RDF in a .NET World

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About Me

- Developer, Consultant
- Co-founder of NetworkedPlanet
- Co-creator of BrightstarDB
- .NET Programmer since 2004

Agenda

- BrightstarDB
- RDF Data Binding
- LINQ to SPARQL
- OData/SPARQL Interop
- Questions

BrightstarDB

- Persistent Quad Store for .NET
  - Pure C# implementation
  - Classic .NET, Mono, Portable Class Library, Android, iOS (soon)
  - Embeddable .NET API
  - REST-based server
  - SPARQL 1.1, lots of RDF syntaxes
  - Small footprint, easy to deploy
  - Open-Source, MIT licensed
  - http://brightstardb.com/

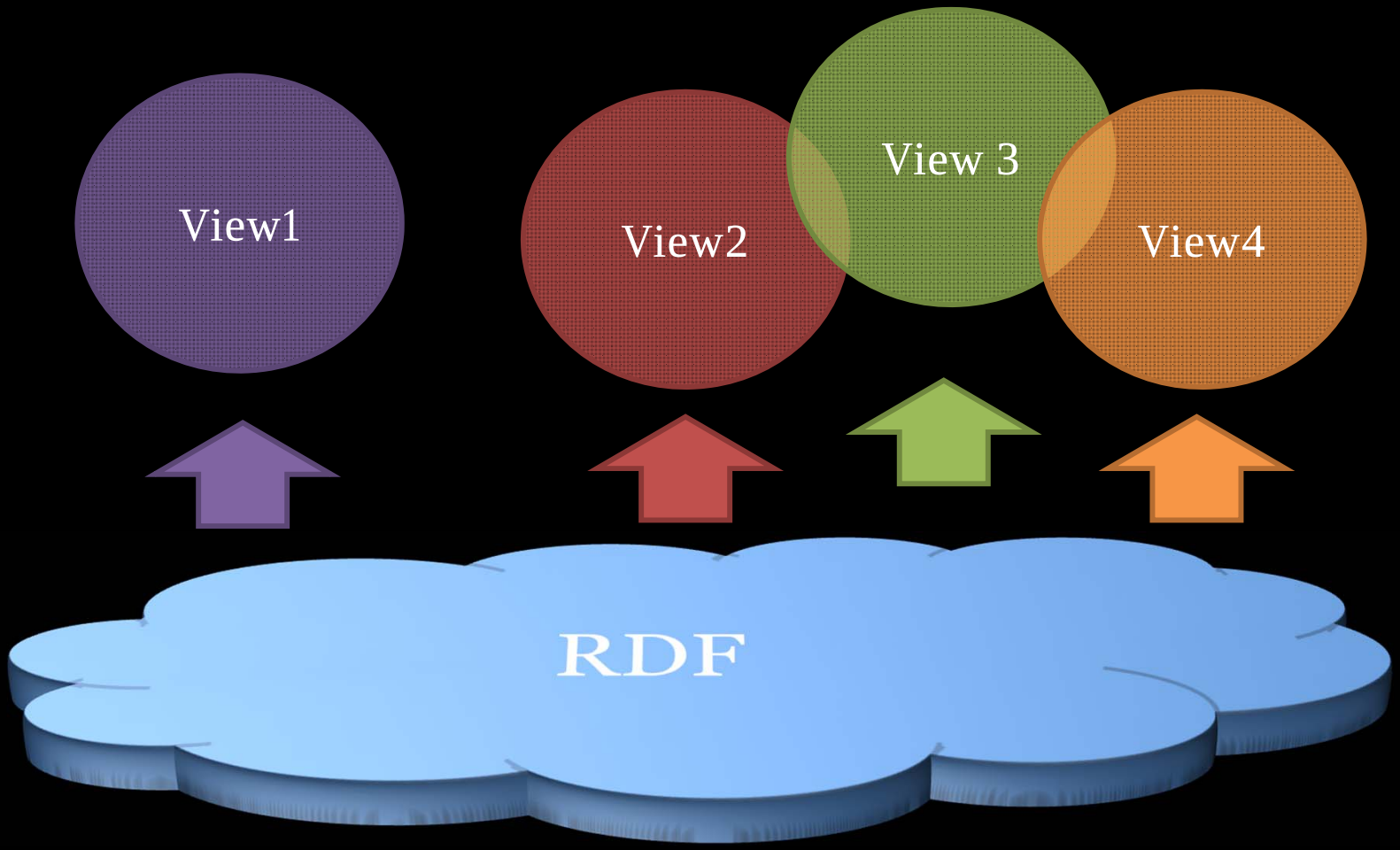
RDF DATA BINDING

Open vs Closed World

- Open World Models
  - Scale better
  - Allow for better data integration
  - Allow for easier data migration
- Closed World Models
  - Easier to reason
  - Easier to integrate
  - Almost always exist at some layer

