Automating the Procurement of Web Services

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Road Map

The Problem
- Automating Web Service Procurement

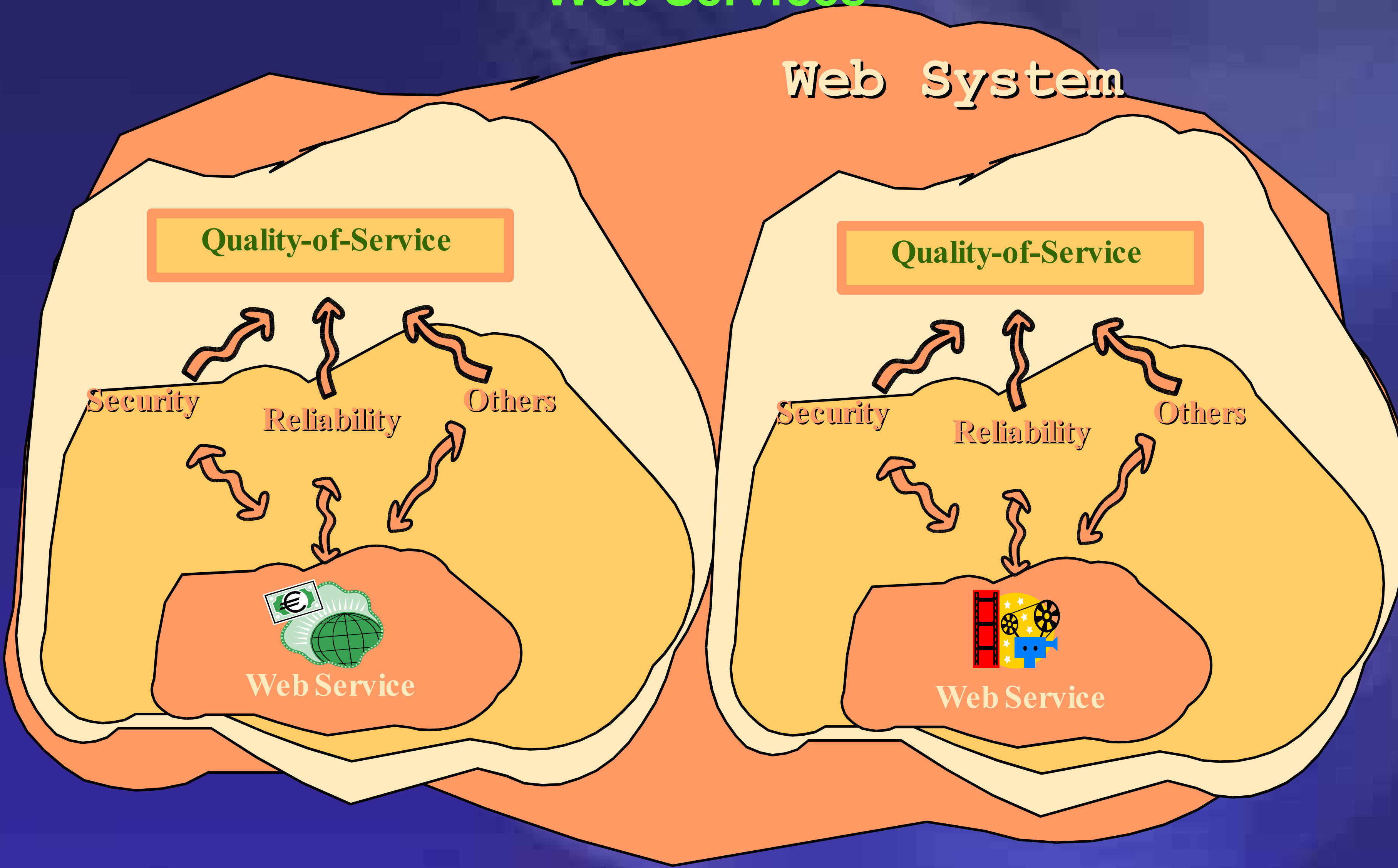
Approaches to the Problem
- State-of-the-Art

Our Solution
- Constraint Programming
- Implementation Aspects
- Experimental Results

Conclusions

The Problem

Web Services



The Problem

Multi-Organisational Web-based Systems

The Problem
Service Level Agreements

The Problem

Activities for an Automated WSP

- **Demands and Offers**
  - Quality-of-service specification
    - consistency checking
- **Matchmaking**
  - Search for available offers
    - conformance checking
  - Selection of best choice
    - utility specification and optimality
- **Service level agreement**

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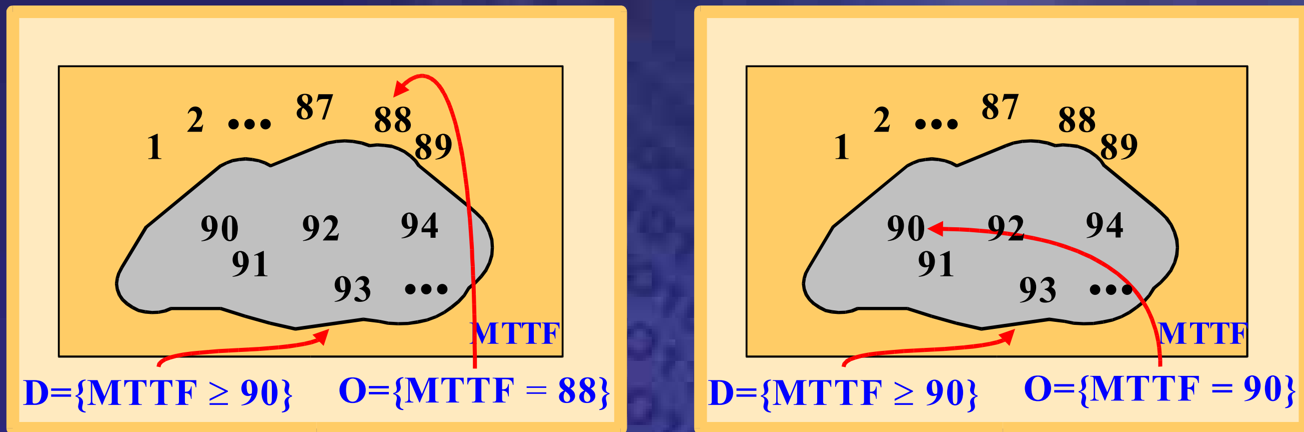
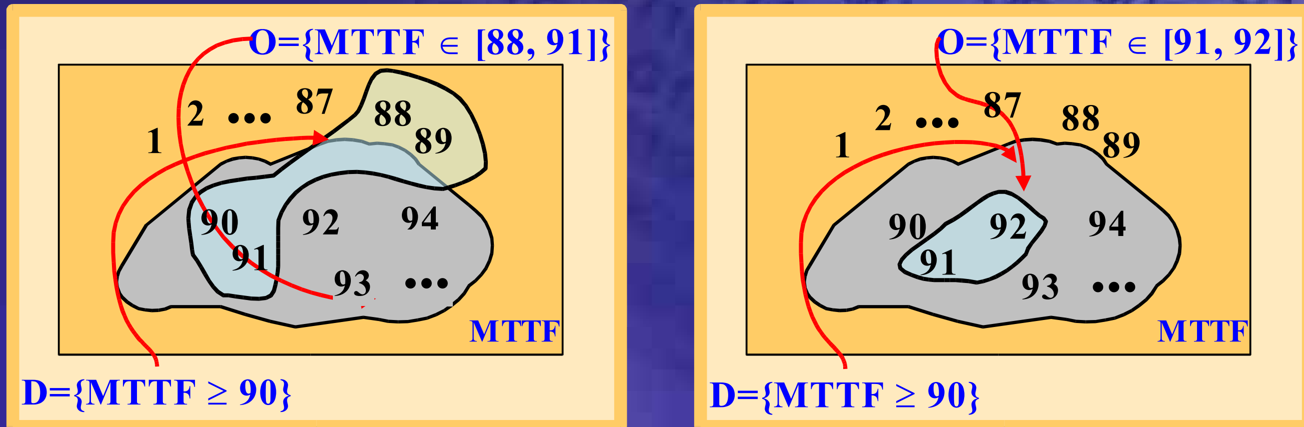
Approaches to the Problem

