Graph Analytics for Subject-Matter Experts: Or, Connecting Graph Analytics to the Data that Needs It

Steve Reinhardt
spr@YarcData.com

The uRiKA developers are extending SPARQL's excellent graph-matching capabilities with global graph-analytic operations, via an interface that researchers can use to plug in their own algorithms.

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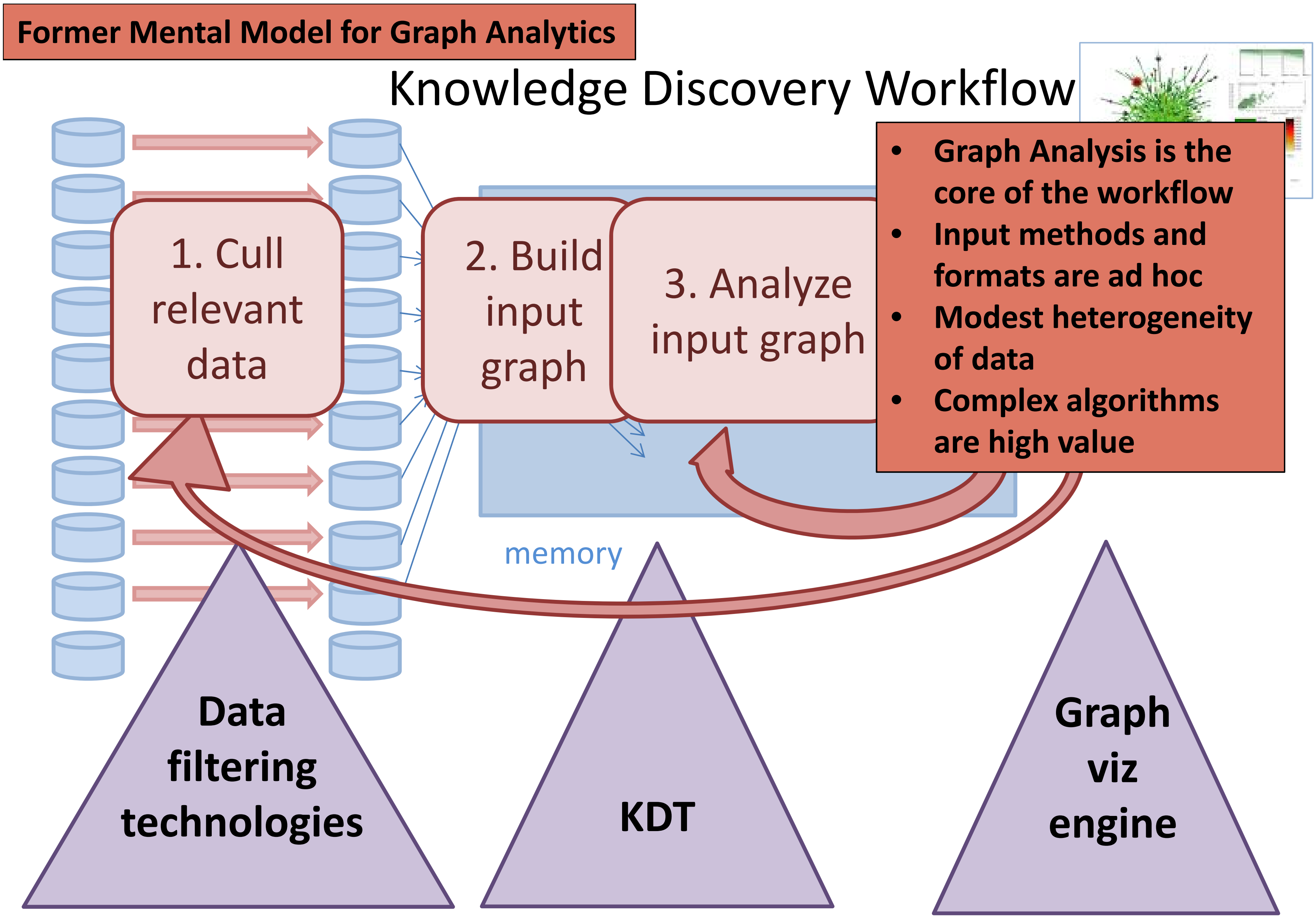
Agenda

- How I viewed graph analytics while working on KDT
- How I view graph analytics while working on uRiKA
- Extending SPARQL for global operations

