SEMANTIC MODELING, TRANSLATION AND MATCHING OF QOS

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Outline

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- QoS and Semantic Modelling
- OWL-QoS
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- QoS with OpenCyc
  - Matchmaking and Translation

Motivation

- Variety of access and transport technologies available in modern computer networks
  - Technologies: WiFi, UMTS, WiMax, …
  - Pricing: pay-as-you-go, flat rate, …
- Application has specific requirements towards the network
  - Video streaming – consistent traffic
  - Push e-mail – low traffic, persistent connection with burst
  - Web browsing – bursts of high traffic
- Selecting appropriate offers based on application requirements becomes challenging with increase in available offers
  - Offer – a combination of technology, guaranteed services and pricing

Quality of Service (QoS)

- Quality:
  - totality of characteristics of an entity that bear on its **ability to satisfy stated and implied needs**".
- Service:
  - type of product […] always the result of an activity or **interaction** between a **service supplier** and a **customer** and can take many forms

Quality management systems – Fundamentals and vocabulary, ISO 9000:2000

Semantic modeling

- Domain abstraction
  - Describing important concepts and relations
- Standard languages for semantic modeling
  - Ontologies
  - Computer readable
- Enable automatic reasoning about domains
- Semantic model of a domain populated with concrete instances is called **knowledge base**

Semantic Modeling of QoS

- Applications and services can have many different and unique requirements towards the transportation services (**TS**s) they use to interconnect.
- Traditionally, applications are required to specify their QoS requirements in a language which the TSs understand. This results in reformulation of intuitive parameters (i.e. desired video resolution) to parameters understood by the TSs (i.e. required bandwidth).
- To this end semantic technologies are used for ontological modeling, translation and matchmaking.

OWL-QoS Ontology Overview

- Developed for the purpose of finding matches between offers from the TS providers, called adverts, and the consumer requests (called request).

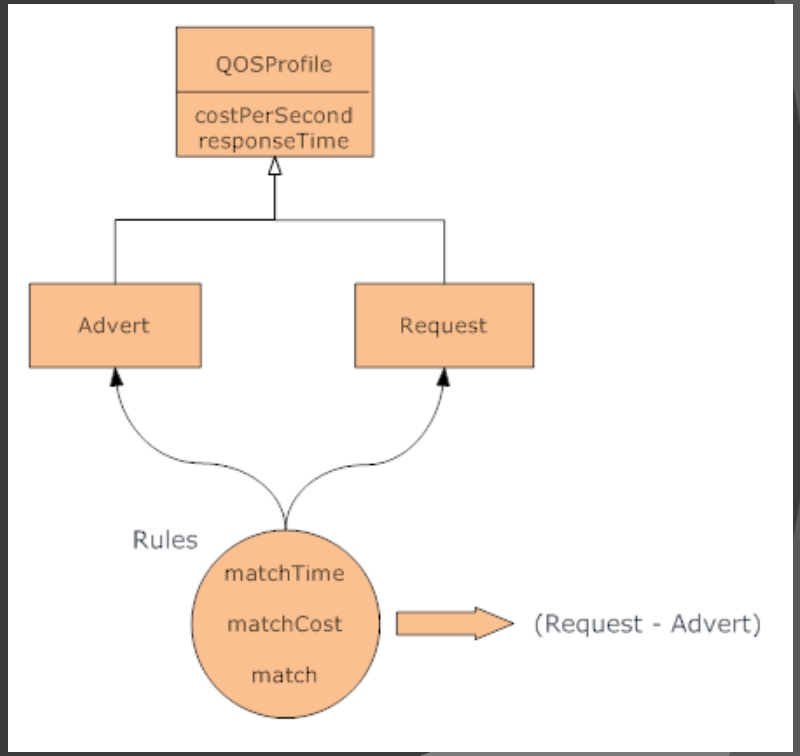
- Three layer representation
  - QoS Profile Layer – used for the matchmaking purpose
  - QoS Property Definition Layer – specifies the domain and range constraints of properties
  - QoS Metrics Layer – contains metrics definition and measurement

OWL-QoS Ontology Overview

- Description of QoS domain
  - Constraints
  - Requirements

Matchmaking

- A match is a pair (*request, advert*) where the objectives requested by the *request* are satisfied by the *advert*
- Both advert and request are QoS profiles
- They are characterized by a response time and cost



Matchmaking Example

	Request1	Request2	Advert1	Advert2
Response time (ms)	500	1000	500	800
Cost per second($)	0.10	0.05	0.07	0.04

- An advert is a match for a request if the cost for the service provided by the advert is lower than the price the requester can pay and the response time advertised is also lower than the one requested.

	Advert1	Advert2
Request1	match	match cost
Request2	match time	match

Matchmaking Using Cyc

- Application requires service from network
  - specifies requirements
- Knowledge base with:
  - semantic description of available services
  - rules specifying for each description parameter what is a “match”

```
(implies
    (and
      (isa ?X QoSRequest)
      (responseTime ?X (MillisecondsDuration ?T1))
      (isa ?Y QoSAdvert)
      (responseTime ?Y (MillisecondsDuration ?T2))
      (or(equals ?T1 ?T2) (lessThan ?T2 ?T1)))
    (matchTime ?X ?Y))

(implies
    (and
      (costPerSecond ?X (USDollarFn ?C1))
      (costPerSecond ?Y (USDollarFn ?C2))
      (or(equals ?C1 ?C2) (lessThan ?C2 ?C1)))
    (matchCost ?X ?Y))
```

Translation

- Automatic translation from *“application requirements”* into *“QoS requirements”*

	QoSList1	QoSList2
Video Codec	MPEG4	
Video Resolution	320 x 320	
Video Format		QVGA
Color Depth (bits)	8	8
Frame Rate (fps)	20	20
Inferred Data Rate (bit/sec)	**12288000**	**12288000**

Translation

- QList is a support for specifying the requirements of one application
- We created a similar structure in OpenCyc, for the translation of application requirements to network requirements.
- Combining the translation with the matchmaking results in a system where application requests, expressed in a language intuitive for their domain (i.e. video streaming) can be automatically matched to the appropriated TS according to their QoS specifications.

Translation Using Cyc

- Can use same approach as for matchmaking:
  - Add semantic model of application requirements to the knowledge base
  - Specify conversion rules for parameters

```
(implies
   (and
      (hasVideoFormat ?Q ?VF)
      (hasFrameRate ?Q ?FR)
      (hasColorDepth ?Q ?CD)
      (formatHasResolution ?VF ?R)
      (frameWidth ?R (Pixel-UnitOfCount ?W))
      (frameHeight ?R (Pixel-UnitOfCount ?H))
      (evaluate ?BS (TimesFn ?W ?H ?FR ?CD)))
   (computeDR ?Q ?BS))
```

Language issues

- multiple users => different languages
- frame size = video resolution
  delay = latency
- For a machine, the equivalence must be explicitly specified. This may cause some issues in the translation phase.

Conclusions

- Demonstrated a vertical QoS mapping prototype.
  - Vertical = application requirements to network requirements
  - In the future we plan to extend this to cover a heterogeneous scenario
- Semantic technologies seem suitable for QoS modeling.
  - Used tools already shown to work with large scale
  - Larger taxonomies and more complex experiments are required to assess the full potential of this approach.