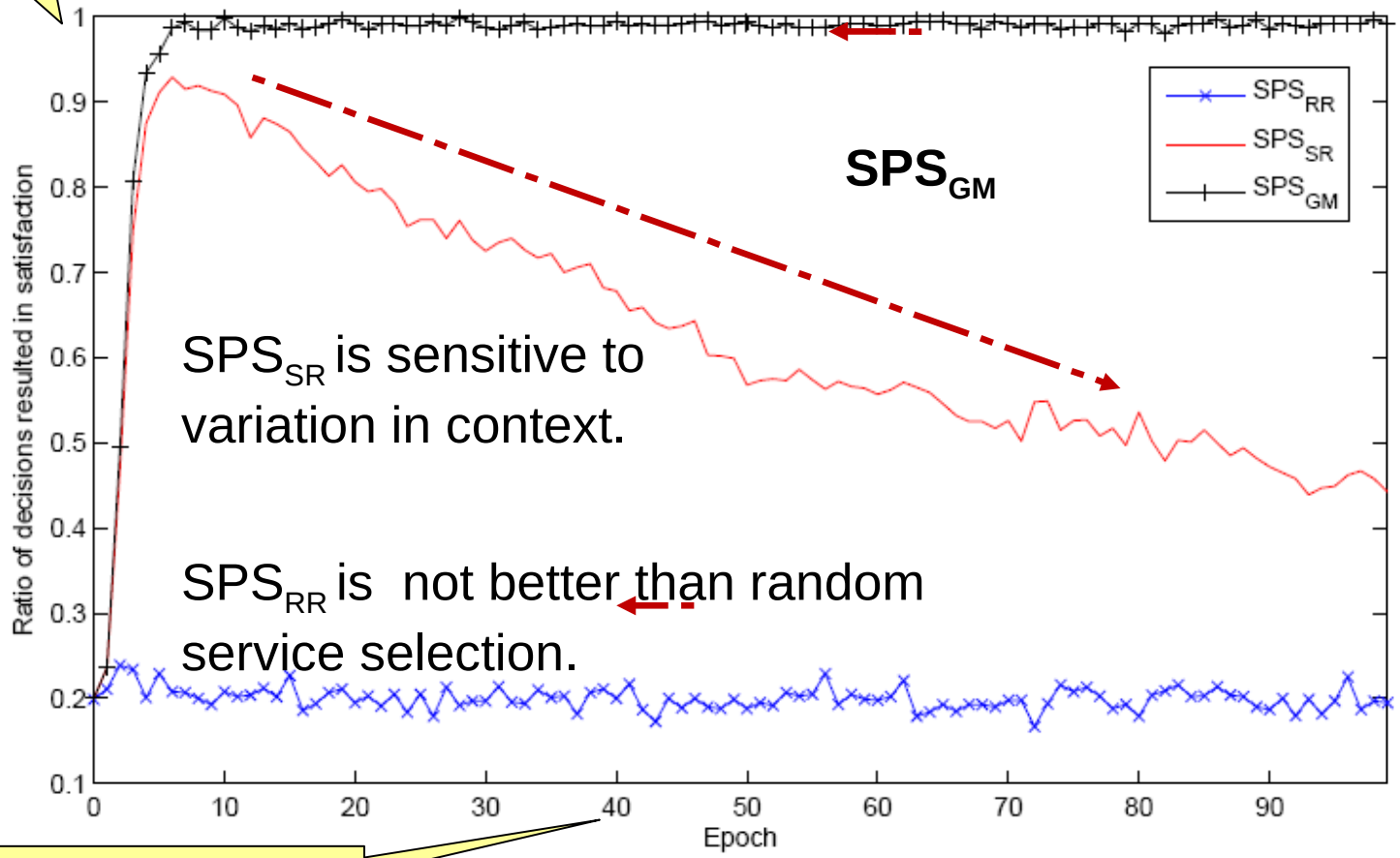
Variations in service satisfaction (R_{subj}):

- ✓ The ratio of consumers who have similar service demands but conflicting satisfaction criteria.
- ✓ Represents the subjectivity in the environment.

Variation in context

Consumers vary the context of their service demands over time but satisfaction criteria of consumers are the same for similar contexts **(R_{subj}=0)**.