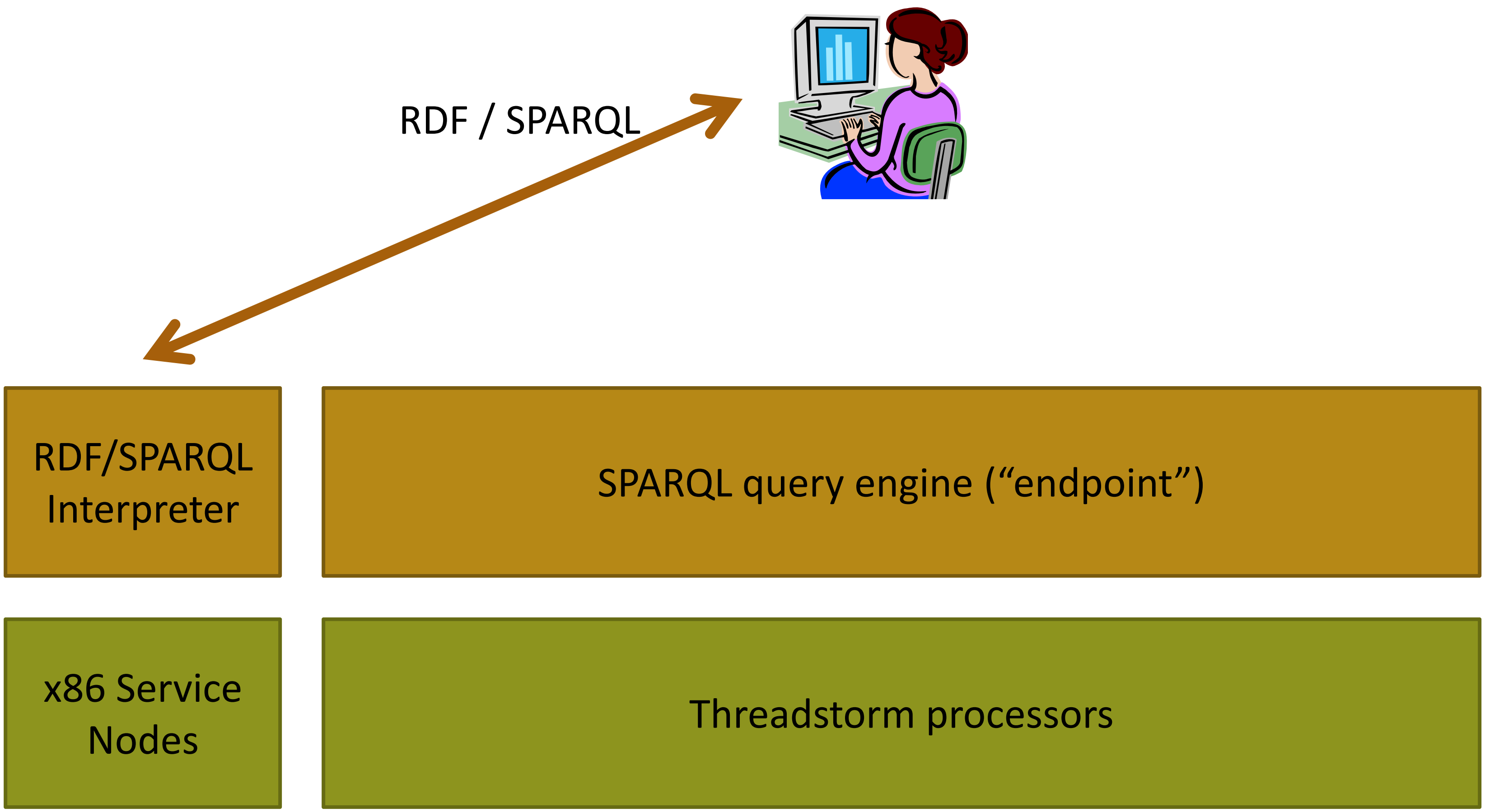

Former Mental Model for Graph Analytics
Knowledge Discovery Workflow
1. Cull relevant data
2. Build input graph
3. Analyze input graph
memory
• Graph Analysis is the core of the workflow
• Input methods and formats are ad hoc
• Modest heterogeneity of data
• Complex algorithms are high value
Data filtering technologies
KDT
Graph viz engine

Current Mental Model for Graph Analytics

Workflow

- Extracting, representing, and converting data as a graph is hard
- The data (both vertices and edges) in the graph will be highly heterogeneous
- Complex algorithms are high value
- Reasoning about data is an important capability
- The RDF/SPARQL community is investing heavily to make those technologies do steps 1, 2, and part of 3 very well
- How can we build on that investment to make graph analytics more widely usable?