Compromise

- Domain Model as a View



Our Approach

- Bind domain type to an rdf:Type
  - Makes it easy to find instances
  - An RDF resource may have multiple types
- Unique instance identifiers bind to RDF resource URIs
  - Use a configured URI prefix + Id
  - Applications will need to share an addressing scheme
- Class properties bind to RDF literal properties
- Class relations bind to RDF resource properties

BrightstarDB "Entity Framework"

- "Contract-First" Code Generation
- Decorated interface definitions + conventions

```
[Entity]
public interface IPerson {
   string Id { get; }
   string Name {get; set;}
   ICollection<IPerson> Knows {get; set;}
}
```

```
[assembly:NamespaceDeclaration(“foaf”,
            “http://xmlns.com/foaf/0.1/”)]

[Entity(“foaf:Person”)]
public interface IPerson {

  [Identifier(“http://example.com/person/”)]
  public string Id { get; }

  [PropertyType(“foaf:name”)]
  public string Name { get; set; }

  [PropertyType(“foaf:knows”)]
  public ICollection<IPerson> Knows {get; set;}

  [InverseProperty(“Knows”)]
  public Icollection<IPerson> KnownBy {get; set;}
}
```

```
[assembly:NamespaceDeclaration("foaf",
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[Entity("foaf:Person")]
public interface IPerson {

  [Identifier("http://example.com/person/")]
  public string Id { get; }

  [PropertyType("foaf:name")]
  public string Name { get; set; }

  [PropertyType("foaf:knows")]
  public ICollection<IPerson> Knows {get; set;}

  [InverseProperty("Knows")]
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```

Data Binding In Operation

- Data object tracks the quads loaded for an entity.
  - Lazy loading by default
  - Can be eager loaded by LINQ queries
- Data context object tracks changes
  - Collection of quads to be added to the store
  - Quad patterns to be removed from the store.
  - Patterns allow wildcard binding

Saving Changes

- BrightstarDB Transaction
  - List of guard patterns
  - List of quad patterns to delete
  - List of quad patterns to add
- SPARQL 1.1 UPDATE
  - DELETE WHERE
  - INSERT DATA

Additional Features

- Type Casting
- Optimistic Locking
- Composite Keys
- “Unique” Identifiers

RDF Data Binding

- It can be useful
- It is relatively easy to implement basic data binding
- The approaches used here should work with Java, Python etc.
- Covers basic CRUD operations, but no query...

LINQ TO SPARQL

LINQ to SPARQL

- Language INtegrated Query
  - Common language for data access in .NET
  - Supports ADO.NET, XML documents, in-memory collections and now SPARQL endpoints.
  - Uses introspection to provide Intellisense auto-completion in Visual Studio

Implementation

- Parse the LINQ query
- Walk the query tree generating SPARQL expressions
- Wrap the expressions in SELECT or CONSTRUCT as appropriate
- Execute the SPARQL query
- Data bind the results

Iterating Entity Collections

```
from p in Context.Dinners select p.Id
OR
From p in Context.Dinners select p
```

```
SELECT ?p WHERE {
  ?p a nerd:Dinner .
}
```

Selecting A Property

```
from p in Context.Dinners
where p.Id.Equals("1")
select p.Rsvps;
```

```
SELECT ?v1 WHERE {
  <http://nerddinner.com/dinners/1>
        a nerd:Dinner .
  <http://nerddinner.com/dinners/1>
        nerd:attendees ?v1 .
}
```

Joins

```
from x in Context.Dinners
from r in x.Rsvps
select r.AttendeeEmail
```

```
SELECT ?v1 WHERE {
    ?x a nerd:Dinner .
    ?r a nerd:Rsvp .
    ?x nerd:attendees ?r .
    ?r nerd:email ?v1 .
}
```

Filters

```
from x in Context.Dinners
where x.EventDate >= DateTime.UtcNow
select x.Id
```

```
SELECT ?x WHERE {
    ?x a nerd:Dinner .
    ?x nerd:eventDate ?v0 .
    FILTER (
 ?v0 >= '2014-03-05T16:13:25Z‘^^xsd:dateTime) .
}
```

Methods

- String methods:
  - String.StartsWith => STRSTARTS
  - String.EndsWith => STRENDS
  - Case-insensitive options map to REGEX
- Math operations
  - Math.Ceil, Math.Floor, Math.Round etc
- Collection operations
  - Contains => IN

Eager Loading

- Avoid N+1 round-trips
- Naïve Approach:

```
CONSTRUCT {
   ?s ?p ?o
} WHERE {
   ?s ?p ?o .
   SELECT ?s WHERE {
      …
   }
}
```

Sorting

- First problem for naïve approach
- Graphs have no sort order
- Cannot rely on serialization order
- No access to sort position in CONSTRUCT

Sorting: Solution

```
CONSTRUCT {
   ?s ?p ?o .
   ?s bs:sortValue0 ?sv0 .
   ?s bs:sortValue1 ?sv1 .
} WHERE {
   ?s ?p ?o .
   SELECT ?s ?sv0 ?sv1 WHERE {
      … bind s and sort values here …
   }
}
```

Paging

- Handled on the server side
- If paged query is also sorted, then the server needs to apply the sorting.

Paging: Example

```
CONSTRUCT {
   ?s ?p ?o .
   ?s bs:sortValue0 ?sv0 .
   ?s bs:sortValue1 ?sv1 .
} WHERE {
   ?s ?p ?o .
   SELECT ?s ?sv0 ?sv1 WHERE {
   ...
   }
   ORDER BY ?sv0 DESC(?sv1)
   OFFSET 10 LIMIT 10
}
```

DISTINCT

- When sorting, projection includes sort variables
- If one entity has multiple possible bindings for a sort value you end up with multiple “distinct” solutions.
- Solution is to use MIN and MAX to ensure that only one value binds to each projected sort variable

DISTINCT: Example

```
CONSTRUCT {
   ?s ?p ?o .
   ?s bs:sortValue0 ?sv0
   ?s bs:sortValue1 ?sv1
} WHERE {
   ?s ?p ?o .
   SELECT DISTINCT ?s
                   (MAX(?sv0_) AS ?sv0)
                   (MIN(?sv1_) AS ?sv1)
   WHERE {
      … bind s, sv0_ and sv1_ here …
   }
   GROUP BY ?s
   ORDER BY ASC(MAX(?sv0_)) DESC(MIN(?sv1_))
}
```

ODATA / SPARQL INTEROP

OData

"OData is a standardized protocol
for creating and consuming
data APIs"

odata.org

Entity-Centric

- Collection of Entity Sets
- Service metadata
  - List of entity sets
  - Schema for entities
- Primary Keys
- Properties & Associations
- Results are returned as entities by default

URL-based access

http://example.org/Films

http://example.org/Films(1234)

http://example.org/Films?$filter=Runtime lt 120

http://example.org/Films(1234)/Director

http://example.org/Films(1234)?$expand=Director,Actor

RESTful Update

- POST to entity set's URL
- PUT, PATCH, MERGE or DELETE to the edit URL of an existing entity
- Associations can also be exposed as a collection of link resources.

Reasons to Like OData

- Schema discovery
- Client tooling support (esp for .NET)
- Easy to experiment
- Easy to use from JavaScript
- Growing set of OData consumers
  - Data browsers
  - GUI controls
  - Applications

Criticisms of OData

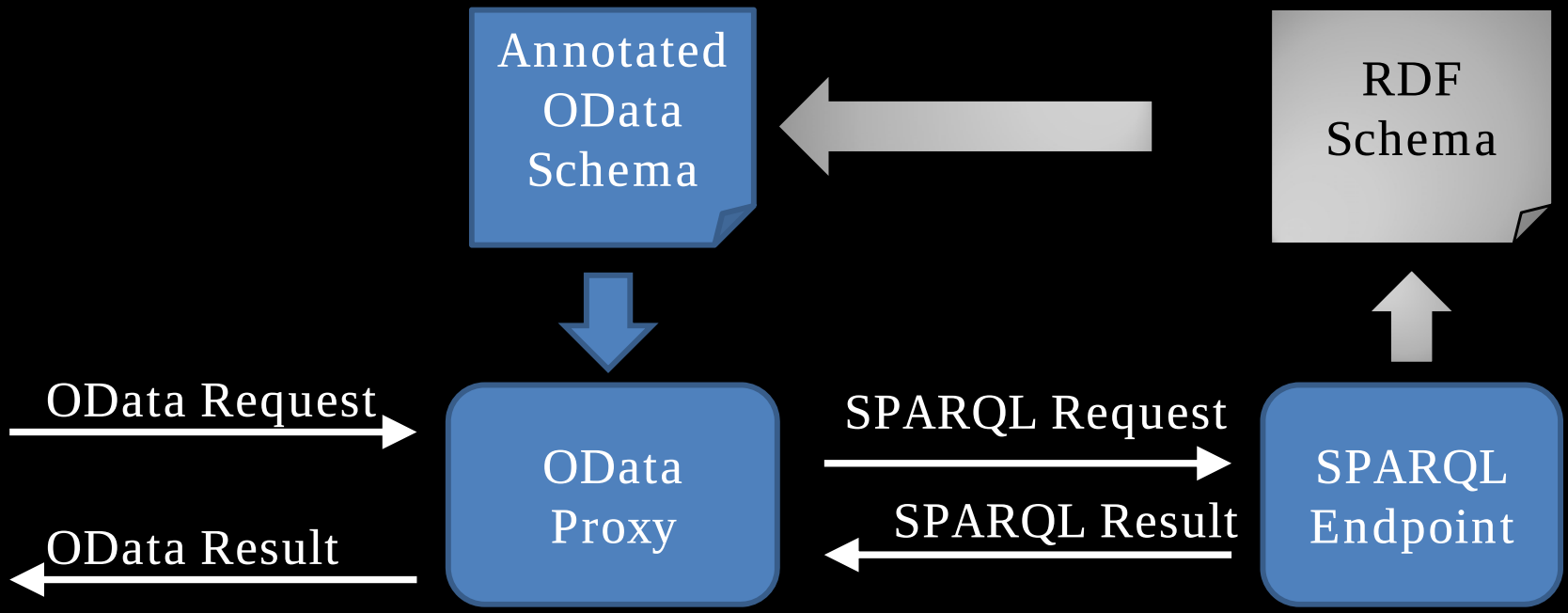
- Services tend to be siloes
- No shared ontologies
- Perceived as a vendor-specific protocol

Motivation

- We like the features of OData
- We like the flexibility of RDF / SPARQL

- Goals:
  - Read access to open SPARQL endpoints via OData
  - Declarative configuration
  - Automatic configuration via RDF schema / SPARQL introspection

Implementation



http://github.com/brightstardb/odata-sparql

Annotating OData Services

- Annotations are part of the OData spec.
- We define annotations for:
  - URI namespace for entity primary keys
  - URIs for entity types
  - URIs for properties and associations
  - Direction of associations

Implementation Issues

- Similar to LINQ-SPARQL
  - DESCRIBE is not an option
  - CONSTRUCTed graphs instead
  - Server-controlled paging for OData
  - Data-bind RDF resources to OData entities

Select a Single Film

OData

/Films('Un_Chien_Andalou')

SPARQL