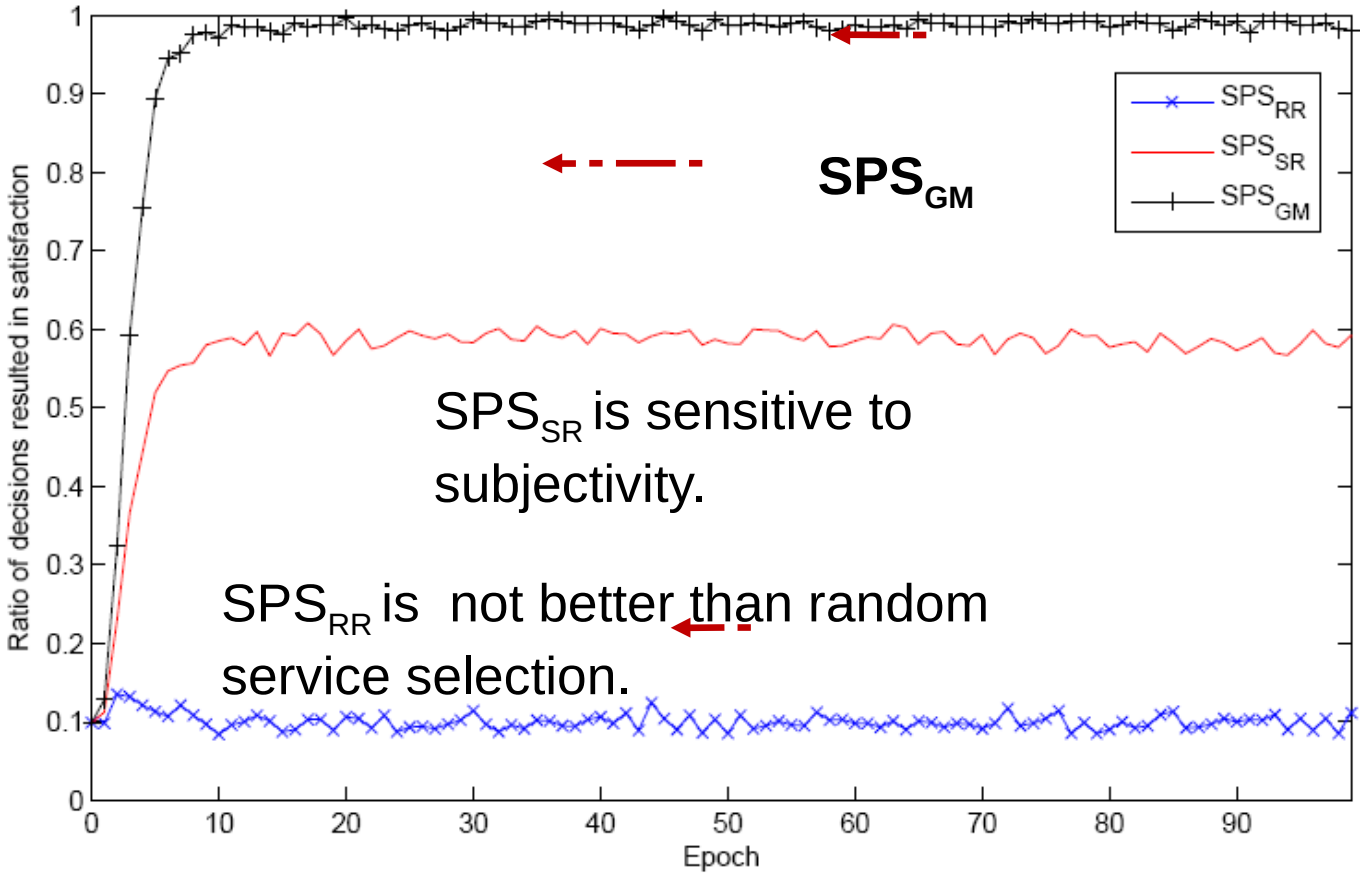
Y-axis: Ratio of satisfaction.



X-axis: Discrete time.