Conformance & Symmetry



Conformance in Asymmetric QoS Specification Models

Shaikhali's UDDIe and IBM's WSME



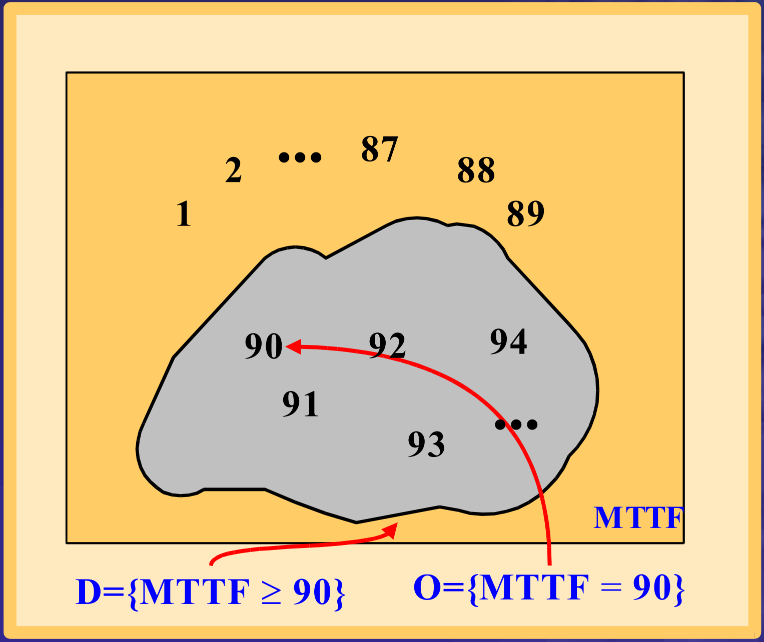
Conformance in Symmetric QoS Specification Models

HP's MME and QRL-based WSP

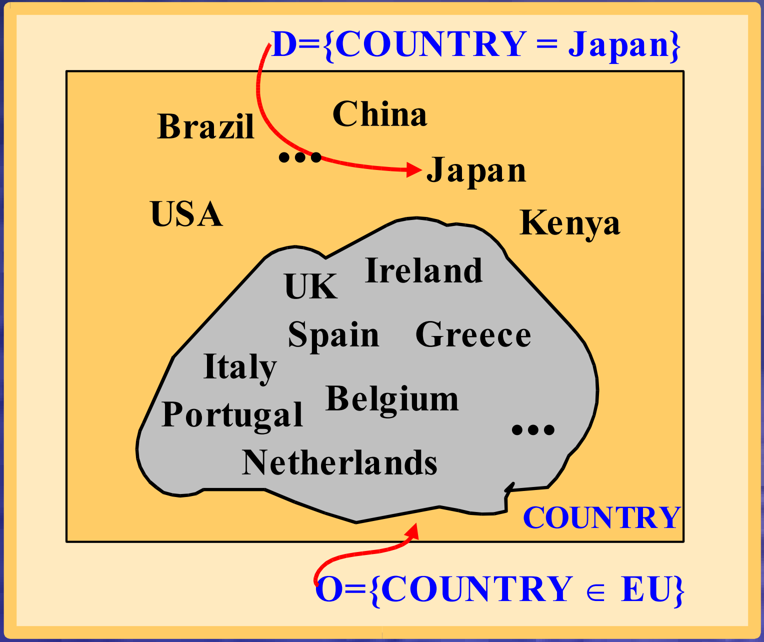
Approaches to the Problem

Conformance & Bilaterality

A demand requires something from an offer, but...



... an offer requires something else from a demand, too



Although this demand seems to be conformant to the offer, it is not because it does not fulfill the requirements imposed by the offer !

IBM's WSME and QRL-based WSP

Approaches to the Problem

Summary of State-of-the-Art

	Underlying Model	Symmetry QoS-Spec	Bilaterality Conformance	Optimisation
IBM's WSME Matchmaking Engine	Rule Scripting	Assymetric	yes	no
HP's MME Matchmaking Engine	DAML D. Logics	Symmetric	no	no
Shaikhali's UDDI Extension	UDDI Programming	Assymetric	no	no

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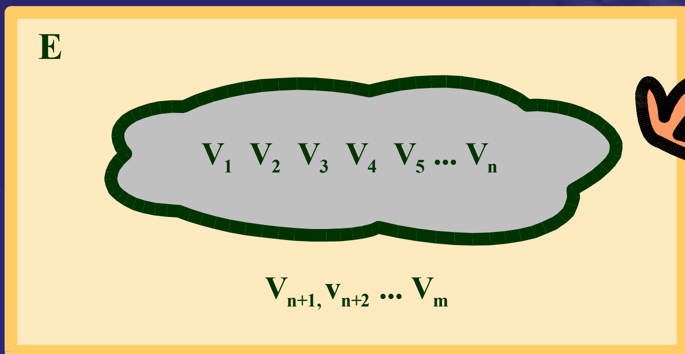
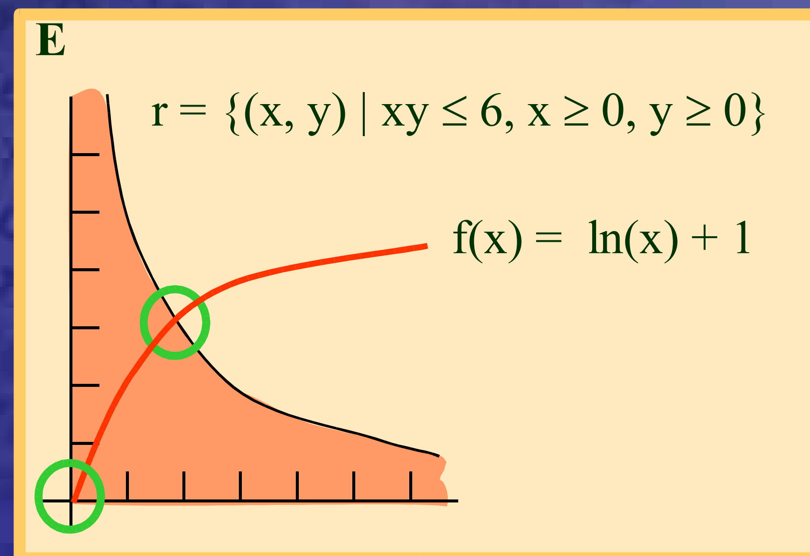
Constraint Programming

Constraint Solving and Optimisation Problems

$$r = \{v \in \mathrm{E} \cdot \mathrm{P}(v)\}$$





MINOS 5.5

LOQO

IBM OSL

ILOG

A wide variety of techniqs and solvers available !

Constraint Programming

An Illustrative Example

Constraint Programming

Quality Requirements Language (QRL)

```
catalogue acme.lsi.us.es {
  attributes {
    MTTF {
      description: “Mean Time To Failure”;
      domain: int [ 0, +inf ) minute;
    }
    LAT {
      descripción: “Latency of Service”;
      domain: int [ 0, +inf ) milliseconds;
    }
}
```

```
quality-of-service specification {
  using acme.lsi.us.es;
  customer WebVideoClub;
  demands for IVideoPlayer {
    d1:MTTF >= 30;
    d2:LAT < 24;
  }
}
```

```
quality-of-service specification {
  using acme.lsi.us.es;
  provider QuickTimeLive;
  offers for IVideoPlayer {
    o1: MTTF >= 360;
    o2: LAT < 24;
  }
}
```

```
quality-of-service specification {
  using acme.lsi.us.es;
  provider RealPlayer;
  offers for IVideoPlayer {
    o1: MTTF >= 15;
    o2: LAT < 3;
  }
}
```

```
quality-of-service specification {
  using acme.lsi.us.es;
  provider MS-Windows;
  offers for IVideoPlayer {
    o1: MTTF >= 60;
    o2: LAT < 1;
  }
}
```

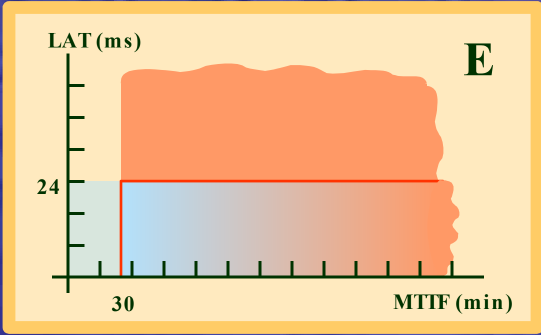
Constraint Programming

Consistency

```
quality-of-service specification {
  using acme.lsi.us.es;
  customer WebVideoClub;
  demands for IVideoPlayer {
    d1:MTTF >= 30;
    d2:LAT < 24;
  }
}
```

