

Semantic Query: Solving the Needs of a Net-Centric Data Sharing Environment

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Agenda

- Problem
- Federated Semantic Queries
 - Background
- Semantic Query Architecture
 - Components
 - Process Flow
- DoD 8320.02-G Directive
- Demonstration

Who is BBN Technologies?

- Advanced technology research and development firm, principal offices in Cambridge, MA and Washington, DC area
- ~670 employees
- Known for taking risks and challenging conventions in pursuit of new and fundamentally better solutions
 - Problems “on the edge of doable”
- Integrator for DARPA Agent Markup Language (DAML) program
- Developer of various Semantic Web tools/apps
- Involvement in W3C Semantic Web Activity
 - RDF Core WG
 - OWL
 - SWRL
 - RIF WG

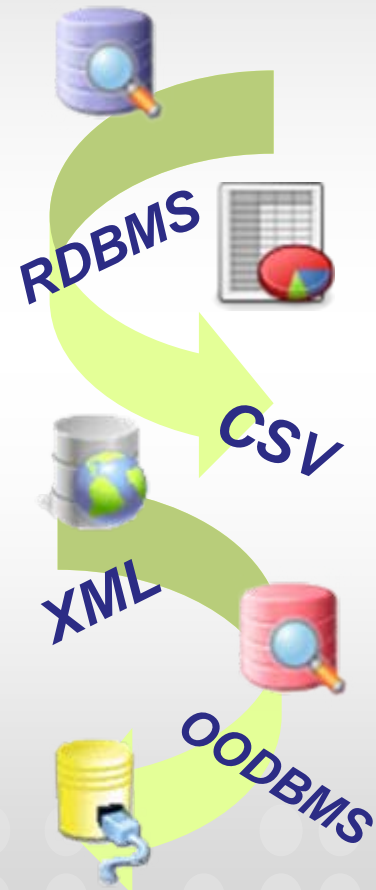


The Need!

- Deliver information:
 - as a single response
 - that is trustworthy and up-to-date
 - from all necessary data sources
 - in a timely fashion
 - with minimal or no human assistance
 - without having intimate knowledge of data sources

The Problem

- Data is inaccessible
 - *Not a data federation issue*
- Data is spread over more than a single repository
- Data is available but ...
 - in varying, sometimes proprietary, formats
 - requires special access, APIs, systems, etc...