```
CONSTRUCT {
  res:Un_Chien_Andalou ?p ?o .
} WHERE {
  res:Un_Chien_Andalou ?p ?o .
}
```

Enumerate Films

OData

/Films

SPARQL

```
CONSTRUCT {
   ?v1 ?v1_p ?v1_o.
   ?v1 ods:variable-binding “v1”
} WHERE {
   ?v1 ?v1_p ?v1_o .
   {
     SELECT { ?v1 rdf:type o:Film . } LIMIT 100
   }
}
```

Property Navigation

OData

/Films('Un_Chien_Andalou')/Director

SPARQL

```
CONSTRUCT {
  ?v1 ?v1_p ?v1_o .
  ?v1 ods:variable-binding "v1" .
} WHERE {
  ?v1 ?v1_p ?v1_o .
  SELECT {
    ?v1 WHERE {
      res:Un_Chien_Andalou  p:director ?v1 .
   } LIMIT 100
}
```

Filtering

OData

/Films?$filter=runtime lt 120

SPARQL

```
CONSTRUCT {
  ?v1 ?v1_p ?v1_o .
  ?v1 ods:variable-binding “v1” .
} WHERE {
  ?v1 ?v1_p ?v1_o .
  SELECT {
    ?v1 WHERE {
      ?v1  p:runtime ?v2 .
      FILTER(?v2 < 120) .
   } LIMIT 100
}
```

Current State

- Proof of concept
  - Built on MS libraries for OData v3
- TODO:
  - Fill in some missing pieces of support
  - Update to a v4 parser / serialization library
  - Implement what we can of v4's new features
  - Implement proxy caching of SPARQL results to improve performance

CONCLUSION

Conclusion

- RDF doesn’t have to be hard for developers to use
- Bridging the gap between Open and Closed World really helps
- This can apply both at the language level and the protocol level

http://BrightstarDB.com/

https://github.com/BrightstarDB/BrightstarDB

http://brightstardb.readthedocs.org/

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