CSP for checking the consistency

MTTF >= 30 & LAT < 24

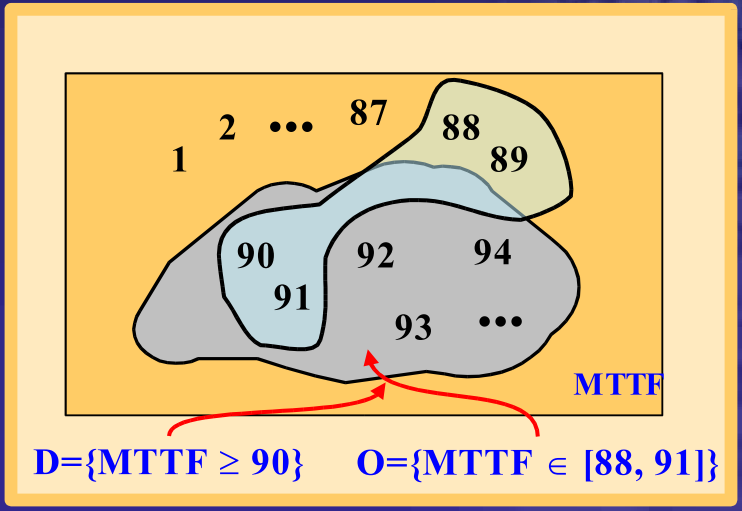


If there is a solution then the CSP is satisfiable, so the demand is consistent !

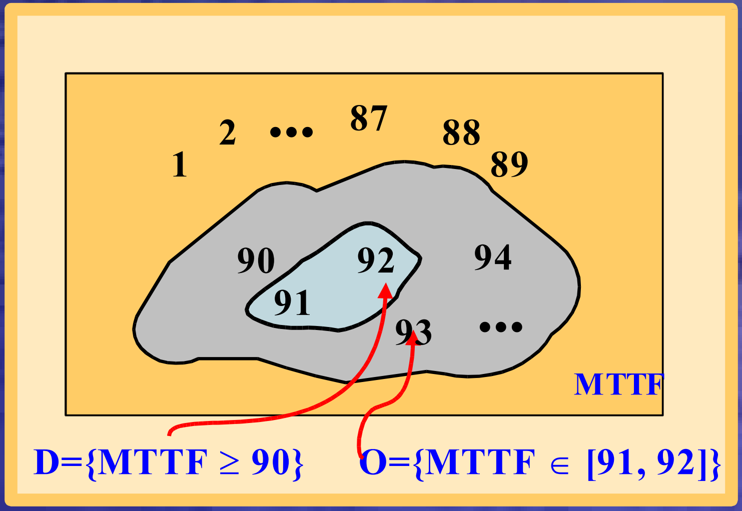
Constraint Programming

Conformance

An offer is conformant to a demand whenever all solutions satisfying the offer also satisfy the demand



Non conformant



Conformant

Symmetric & Bilateral

Constraint Programming

Conformance

```
quality-of-service specification {
  using acme.lsi.us.es;
  provider QuickTimeLive;
  offers for IVideoPlayer {
    o1: MTTF >= 360;
    o2: LAT < 24;
```

```
quality-of-service specification {
  using acme.lsi.us.es;
  provider RealPlayer;
  offers for IVideoPlayer {
    o1: MTTF >= 15;
    o2: LAT < 3;
```

```
quality-of-service specification {
  using acme.lsi.us.es;
  provider MS-Windows;
  offers for IVideoPlayer {
    o1: MTTF >= 60;
    o2: LAT < 1;
  }
}
```

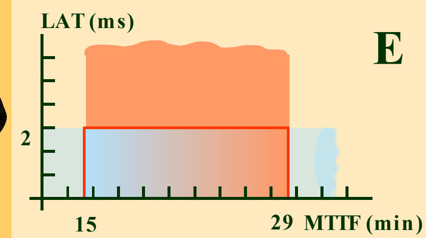
```
quality-of-service specification {
  ...
  demands for IVideoPlayer {
    d1:MTTF >= 30;
    d2:LAT < 24;
  }
}
```

Marriot's CSP for checking the conformance

(MTTF >= 360 & LAT < 24)
& not (MTTF >= 30 & LAT < 24)

No solution !

(MTTF >= 15 & LAT < 3)
& not (MTTF >= 30 & LAT < 24)



(MTTF >= 60 & LAT < 1)
& not (MTTF >= 30 & LAT < 24)

No solution !

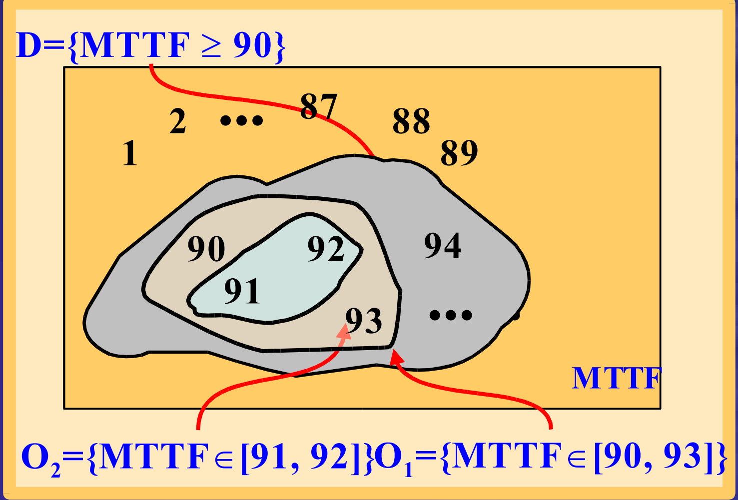
Instead, if there is not solution then CSP is not satisfiable, so the demand is

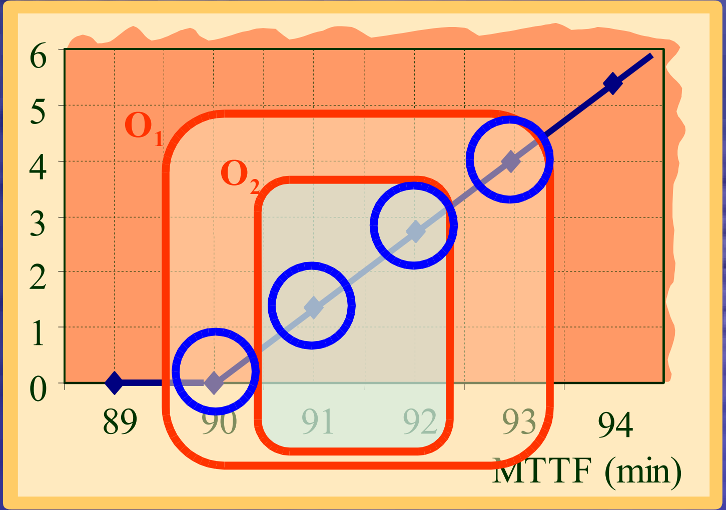
If there were a solution then the CSP would be satisfiable, so the demand would *not* be conformant !

Constraint Programming

Optimality

Among all conformant offers, the best choice maximises the customer's preferences...



