Simplified RDB2RDF Mapping

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Outline

1. *Motivation*
2. *R2RML in a Nutshell*
3. *SML in a Nutshell*
4. *SML Step by Step Example*
5. *Evaluation*

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Motivation - RDB2RDF Approaches

Several tools exist that implemented different approaches for mapping relational databases to RDF, of which R2RML became a W3C standard (http://www.w3.org/TR/r2rml/).

```
map:eventTitle a d2rq:PropertyBridge;
    d2rq:belongsToClassMap map:
         Conference;
    d2rq:property :eventTitle;
    d2rq:column "Conferences.Name";
    d2rq:datatype xsd:string;
```

D2RQ

```
graph <http://localhost/testdata/
     products#>
subject prd:product_iri(PRODUCT.
     PRODUCT_ID)
predicate rdf:type
object prd:Product
```

Virtuoso RDF views

```
[MappingDeclaration] @collection [[
  mappingId     Book collection
  target        :BID_{id} a :Book .
  source        SELECT id FROM books
]]
```

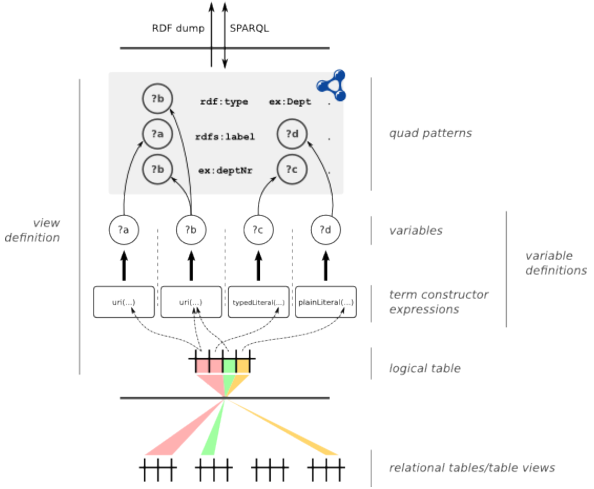
Ontop

```
<#emps>
  rr:logicalTable [
    rr:tableName "employees"
  ] ;
  rr:subjectMap [
    rr:template "http://ex.org/{id}"
    rr:class foaf:Person
  ] .
```

R2RML

From Tables to Triples

All these approaches iterate tables and on every row they first create RDF terms and then arrange them to triples:



Our Approach

- In SQL, there is the well known `CREATE VIEW` statement to create views from tables and other views.

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Our Approach

- In SQL, there is the well known `CREATE VIEW` statement to create views from tables and other views.
- Quad stores essentially use a table with four columns to store RDF data.
- Current RDB2RDF approaches are quite different from how views are created in SQL.
- Our approach is to blend the traditional SQL CREATE VIEW statements with SPARQL CONSTRUCT queries:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX ex: <http://example.org/>
CREATE VIEW emps AS
  CONSTRUCT {
    ?s a foaf:Person
  }
  With
    ?s = uri(ex:, ?id)
  From
    employees
```

Contributions

- Definition of the compact **Sparqlification Mapping Language** (SML) mapping language with equal expressiveness to R2RML

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Contributions

- Definition of the compact **Sparqlification Mapping Language** (SML) mapping language with equal expressiveness to R2RML
- A unified formal model of RDB2RDF mapping languages.
- User Study which compares SML to R2RML
- Tooling: SML/R2RML Converters and Syntax Highlighters

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R2RML in a Nutshell

An **R2RML mapping** is an RDF resource that must be described with the following properties:

- exactly one **rr:logicalTable**, which refers to the view's logical table, i.e. an SQL query, SQL table or SQL view.

Note, that R2RML offers a set of **shortcut properties**, which we do not discuss for brevity.

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- zero or more instances of **rr:predicateObjectMap**, that attach a set of predicate/object pairs using **rr:predicateMap** and **rr:objectMap** to the corresponding subject.

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- zero or more instances of **rr:predicateObjectMap**, that attach a set of predicate/object pairs using **rr:predicateMap** and **rr:objectMap** to the corresponding subject.
- Each of **rr:subjectMap**, **rr:predicateMap** and **rr:objectMap** must be further described to specify what RDF terms to create from every row of the logical table.

Note, that R2RML offers a set of **shortcut properties**, which we do not discuss for brevity.

Example of an R2RML mapping

Generic form of an R2RML mapping without the use of shortcuts:

- R2RML Example:

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

<#emps>
  rr:logicalTable [ rr:tableName "employees" ] ;
  rr:subjectMap [ rr:template "http://example.org/{id}" ];
  rr:predicateObjectMap [
    rr:predicateMap [ rr:constant rdf:type ] ;
    rr:objectMap [ rr:constant foaf:Person ]
  ] .
```