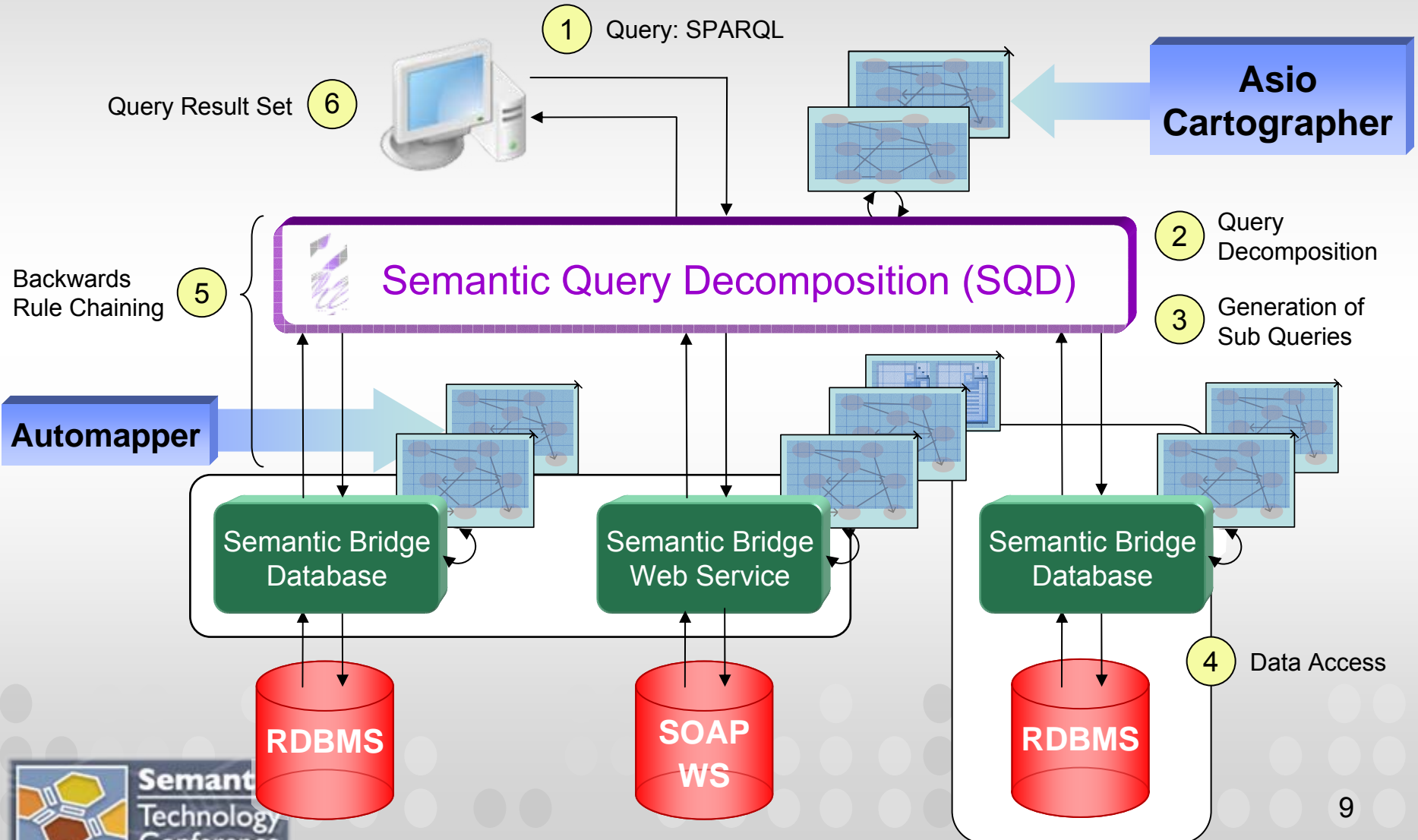
The Problem

- Data and its semantics are known to a subset of key personnel
 - Widespread organizational threat
- Data is currently aggregated but requires manual intervention
 - Resource intensive
 - Error prone
 - Depends on experienced personnel

A Federated Semantic Solution

- Asio Semantic Distributed Query
 - Developed in Java
 - Incorporates standards-based languages
 - OWL, SWRL, SPARQL
 - Integration of three Asio tools
 - Semantic Query Decomposition (SQD)
 - Semantic Bridge for Relational Databases (SBRD)
 - Semantic Bridge for Web Services (SBWS)

SDQ Architecture



Asio Tools

- Semantic Query Decomposition (SQD)
 - Responsible for query division, bridge invocation, aggregating bridge result sets, returning domain-based response
- Semantic Bridge
 - Responsible for taking SPARQL query, translating it to “native” language, executing query and returning query results (data source ontology)

Semantic Languages

- **OWL DL**
 - Reasoning, computational tractability
- **SWRL**
 - Semantic Web Rule Language
 - Horn-like rules
 - Use of antecedents and consequents
 - Combination
 - OWL DL/Lite, Unary/Binary Datalog RuleML languages
 - Allows new statements to be added based on the assertion of other statements

Semantic Languages (con't)

- SWRL
 - W3C Member Submission May 2004
 - SWRL/RDF Allows storage with ontology, data
 - Sample tool support:
 - Pellet: UMD – DL-safe rules
 - Jena: HP – via SweetRules translation
 - Protégé: rule engine agnostic, editor & execution
 - RacerPro: Germany, based on Racer
 - Bossam: South Korea

Semantic Languages (con't)

■ SPARQL

- SPARQL Protocol and RDF Query Language
- Query RDF graphs via pattern matching
 - Reasonably familiar to SQL users
 - Query forms:
 - SELECT
 - DESCRIBE
 - CONSTRUCT
 - ASK
 - Support for
 - Blank nodes (non-distinguishing vars)
 - FILTERs
 - RDF Collections
 - OPTIONALs
 - UNIONs

SBRD Example

Staffing Table

Name	Project	Department ID	Hours	Role
MattF	Alpha	1	100.5	Developer
MikeD	Alpha	2	50.2	Tech Lead
MattG	Beta	1	92.0	Architect
DaveK	Beta	1	120.0	Developer
MikeD	Beta	2	30.8	Consultant
DaveK	Alpha	1	87.8	Indagator

Departments Table

ID	Name
1	System Solutions
2	Research and Development
3	Management

 Primary Key

Automapper (1/2)

- Uses JDBC to retrieve schema of database
 - Creates the data source ontology
 - Tables → owl:Class
 - Columns → owl:DatatypeProperty, owl:ObjectProperty
 - Restrictions: owl:maxCardinality owl:Cardinality owl:FunctionalProperty owl:allValuesFrom
 - Inverse Functionality (via SWRL)
 - Based on primary key(s)
 - Class-specific

Automapper (1/2)

Data Source Ontology

```

dsont:Owled.Departments a owl:Class;
rdfs:subClassOf
  [ a owl:Restriction ;
    owl:onProperty dsont:owled.departments.id ;
    owl:allValuesFrom xsd:decimal ],
  [ a owl:Restriction ;
    owl:onProperty dsont:owled.departments.id ;
    owl:maxCardinality "1"^^xsd:nonNegativeInteger ] .

```

```

dsont:Owled.Staffing a owl:Class;
rdfs:subClassOf
  [ a owl:Restriction ;
    owl:onProperty dsont:owled.staffing.name ;
    owl:maxCardinality "1"^^xsd:nonNegativeInteger ],
  [ a owl:Restriction ;
    owl:onProperty dsont:owled.staffing.name ;
    owl:allValuesFrom xsd:string ],
  [ a owl:Restriction ;
    owl:onProperty dsont:owled.staffing.deptid.Object ;
    owl:maxCardinality "1"^^xsd:nonNegativeInteger ] .