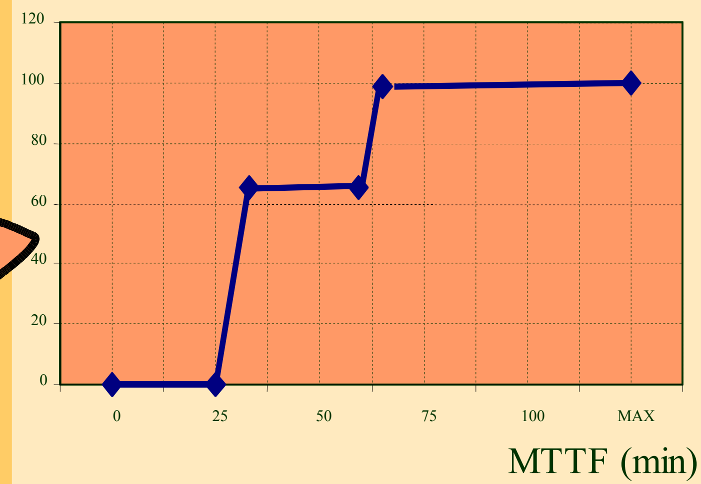


... but comparing the worst cases

Constraint Programming

Optimality

```
quality-of-service specification {
  using acme.lsi.us.es;
  customer WebVideoClub;
  demands for IVideoPlayer {
    d1:MTTF >= 30;
    d2:LAT < 24;
  }
  assessment {
    MTTF {100, { (0,0), (29,0), (30,0.75), (60,0.75), (61,1) } };
  }
}
```



Among conformant offers...

```
quality-of-service specification {
  using acme.lsi.us.es;
  provider QuickTimeLive;
  offers for IVideoPlayer {
    o1: MTTF >= 360;
    o2: LAT < 24;
  }
}
```

U(MTTF=360) = 1

U (MTTF=60) = 0.75

```
quality-of-service specification {
  using acme.lsi.us.es;
  provider MS-Windows;
  offers for IVideoPlayer {
    o1: MTTF >= 60;
    o2: LAT < 1;
  }
}
```

... this is the best !

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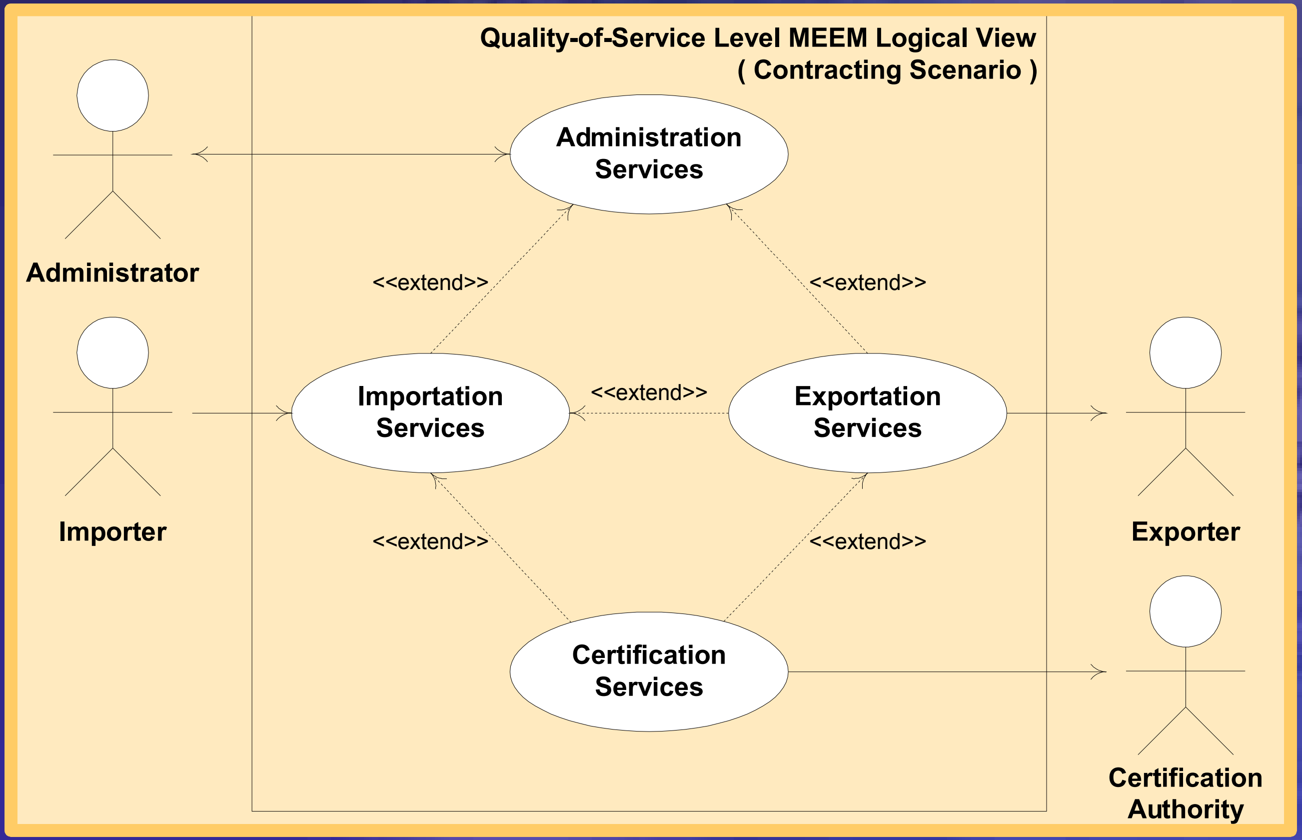
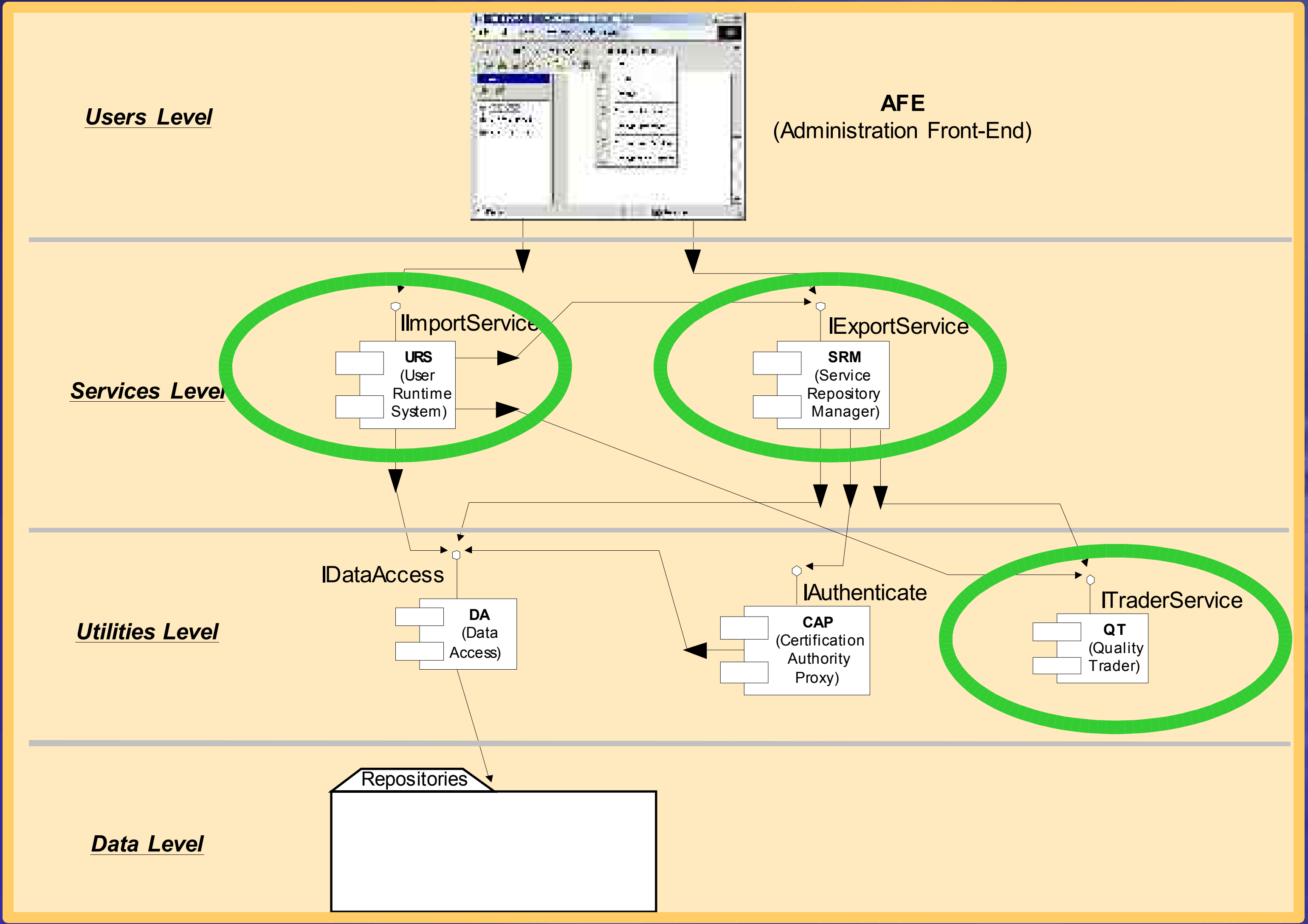
Implementation Issues