uRiKA Architecture



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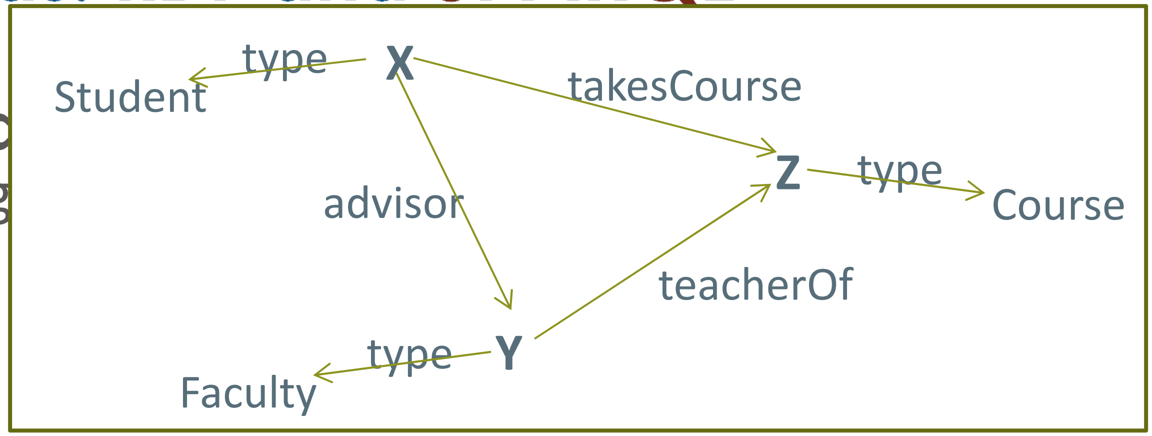
Emerging Standards: RDF and SPARQL

- **Resource Description Framework (RDF)**
  - Designed to enable a) semantic web searching and b) integration of disparate data sources
  - W3C standard formats
  - Every datum represented as subject/predicate/object(/graph)
    - Ideally with each of those expressed with a URI
  - Standard ontologies in some domains
    - *e.g.*, SnoMED/CT for clinical medical terms
  - Example:

```
<ncbitax:NCBITaxon_8401>   rdf:type          owl:Class   .
<ncbitax:NCBITaxon_1954>   rdfs:subClassOf   <ncbitax:NCBITaxon_185881>   .
<ncbitax:NCBITaxon_8681>   rdfs:label        "Characiformes sp. BOLD:AAG5151"@en .
<http://cs.org/pDNS#2>     cs:hasQueryDomain <http://cs.org/domain#ns1.secure.net>   .
nf:NetflowRecord_2         nf:hasDstAddr
                                   <http://netflow.org/nf#IPAddress_255.255.23.18>   .
```

Emerging Standards: RDF and SPARQL

- **SPARQL Protocol and**
  - Enables matching of g
  - Reminiscent of SQL
  - **Minimal ability to do**




```
# Lehigh University BenchMark (LUBM) Query 9
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX ub: <http://www.lehigh.edu/~zhp2/2004/0401/univ-bench.owl#>
SELECT ?X, ?Y, ?Z
WHERE
{?X rdf:type ub:Student .
 ?Y rdf:type ub:Faculty .
 ?Z rdf:type ub:Course .
 ?X ub:advisor ?Y .
 ?Y ub:teacherOf ?Z .
 ?X ub:takesCourse ?Z .
}
```

PREFIX == shorthand for a URI

variables to be returned from the query

"find each student who took a course from her advisor"

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Example: Betweenness Centrality on Semantic Graph

- Choose only vertices representing people, and edges between those vertices representing phone calls and text messages during the last hour
- Calculate BC for the vertices in the graph created by those vertices and edges

```
# in KDT
def vfilter(self, vTypes):
    return self.type in vTypes

def efilter(self, eTypes, sTime, eTime):
    return (self.type in eTypes) and ((self.sTime > sTime) and (self.eTime < eTime))

wantedVTypes = (People)
wantedETypes = (PhoneCall, TextMessage)
start = dt.now() – dt.timedelta(hours=1)
end = dt.now()
bc = G.centrality(‘BC’,filter=((vfilter, wantedVTypes),(efilter, wantedETypes, start, end)))
```