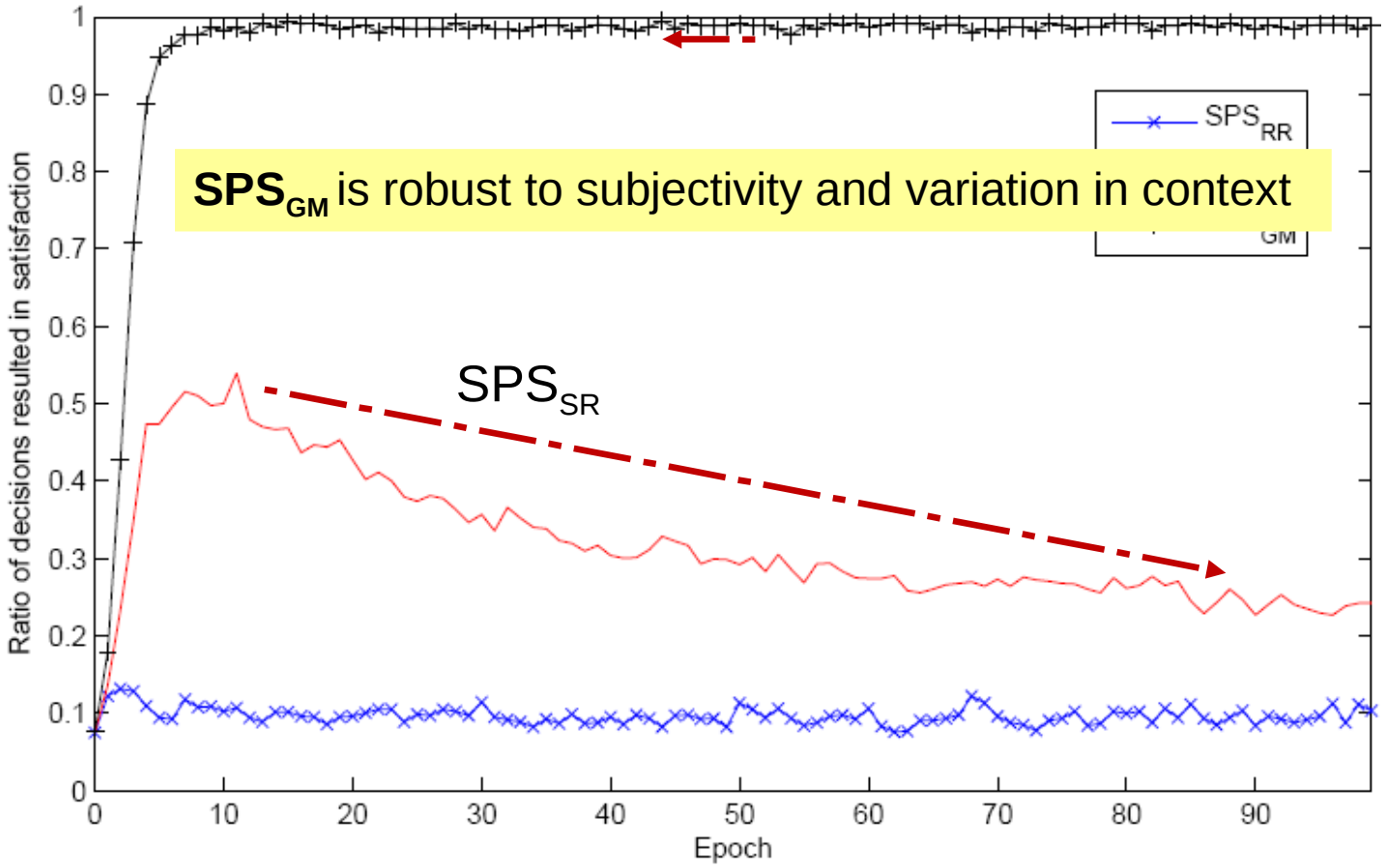
Subjectivity

Consumers do not vary the context of their service demands over time **(P_{CD}=0.0)**, but half of the consumes having similar demands have conflicting satisfaction criteria **(R_{subj}=0.5)**.



Context and subjectivity

Consumers vary the context of their service demands over time **(P_{CD}=0.2)**, and half of the consumes having similar demands have conflicting satisfaction criteria **(R_{subj}=0.5)**.



Results

Performances of SPS_{GM} and SPS_{CBR} are the same in terms of the success in service selection.

SPS_{CBR} is around 7 times faster than SPS_{GM} on the average.

SPS_{CBR} can replace SPS_{GM}.

We assume that providers consistently produce similar services in the similar contexts. This assumption supports SPS_{CBR}.

Service Selection Performance

P_{CD}	SPS_{GM}		SPS_{CBR}	
	$R_{subj} = 0$	$R_{subj} = 0.5$	$R_{subj} = 0$	$R_{subj} = 0.5$
0.0	0.96	0.96	0.96	0.96
0.1	0.97	0.96	0.97	0.96
0.2	0.97	0.96	0.97	0.96
0.4	0.97	0.96	0.97	0.96
0.6	0.97	0.96	0.97	0.96
0.8	0.97	0.98	0.97	0.98
1.0	0.97	0.97	0.97	0.97

Time Performance (in ms.)