Logic View of Run-Time Framework



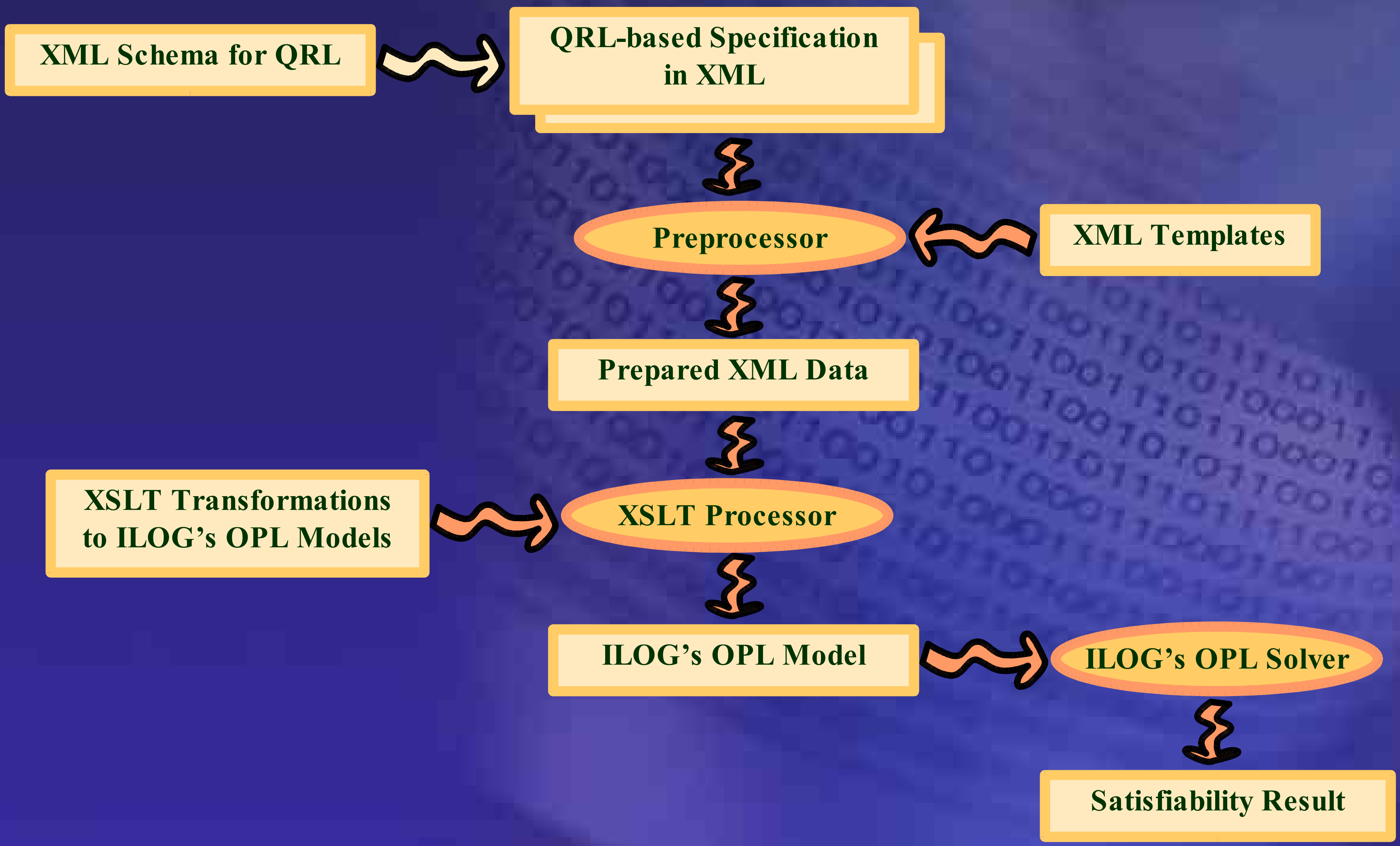
Implementation Issues

Physical View of Run-Time Framework



Implementation Issues

Quality Trader



Implementation Issues

ILOG's OPL Models

```
// The WebVideoClub's demand
// for IVideoPlayer

range TYPE_MTTF 0..9999;
var TYPE_MTTF MTTF;
range TYPE_LAT 0..9999;
var TYPE_LAT LAT;

solve {
  MTTF >= 30 && LAT < 24;
};
```

```
// Conformance of QuickTimeLive to
// WebVideoClub's demand

range TYPE_MTTF 0..9999;
var TYPE_MTTF MTTF;
range TYPE_LAT 0..9999;
var TYPE_LAT LAT;

solve {
  ( MTTF >= 360 & LAT < 24 )
 & not ( MTTF >= 30 & LAT < 24 );
};
```

```
// Computing assessment of QuickTimeLive
// according to WebVideoClub's demand

range TYPE_MTTF 0..9999;
var TYPE_MTTF MTTF;
range TYPE_LAT 0..9999;
var TYPE_LAT LAT;

minimize
  piecewise(0 -> 29; 75 -> 30; 0 -> 60; 25 -> 61; 0) MTTF

subject to {
  MTTF >= 360 & LAT < 24;
};
```

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Test Overview

Construction of an Uniform Random-3-SAT Test

Instance (N,K=Number of Clauses)

1	$Literal_{1,1}$	$Literal_{2,1}$	$Literal_{3,1}$
...	...	...	...
K	$Literal_{1,K}$	$Literal_{2,K}$	$Literal_{3,K}$

Literals (N=Number of QoS Parameters)

1	$Literal_1$	$\overline{Literal}_1$
...	...	...
N	$Literal_N$	$\overline{Literal}_N$