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SML in a Nutshell

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- a **CONSTRUCT** clause for which quads to create
- a **FROM** clause for the underlying logical table.
- a **WITH** clause that creates RDF terms from the columns of the logical table and assigns them to variables

SML in a Nutshell

A SML view is comprised of:

- a name
- a **CONSTRUCT** clause for which quads to create
- a **FROM** clause for the underlying logical table.
- a **WITH** clause that creates RDF terms from the columns of the logical table and assigns them to variables
- optionally, a **CONSTRAINT** clause, where URI prefixes of variables can be stated (can be used for pruning joins in SPARQL-to-SQL rewriters).

Example of an SML View

- SML Example:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX ex: <http://example.org/>
CREATE VIEW emps AS
  CONSTRUCT {
    ?s a foaf:Person
  }
  With
    ?s = uri(ex:, ?id)
  From
    employees
```

Creating RDF Terms in SML and R2RML

SML RDF term constructor	R2RML term map
`bNode(?COL)`	`... [ rr:column "COL" ; rr:termType rr:blankNode ]`
`bNode(expr)`	`... [ rr:template "asTemplate(expr)" ; rr:termType rr:blankNode ]`
`uri(expr)`	`... [ rr:(constant|column|template) "asTemplate(expr)"; rr:termType rr:IRI ]`
`plainLiteral(?COL)`	`... [ rr:column "COL" ]`
`plainLiteral(expr)`	`... [ rr:template "asTemplate(expr)" ]`
`typedLiteral(?COL, xsd:int)`	`... [ rr:column "COL" ; rr:datatype xsd:int ]`
`typedLiteral(expression, xsd:int)`	`... [ rr:template "asTemplate(expr)" ; rr:datatype xsd:int ]`

Table : Transformation of SML term constructors to R2RML term maps

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SML Mapping Example

- The following slides demonstrate how to map relational data to RDF with the Sparqlification Mapping Language (SML).
- Thereby, these prefixes are used:

Prefixes	
prefix	**IRI**
rdfs	`http://www.w3.org/2000/01/rdf-schema#`
ogc	`http://www.opengis.net/ont/geosparql#`
geom	`http://geovocab.org/geometry#`
lgd	`http://linkedgeodata.org/triplify/`
lgd-geom	`http://linkedgeodata.org/geometry/`

SML - Mapping Example: The Goal (1/4)

Input Table

nodes	
id	**geom**
1	POINT(0 0)
2	POINT(1 1)

- How to map tables to RDF?
  - How to introduce the commonly used distinction in GIS between feature and geometry?

Aimed for RDF Output

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
...

lgd:node1 geom:geometry lgd-geom:node1 .
lgd:node2 geom:geometry lgd-geom:node2 .

lgd-geom:node1 ogc:asWKT "POINT(0 0)"^^ogc:wktLiteral .
lgd-geom:node2 ogc:asWKT "POINT(1 1)"^^ogc:wktLiteral .
```

SML - Mapping Example: SML Syntax Outline (2/4)

Input Table

nodes	
id	**geom**
1	POINT(0 0)
2	POINT(1 1)

```
Create View myNodesView As
  Construct {
    ...
  }
  With
    ...
  From
    ...
```

Aimed for RDF Output

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
...

lgd:node1 geom:geometry lgd-geom:node1 .
lgd:node2 geom:geometry lgd-geom:node2 .

lgd-geom:node1 ogc:asWKT "POINT(0 0)"^^ogc:wktLiteral .
lgd-geom:node2 ogc:asWKT "POINT(1 1)"^^ogc:wktLiteral .
```

SML - Mapping Example: Construct and From (3/4)

Input Table

nodes	
id	**geom**
1	POINT(0 0)
2	POINT(1 1)

