Matchmaking Portal for the Discovery of Numerical and Symbolic Services

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Presentation Outline

- Motivation
- Description of Mathematical Services
- Matchmaking Architecture
- Implementation
- Demonstration
- Conclusion

Motivation

- Mathematical services are needed in many application scenarios such as Grid applications, BioInformatics applications, Data mining etc.
- Matchmaking portal developed focuses on the provision, discovery and use of mathematical services
- It is assumed that in future there will be a service-rich environment with mathematical libraries available

Mathematical Service Description

- OpenMath is a markup language for representing the semantics of mathematical objects
- Example definitions are:
  - OMA (OpenMath Application)
  - OMI (OpenMath Integer)
  - OMS (OpenMath Symbol)
  - OMV (OpenMath Variable)

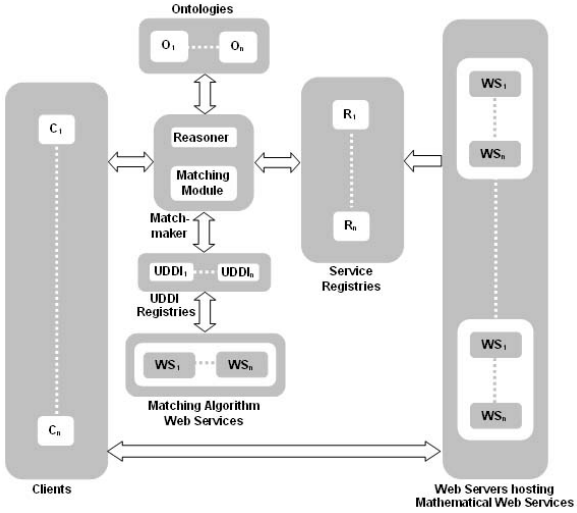
Example: $x^2 - y^2$

```
<om:OMOBJ>
  <om:OMA>
  <om:OMS cd="arith1" name="minus"/>
    <om:OMA>
      <om:OMS cd="arith1" name="power"/>
      <om:OMV name="x"/>
      <om:OMI>2</om:OMI>
    </om:OMA>
    <om:OMA>
      <om:OMS cd="arith1" name="power"/>
      <om:OMV name="y"/>
      <om:OMI>2</om:OMI>
    </om:OMA>
  </om:OMA>
</om:OMOBJ>
```

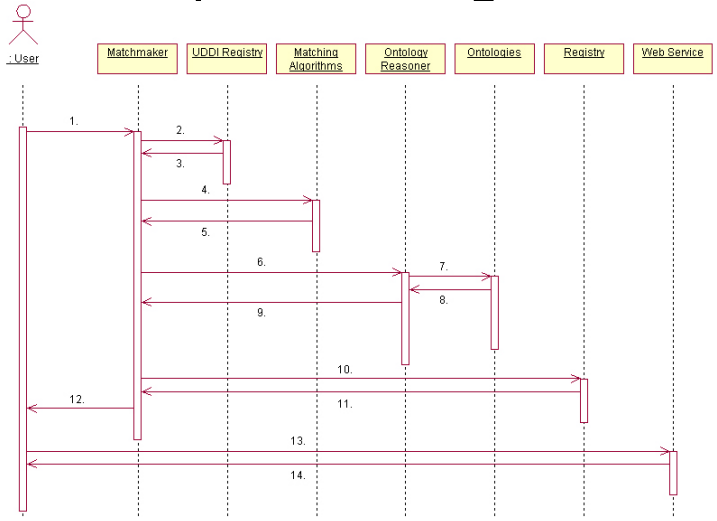

Matchmaking Requirements

- Plug-in architecture should support an arbitrary number of matchers
- A ranking mechanism is required to take into account technical (pre- and post-conditions) and quantitative and qualitative aspects (multiple matching services)

Matchmaking Architecture



Sequence Diagram



Matching Modes

- Structural match
  - compares OM symbols
- Syntax and ontological match
  - goes a step deeper ->compares also OMS
- Algebraic equivalence match
  - tests if two expressions are the same
- Value substitution
  - substitution method

Structural Match Mode

- The pre- and post-conditions are extracted and an SQL query is constructed to find the same Open-Math structure of the pre- or post-conditions of the service descriptions in the database

Syntax and Ontological Match Mode

- Performed similarly, however, Open-Math elements are compared with an ontology representing OpenMath elements
- Example of an user query:
  <om:OMS cd=’setname1’ name=’Z’/>

  and the service description contains the OpenMath element:
  <om:OMS cd=’setname1’ name=’P’/>