Current Parameters of the Test

Latency of Consistency
Latency of Conformance

N from 50 to 500 every 50
K = 2, 5, 10, 15, 25 and 50

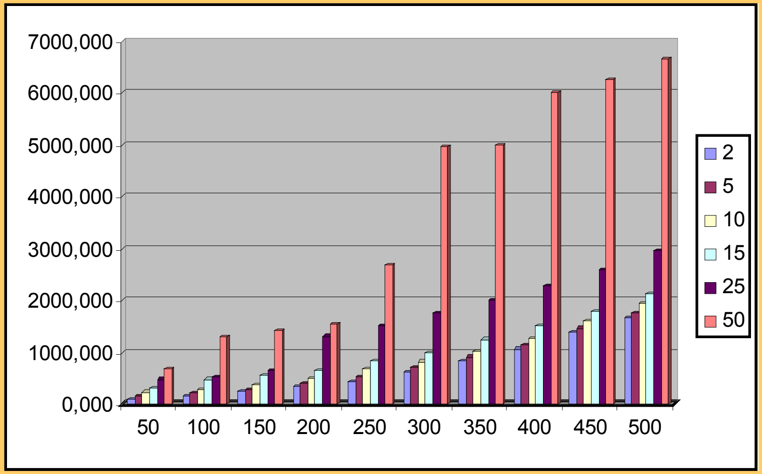
Latency of Optimisation

30 demands and 30 offers each
N from 50 to 400 every 50
K = 2, 5, 10 and 15

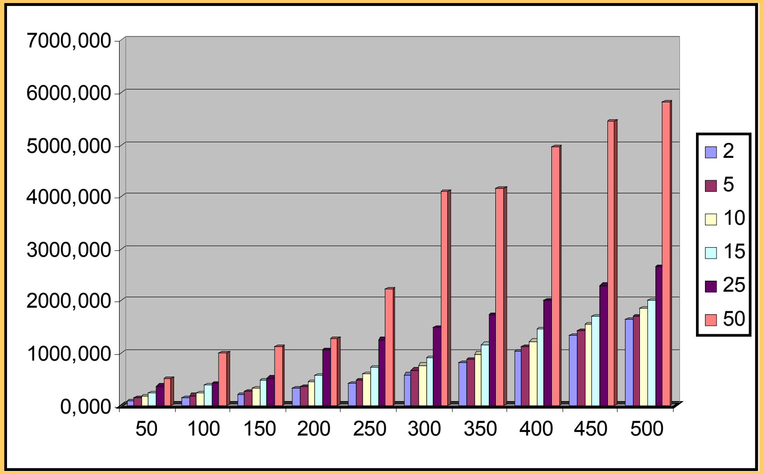
Total Time
Xslt Time
Solver Time

Experimental Results

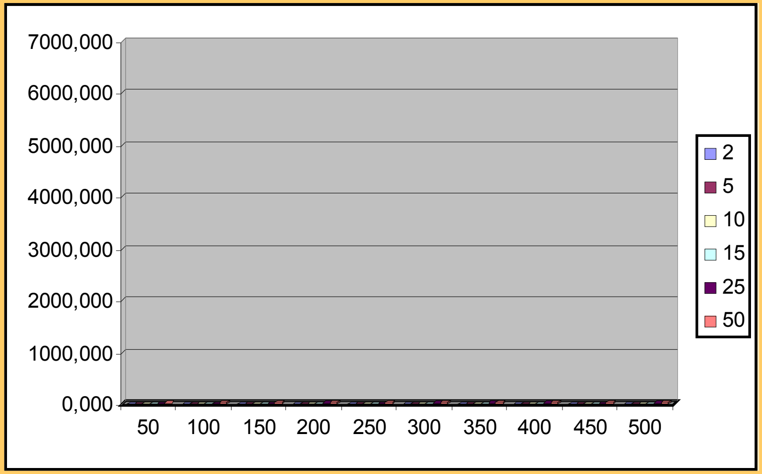
Latency of Service for Consistency Checking



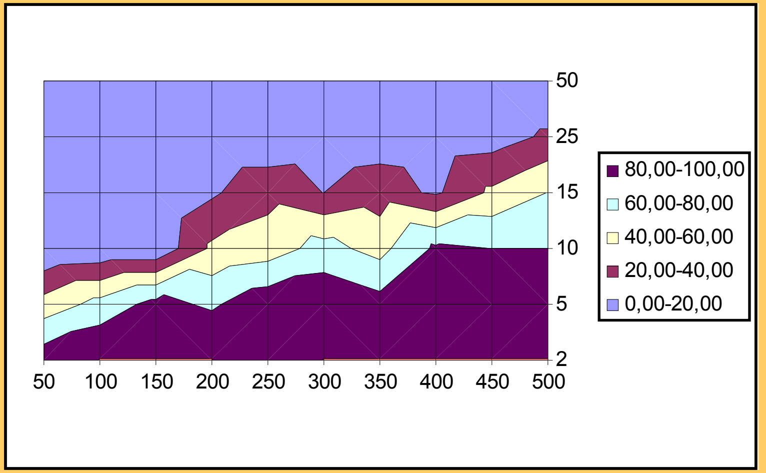
Latency of service: total time of execution



Latency of service: Xslt time of execution



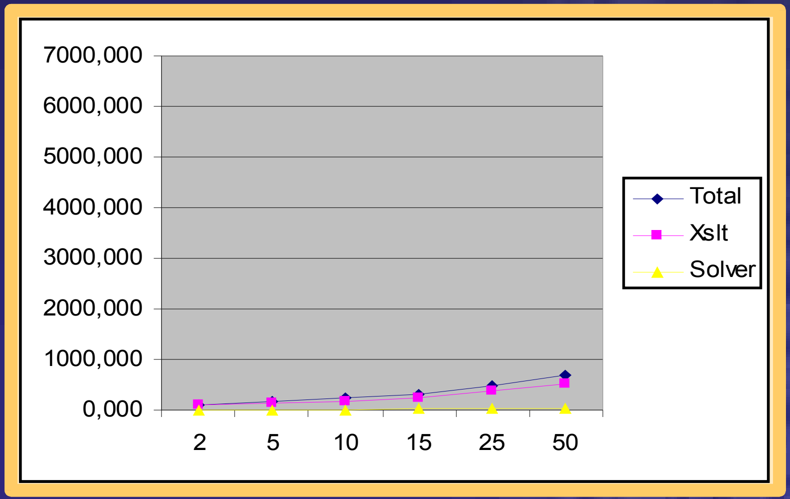
Latency of service: solver time of execution



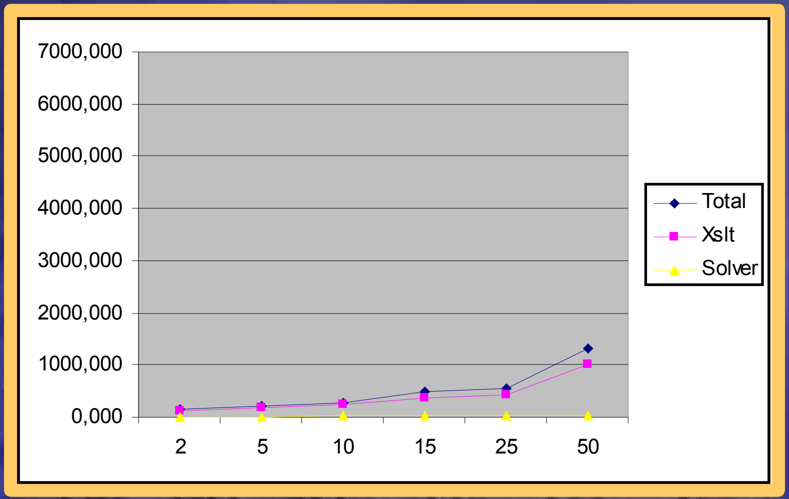
Percentage of consistent QoS specifications

Experimental Results

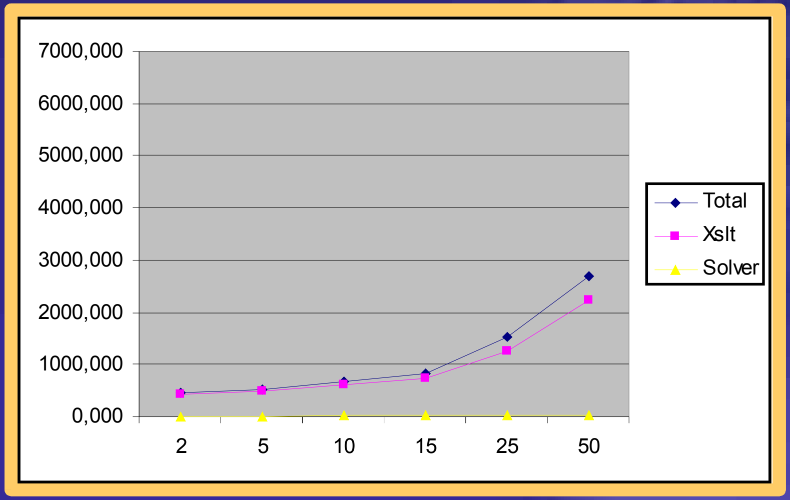
Latency of Service for Consistency Checking