```

```

dsont:Owled.DepartmentsSameIndividual a ruleml:Imp ;
ruleml:body
  ( [ a swrl:ClassAtom ;
    swrl:argument1 :A ;
    swrl:classPredicate dsont:Owled.Departments ]
  [ a swrl:ClassAtom ;
    swrl:argument1 :B ;
    swrl:classPredicate dsont:Owled.Departments ]
  [ a swrl:DatavaluedPropertyAtom ;
    swrl:argument1 :A ;
    swrl:argument2 :Var0 ;
    swrl:propertyPredicate dsont:owled.departments.id ]
  [ a swrl:DatavaluedPropertyAtom ;
    swrl:argument1 :B ;
    swrl:argument2 :Var0 ;
    swrl:propertyPredicate dsont:owled.departments.id ] ) ;
ruleml:head
  ( [ a swrl:SameIndividualAtom ;
    swrl:argument1 :A ;
    swrl:argument2 :B ] ) .

```

Automapper (2/2)

- Generates mapping data
 - Transform data from database to data source ontology
 - Based on D2RQ mapping ontology
 - Removed
 - :AdditionalProperty
 - :join
 - Added
 - :constraint
 - :KeyConstraint (Foreign Key equality)

Automapper (2/2)

Mapping Data

```
:OWLED.STAFFING.DEPTID.OBJ a map:ObjectPropertyBridge;
  map:constraint
    [ a map:KeyConstraint;
      map:objectColumnOperand "ID";
      map:operator map:EqualsOperator;
      map:subjectColumnOperand "DEPTID" ];
  map:objectClassMap dsont:Owled.Departments;
  map:property dsont:owled.staffing.deptid.Object .
```

```
:OWLED.DEPARTMENTS.ID a map:DatatypePropertyBridge;
  map:column "ID";
  map:datatype xsd:decimal;
  map:language "en";
  map:property dsont:owled.departments.id .
```

```
:Owled.Departments a map:ClassMap;
  map:datatypePropertyBridge :OWLED.DEPARTMENTS.ID,
                             :OWLED.DEPARTMENTS.NAME;
  map:table "DEPARTMENTS";
  map:type dsont:Owled.Departments;
  map:uriPattern "http://asio.bbn.com/2007/05/stc/ds-ont#Owled.Departments@@ID@@".
```

Putting it all together

SWRL rules allow data source statements to be “translated” into domain ontology statements

- Data integration
without modifying ontologies
- Customized Domain
- User Defined Operational Picture



Example

?s dsont:department.id “1”

=> ?s dom:hasDepartment :SystemSolutions

Correlation Configuration Registry

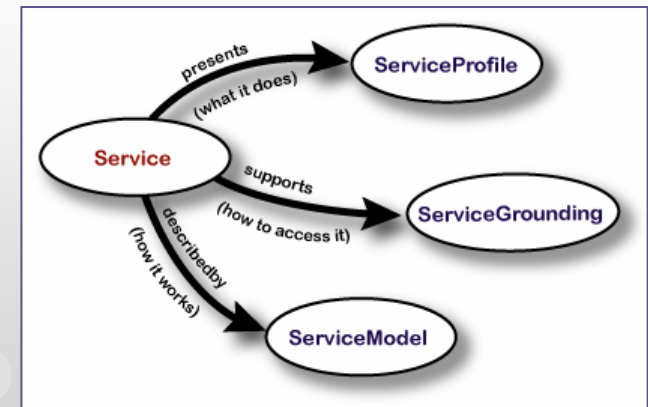
- Personalized workspace that determines the ontologies, rules used by SDQ architecture
- Loaded once at initialization
- Workspace is based on a configuration ontology

SBWS Conceptual Example

- Similar to SBRD
- WSDL is foundational artifact for data source ontology
- Data accessibility remains in the control of owner/maintainer
- Use of OWL-S
 - Interfacing via SOAP to web service
 - Transform results to RDF

OWL-S

- Semantic Web Service
 - Enables automated discovery, invocation, composition, monitoring
- [W3C](#) Member Submission November 2004
- Potential Alternatives: SAWSDL, WSMO, SWSF
- Simple description of a web service
 - Presents ⇒ Service Profile
 - Supports ⇒ Service Grounding
 - DescribedBy ⇒ Service Model



DoD 8320.02-G Directive

- Released April 2006
- Assisting DoD IT departments with supporting the net-centric vision
 - Defines COIs: roles and responsibilities
 - COI formation, evolution, execution
 - Identify information key to mission success and ensure information is *visible*, *accessible*, *understandable* and *promotes trust*



8320 Information Directives

Visible

Identify
Policy Guidelines
Metadata
Discovery services

Accessible

Using network-based methods
Humans and Machines
“Pull on Demand”
Standards vs. proprietary APIs

Promoting Trust

Pedigree/Provenance
Embedded in Metadata
Security Labels

Understandable

Informational Context
DoD Metadata Registry
Semantics!
Taxonomies, Ontologies

Current Availability

- Part of BBN's Asio Suite
 - www.asio.bbn.com
- Reusable Semantic Web Tools
- Developed with a focus as standalone component
 - Successful fusion of tools

Demonstration

Q & A

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