```
Create View myNodesView As
  Construct {
    ?n geom:geometry ?g .
    ?g ogc:asWKT ?o
  }
  With
    ...
  From
    nodes
```

Aimed for RDF Output

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
...

lgd:node1 geom:geometry lgd-geom:node1 .
lgd:node2 geom:geometry lgd-geom:node2 .

lgd-geom:node1 ogc:asWKT "POINT(0 0)"^^ogc:wktLiteral .
lgd-geom:node2 ogc:asWKT "POINT(1 1)"^^ogc:wktLiteral .
```

SML - Mapping Example: Complete! (4/4)

Input Table

nodes	
id	**geom**
1	POINT(0 0)
2	POINT(1 1)

```
Create View myNodesView As
  Construct {
    ?n geom:geometry ?g .
    ?g ogc:asWKT ?o
  }
  With
    ?n = uri(lgd:node, ?id)
    ?g = uri(lgd-geom:node, ?id)
    ?o = typedLiteral(?geom,
                      ogc:wktLiteral)
  From
    nodes
```

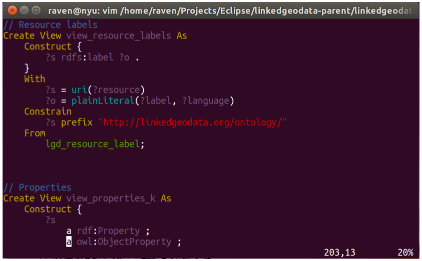
Aimed for RDF Output

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
...
lgd:node1 geom:geometry lgd-geom:node1 .
lgd:node2 geom:geometry lgd-geom:node2 .

lgd-geom:node1 ogc:asWKT "POINT(0 0)"^^ogc:wktLiteral .
lgd-geom:node2 ogc:asWKT "POINT(1 1)"^^ogc:wktLiteral .
```

Website: `http://sml.aksw.org`

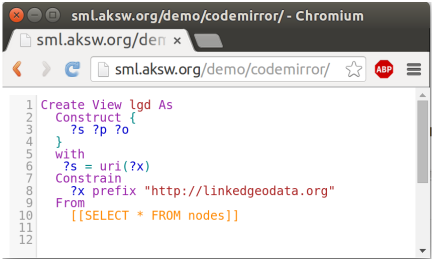
- R2RML $\leftrightarrow$ SML converter
- Syntax Highlighters for vim and CodeMirror (a JavaScript IDE component; used in the user study).
- SML in use at LinkedGeoData and Panlex


raven@nyu: vim /home/raven/Projects/Eclipse/linkedgeodata-parent/linkedgeodat

```
// Resource labels
Create View view_resource_labels As
    Construct {
        ?s rdfs:label ?o .
    }
    With
        ?s = uri(?resource)
        ?o = plainLiteral(?label, ?language)
    Constrain
        ?s prefix "http://linkedgeodata.org/ontology/"
    From
        lgd_resource_label;



// Properties
Create View view_properties_k As
    Construct {
        ?s
            a rdf:Property ;
            a owl:ObjectProperty ;
                                                        203,13          20%
```


sml.aksw.org/demo/codemirror/ - Chromium
sml.aksw.org/den
sml.aksw.org/demo/codemirror/
ABP