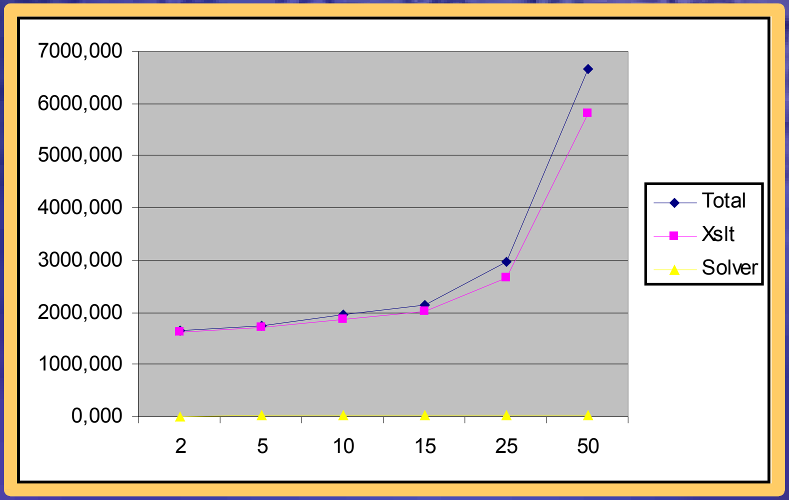
Number of QoS parameters = 50



Number of QoS parameters = 100



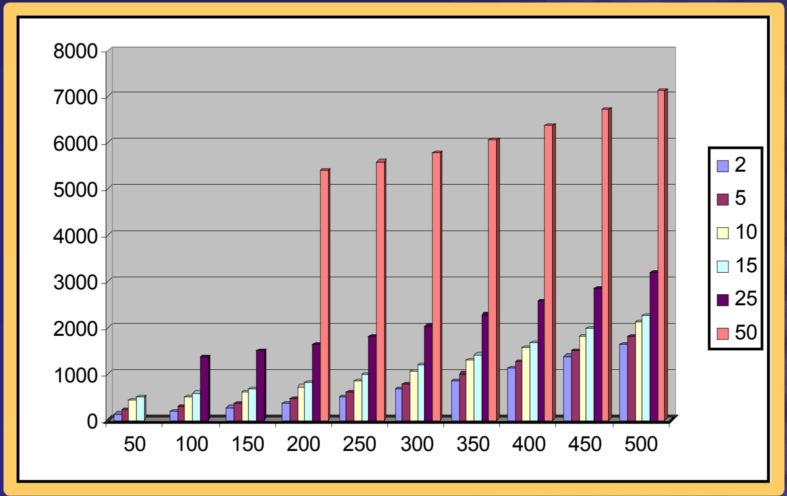
Number of QoS parameters = 250



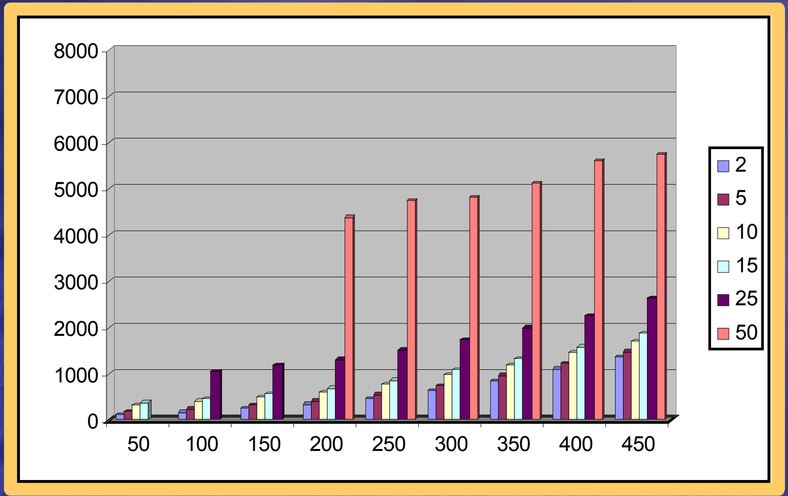
Number of QoS parameters = 500

Experimental Results

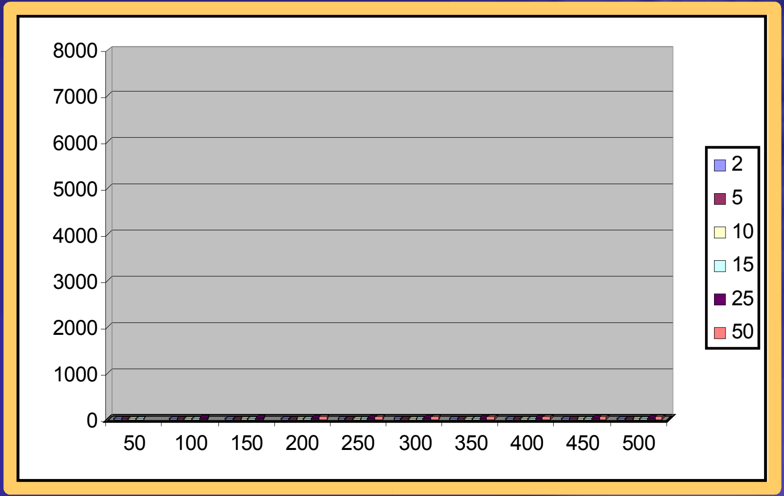
Latency of Service for Conformance Checking



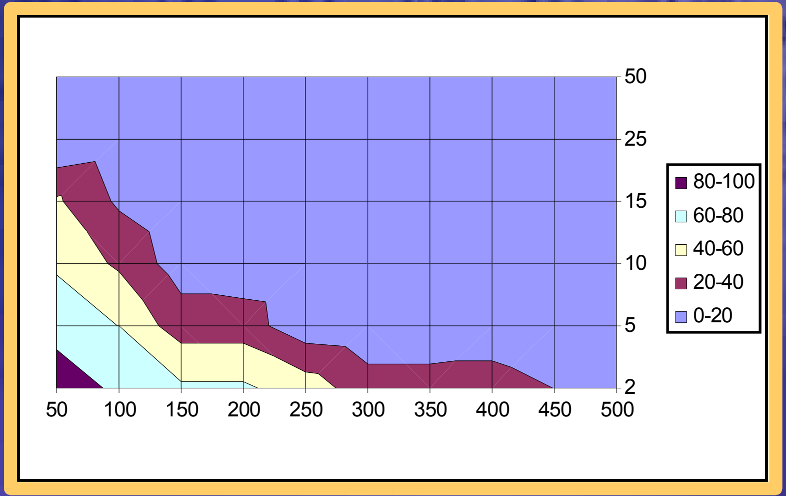
Latency of service: total time of execution



Latency of service: Xslt time of execution



Latency of service: solver time of execution

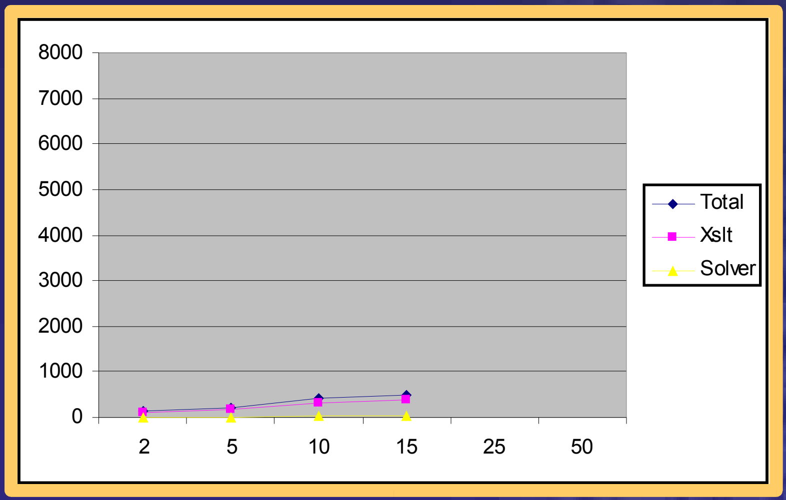


Percentage of conformant QoS specs

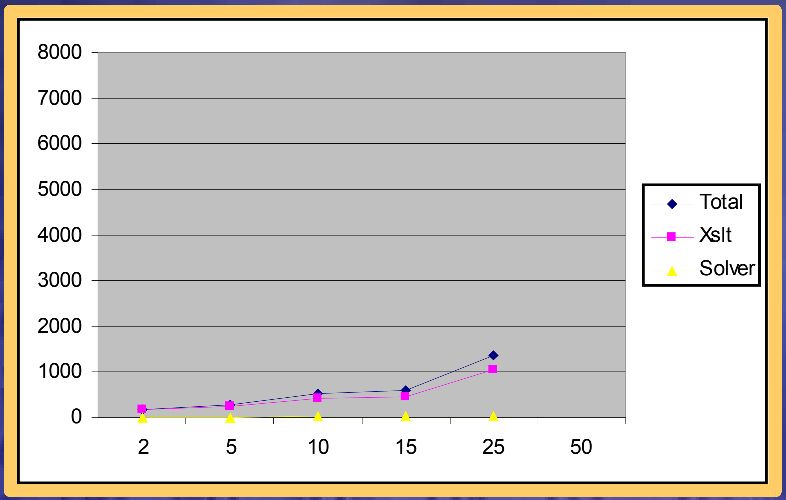
IcSoc 2003: "Automating The Procurement of Web Services"