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Example: Betweenness Centrality on Semantic Graph (2)

```
# in SPARQL
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX comm: <http://www.comm.org#>      # a fictional communication ontology
SELECT ?p1, ?p2
WHERE
{ ?p1 rdf:type foaf:Person .
  ?p2 rdf:type foaf:Person .
  { ?call rdf:type comm:PhoneCall . } UNION { ?call rdf:type comm:TextMessage .}
  ?call comm:hasCaller ?p1 .
  ?call comm:hasCallee ?p2 .
  ?call comm:hasTime ?time
  FILTER ( ?time > xsd:dateTime("2012-07-11T09:30:00Z") )
}
#
# Here, need to do betweenness centrality, but no good interface
#
```

Example 2: More-complicated pattern

- Choose people via a more complicated pattern, e.g. only Students from LUBM Query 9

```
# in KDT
<<No way to do this today>>
def vfilter(self, vTypes):
    return self.type in vTypes

def efilter(self, eTypes, sTime, eTime):
    return (self.type in eTypes) and ((self.sTime > sTime) and (self.eTime < eTime))

wantedVTypes = (People)
wantedETypes = (PhoneCall, TextMessage)
start = dt.now() – dt.timedelta(hours=1)
end = dt.now()
bc = G.centrality(‘BC’,filter=((vfilter, wantedVTypes),(efilter, wantedETypes, start, end)))
```

Example: More-complicated pattern (2)

```
# in SPARQL
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX comm: <http://www.comm.org#>         # a fictional communication ontology
SELECT ?x, ?call
WHERE
{ ?X rdf:type ub:Student .
  ?Y rdf:type ub:Faculty .
  ?Z rdf:type ub:Course .
  ?X ub:advisor ?Y .
  ?Y ub:teacherOf ?Z .
  ?X ub:takesCourse ?Z .
  { ?call rdf:type comm:PhoneCall . } UNION { ?call rdf:type comm:TextMessage .}
  ?call comm:hasCaller ?X .
  ?call comm:hasCallee ?p2 .
  ?call comm:hasTime ?time
  FILTER ( ?time > xsd:dateTime("2012-07-11T09:30:00Z") )
}
#
# Here, need to do betweenness centrality, but no good interface
#
```

Extending Global Operations in SPARQL

- SPARQL already has the idea of global graph operations

```
SELECT ?var1 ?var2
WHERE
{   …
} ORDER BY ?var ?var2
```

or

```
SELECT ?var1 ?var2
WHERE
{   …
} GROUP BY ?var ?var2
```

- … we just need to denote the right function, inputs, and outputs
- One possibility: property functions
  - Can be defined externally just as any other RDF object
  - (Obviously) needs to point to a function that can be executed within the SPARQL endpoint
  - Syntax

```
(?in1 ?in2 … ) <function-name> (?out1 ?out2 … )
```