  The query finds the entities Z and P and determines the similarity value depending on the distance between the two entities (inclusive, on one side) which in this case is SV = 1 / n = 0.5, where n is the degree of separation of the concepts

Algebraic Equivalence Match Mode

- With this approach we try to show that the expression Q - S = 0 using algebraic means. There are many cases were this approach will work, however it has been proved (Richardson, 1968) that in general this problem is undecidable
- Another approach involves substitution of r determined from the condition r S into r Q, and subsequently proving their equivalence

Value Substitution Match Mode

- With this approach we try to show that Q - S = 0 by substituting random values for each variable in the expression, then evaluating and checking to see if the valuation we get is zero. This is evidence that Q- S = 0, but is not conclusive, since we may have been unlucky in the case that the random values coincide with a zero of the expression

Match Score

$$M_O = \frac{M_A + M_B}{2} \quad (1)$$

$$M_A = \frac{w_a}{|A_Q| + |A_S|} * \frac{|A_Q|}{|A_S|} * \frac{\sum_{i=1}^{|A|}(SV_A(i)))}{|A|} \quad \text{where } 0 \leq w_a \leq 1 \quad (2)$$

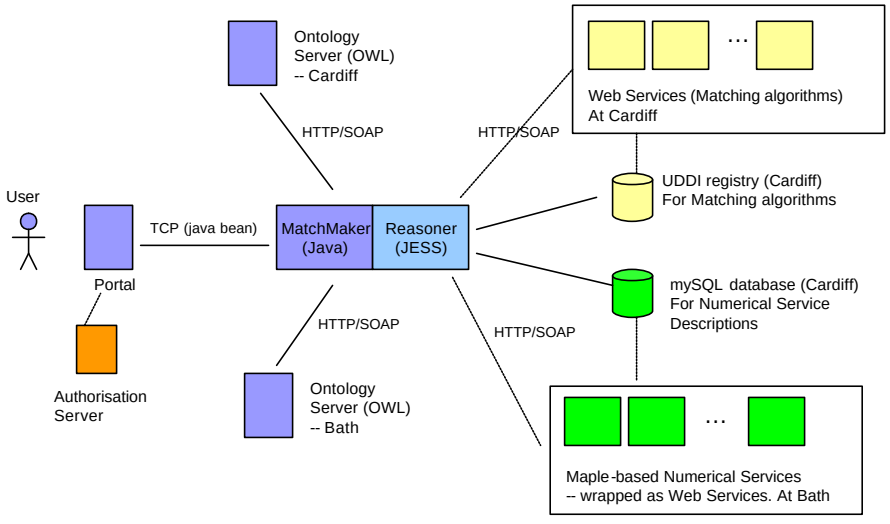
$$M_B = \frac{w_b}{|B_Q| + |B_S|} * \frac{|B_Q|}{|B_S|} * \frac{\sum_{j=1}^{|B|}(SV_B(j)))}{|B|} \quad \text{where } 0 \leq w_b \leq 1 \quad (3)$$

- M_O, M_A, M_B are the overall, pre-condition and post-condition match scores respectively
- $|\{c\}|$ denotes the number of conditions in {c}
- A_Q and A_S are pre-conditions, B_Q and B_S are post-conditions
- subscripts Q and S refer to the queries and services respectively
- A, B are a set of matched pre-conditions, post-conditions respectively
- $SV_A(i)$, $SV_B(j)$ are the similarity values for the i^{th} matched pre-condition and the j^{th} matched post-condition respectively

Implementation

- Client portal – web client using JSPs
- Matchmaking service – Web service using WSDL and SOAP
- Matchmaking algorithms – Web services registered in UDDI
- Service registry – MySQL database
- Ontology service – OWL ontology and JESS engine
- Mathematical services – "maple-wrapped" Web services

Physical Architecture



Differences to JSR 168 and WSRP Standard

- Development of prototype was outside any portal standards
  - No personalisation
  - No sign-on
  - No security
- Primary focus was on a proof of concept prototype
- However, sign-on and security issues must be considered in case of more commercial usage

Demonstration

- The Matchmaker's Website is accessible at: http://agentcities.cs.bath.ac.uk:8080/genss_axis/GENSSMatchmaker/index.htm
- Demo

Conclusions

- Extensible matchmaker architecture supporting plug-in matchers that may employ a variety of reasoning techniques
- Use of OM to describe mathematical services is suitable
- Although set of test cases are yet quite small -> results are promising
- Possible expansion – more mathematical reasoning matchers