P_{CD}	SPS_{GM}		SPS_{CBR}	
	$R_{subj} = 0$	$R_{subj} = 0.5$	$R_{subj} = 0$	$R_{subj} = 0.5$
0.0	1250	1081	448	270
0.1	3016	2879	680	651
0.2	5376	4292	982	674
0.4	7015	7976	1078	1287
0.6	10154	8163	1586	680
0.8	14983	21610	2555	3360
1.0	20377	17711	2583	1272

Variations in service quality

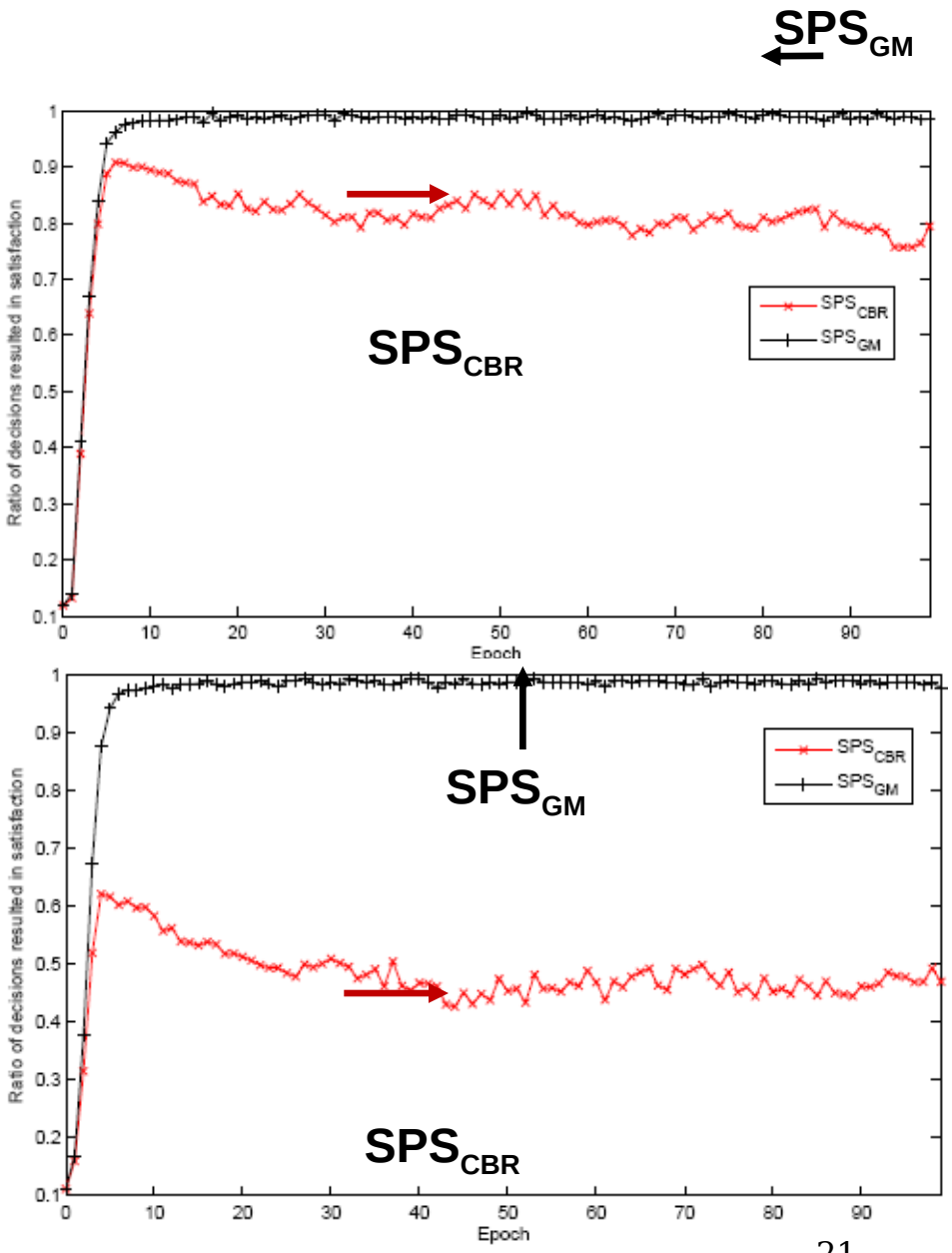
Variations in service quality: Enable providers to deviate from their expected behavior in the favor of consumers with a small probability: probability of indeterminism (*PI*).

Results

Performance of SPS_{CBR} decreases when ***PI* = 0.001**.

Performance of SPS_{CBR} decreases further, when ***PI* = 0.01**.

Performance of SPS_{GM} does not decrease with these values of ***PI***.



Observations

- Rating-based approaches are sensitive to context-change and subjectivity.

- Using ontology-based experiences, service selection can be made successfully even in subjective environments where consumers change the context of their service demands.

- Unlike rating-based approaches, experience-based approaches are context-aware and can successfully handle subjectivity.

Observations

- Most approaches attempt to find the most trustworthy
  - Cost and constraints of the SP are not taken into account

- General assumption is that there are previous data on service providers
  - Some services are needed rarely, thus few interactions with SPs.
  - One approach is to formalize stereotype (Burnett *et al.,* 2011)
  - Ex: Tall people play basketball better
  - Learn rules from visible features
  - Classify new service providers using the rules