Example: BC in SPARQL

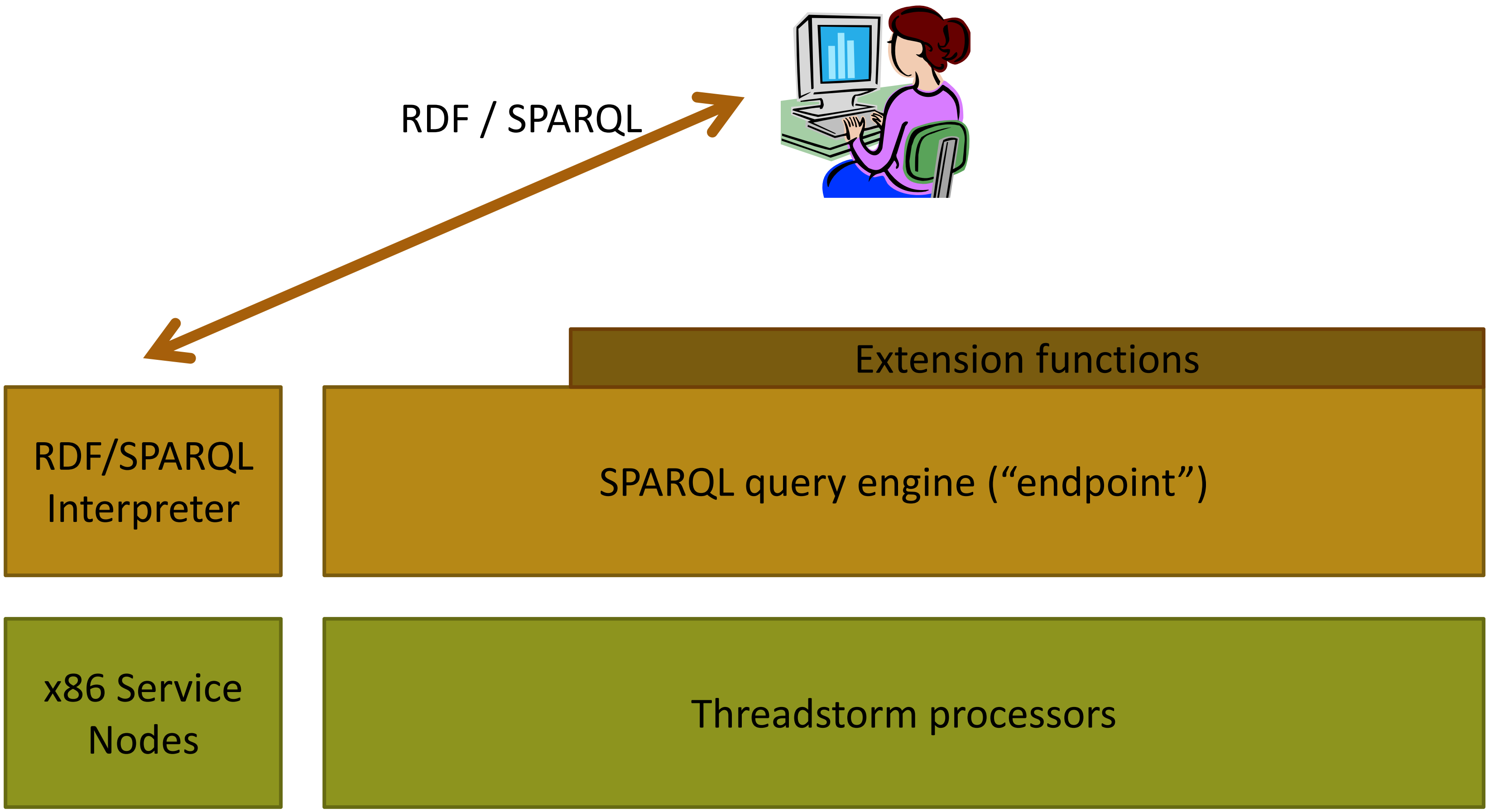
```
# in SPARQL
PREFIX rdf:  <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX comm: <http://www.comm.org#>   # a fictional communication ontology
PREFIX ga:   <http://www.graphanalytics.org#>  # graph-analytic operation identifiers
SELECT ?X, ?call, ?bc
WHERE
{ ?X rdf:type ub:Student .
  ?Y rdf:type ub:Faculty .
  ?Z rdf:type ub:Course .
  ?X ub:advisor ?Y .
  ?Y ub:teacherOf ?Z .
  ?X ub:takesCourse ?Z .
  { ?call rdf:type comm:PhoneCall . } UNION { ?call rdf:type comm:TextMessage .}
  { ?call comm:hasCaller ?X . } UNION { ?call comm:hasCallee ?X . }
} ORDER BY (?call ?X) ga:BC (?bc ?X)
```

Key Points

- **The set of functions will be extensible**
  - (Still need to point to function(s) that can execute within the SPARQL endpoint!)
- **APIs will be provided so that researchers can implement their own functions**
  - Think CombBLAS or Mex

- **SPARQL extended with global graph ops provides a mechanism for graph-analytic researchers to test their algorithms on real data at scale**
- **If you're interested in using this interface, please contact me**

uRiKA Architecture with Extensions



YarcData $100K Graph-Analytic Challenge

- A challenge to focus attention on big-data graph analytics with societal value
- Solutions via RDF and SPARQL
- Submissions open now until Sep 15, 2012
- Criteria: importance and complexity of the problem, scalability and performance of solution, innovativeness of solution
- $70K first prize, $13K, $8K, $3K, $3K, $3K
- http://yarcdata.com/graph-analytic-challenge.html

The uRiKA developers are extending SPARQL's excellent graph-matching capabilities with global graph-analytic operations, via an interface that researchers can use to plug in their own algorithms.

Learn More

- SPARQL by Example tutorial, by Lee Feigenbaum,
  http://www.cambridgesemantics.com/2008/09/sparql-by-example/
- Search RDF data with SPARQL, by Philip McCarthy
  http://www.ibm.com/developerworks/xml/library/j-sparql/
- Semantic Web for the Working Ontologist, by Dean Allemang and James Hendler, ISBN 978-0123859655
- Learning SPARQL, by Bob DuCharme, O'Reilly,
  ISBN 978-1-449-30659-5

- RDF: www.w3.org/**RDF/**
- SPARQL: www.w3.org/TR/rdf-**sparql**-query/

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