```
Create View lgd As
  Construct {
    ?s ?p ?o
  }
  with
   ?s = uri(?x)
  Constrain
    ?x prefix "http://linkedgeodata.org"
  From
    [[SELECT * FROM nodes]]
```

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User Study - Goals

We performed a user study with the goal to answer the following questions:

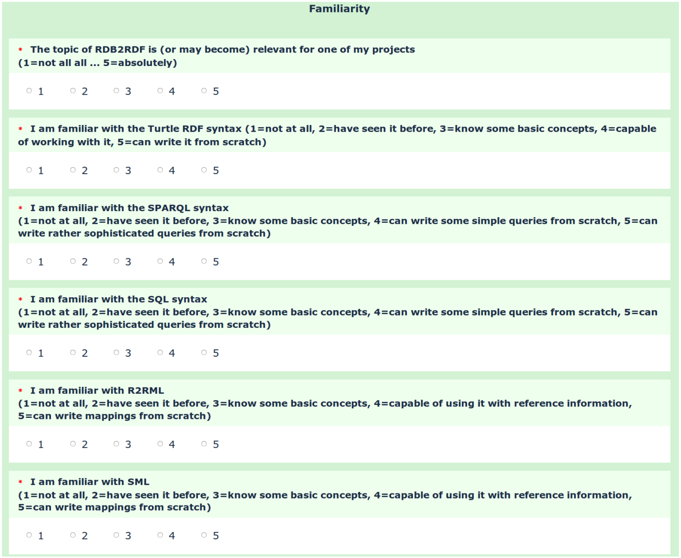
- Is SML easier to read than R2RML and does SML have a lower entry barrier than R2RML?
- Can people understand SML mappings or R2RML mappings faster?
- If given the choice, would people prefer SML or R2RML?

46 humans completed the survey of which 28 performed all tasks correctly.

User Study - Approach

- Participants first were asked to do a self-assessment on their familiarity with technologies related to RDB2RDF.
- Then they were presented 5 multiple-choice tasks each for R2RML and SML (10 tasks in total).
- Finally, after having completed the tasks, users could score their impression and preference on R2RML / SML.

User Study - Familiarity


Familiarity

* **The topic of RDB2RDF is (or may become) relevant for one of my projects (1=not all all ... 5=absolutely)**

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

* **I am familiar with the Turtle RDF syntax (1=not at all, 2=have seen it before, 3=know some basic concepts, 4=capable of working with it, 5=can write it from scratch)**

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

* **I am familiar with the SPARQL syntax (1=not at all, 2=have seen it before, 3=know some basic concepts, 4=can write some simple queries from scratch, 5=can write rather sophisticated queries from scratch)**

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

* **I am familiar with the SQL syntax (1=not at all, 2=have seen it before, 3=know some basic concepts, 4=can write some simple queries from scratch, 5=can write rather sophisticated queries from scratch)**

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

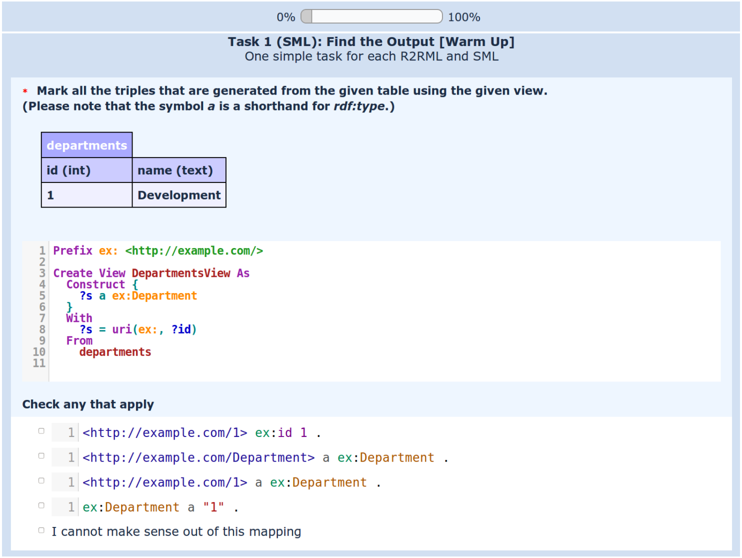
* **I am familiar with R2RML (1=not at all, 2=have seen it before, 3=know some basic concepts, 4=capable of using it with reference information, 5=can write mappings from scratch)**

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

* **I am familiar with SML (1=not at all, 2=have seen it before, 3=know some basic concepts, 4=capable of using it with reference information, 5=can write mappings from scratch)**

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

User Study - Task 1 - SML



0% 100%

Task 1 (SML): Find the Output [Warm Up]
One simple task for each R2RML and SML

* **Mark all the triples that are generated from the given table using the given view.**
(Please note that the symbol *a* is a shorthand for *rdf:type*.)

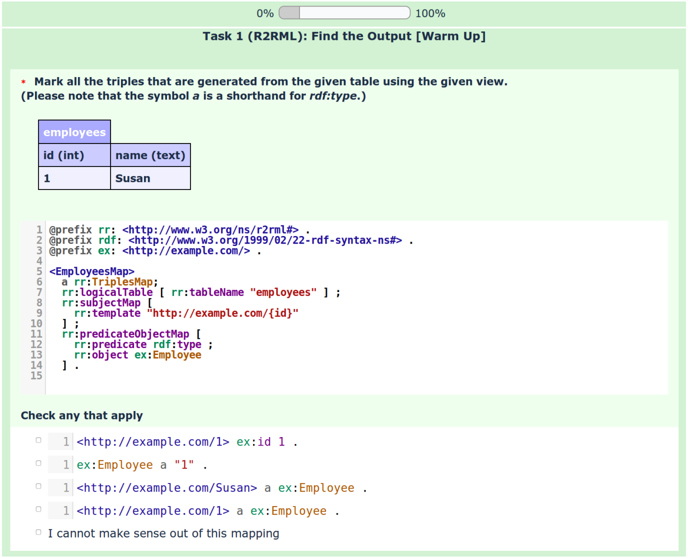
departments	
id (int)	**name (text)**
1	**Development**