Experimental Results

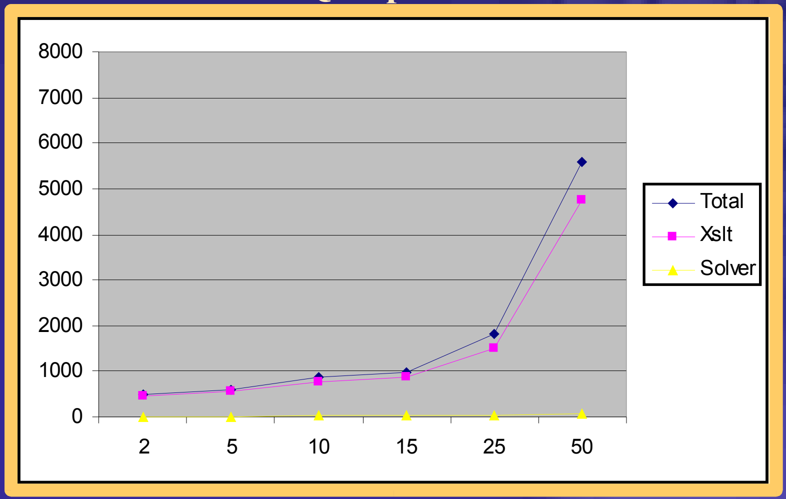
Latency of Service for Conformance Checking



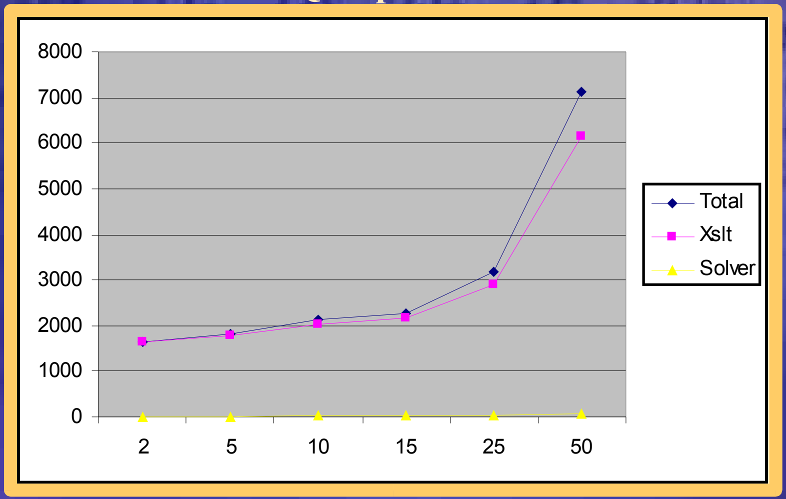
Number of QoS parameters = 50



Number of QoS parameters = 100



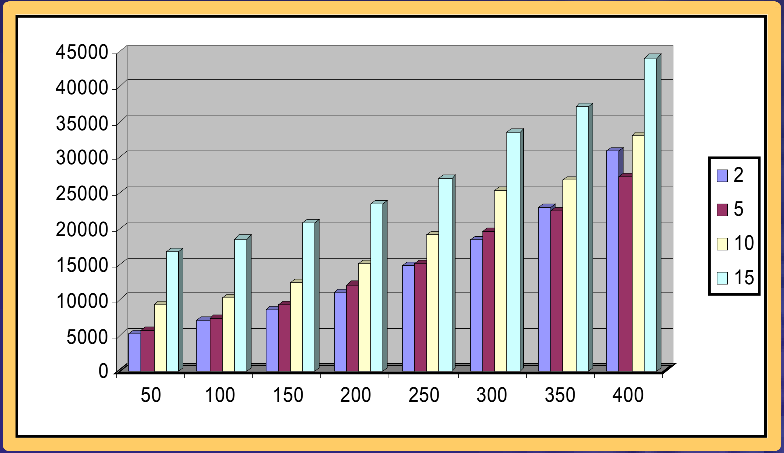
Number of QoS parameters = 250



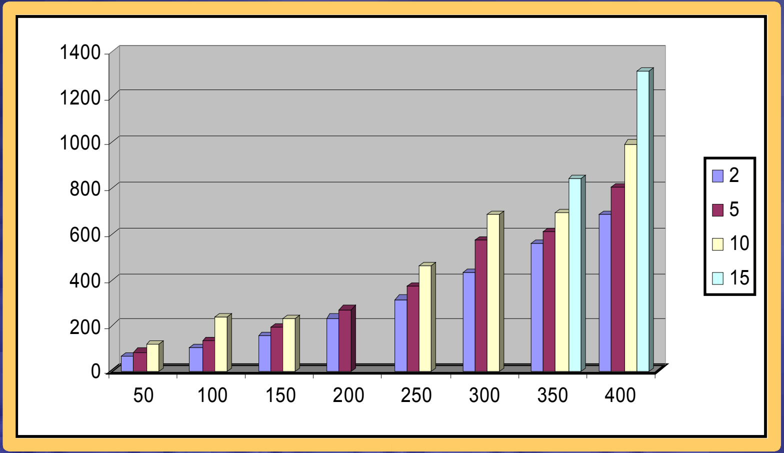
Number of QoS parameters = 500

Experimental Results

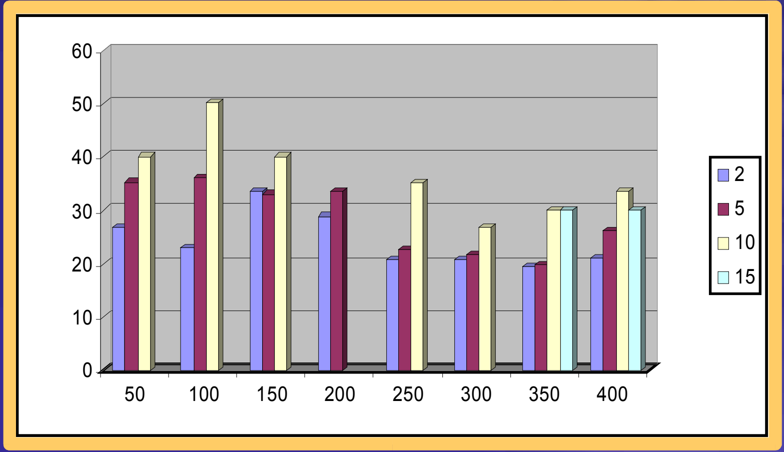
Latency of Service for Optimality Checking



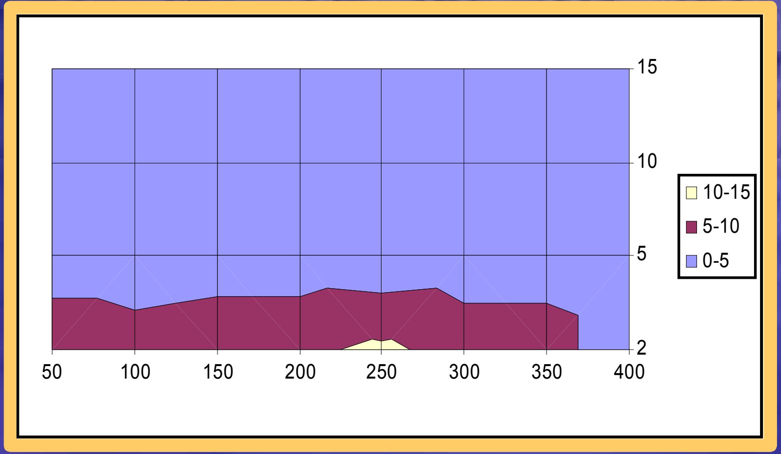
Latency of service: total time of execution



Latency of service: Xslt time of execution



Latency of service: solver time of execution



Percentage of conformant QoS specs

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Quality-of-service Specification (based on QRL)

- Symmetry
- Bilaterality

Quality-Aware Matchmaking

- Constraint programming
  - constraint solving & optimisation problems
- Checking of properties
  - consistency, conformance & optimality

Run-Time Framework for WSP

- XML schemas for QRL
- XSLT transformations to OPL models
- ILOG's OPL Studio as a solver
- Experimental results

Thank You !

If you have any suggestion

- Contact us at: octavio@lsi.us.es, tdg@lsi.us.es
- Drop by our e-pages at: http://www.lsi.us.es/~octavio http://www.lsi.us.es/~tdg

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