```
Prefix ex: <http://example.com/>

Create View DepartmentsView As
  Construct {
    ?s a ex:Department
  }
  With
    ?s = uri(ex:, ?id)
  From
    departments

```

Check any that apply

- ▢ `<http://example.com/1> ex:id 1 .`
- ▢ `<http://example.com/Department> a ex:Department .`
- ▢ `<http://example.com/1> a ex:Department .`
- ▢ `ex:Department a "1" .`
- ▢ I cannot make sense out of this mapping

User Study - Task 1 - R2RML



0% 100%

Task 1 (R2RML): Find the Output [Warm Up]

* **Mark all the triples that are generated from the given table using the given view.**
(Please note that the symbol *a* is a shorthand for *rdf:type*.)

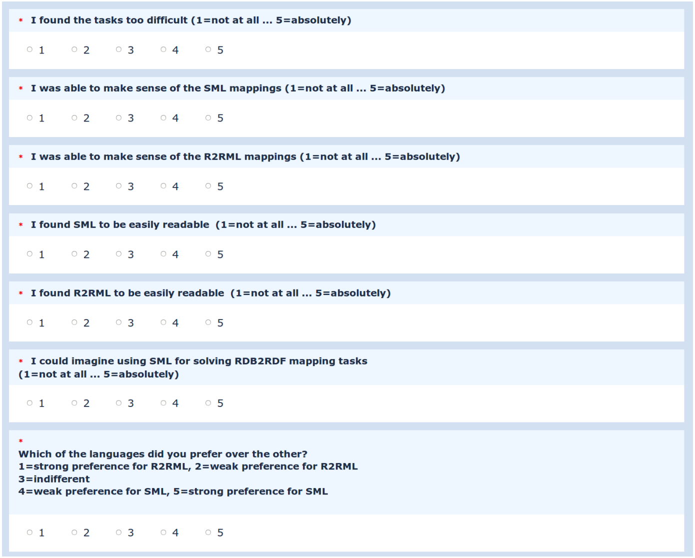
employees	
id (int)	**name (text)**
1	**Susan**

```
@prefix rr: <http://www.w3.org/ns/r2rml#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix ex: <http://example.com/> .

<EmployeesMap>
  a rr:TriplesMap;
  rr:logicalTable [ rr:tableName "employees" ] ;
  rr:subjectMap [
    rr:template "http://example.com/{id}"
  ] ;
  rr:predicateObjectMap [
    rr:predicate rdf:type ;
    rr:object ex:Employee
  ] .

```

Check any that apply

- ▢ `<http://example.com/1> ex:id 1 .`
- ▢ `ex:Employee a "1" .`
- ▢ `<http://example.com/Susan> a ex:Employee .`
- ▢ `<http://example.com/1> a ex:Employee .`
- ▢ I cannot make sense out of this mapping

User Study -



* I found the tasks too difficult (1=not at all ... 5=absolutely)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

* I was able to make sense of the SML mappings (1=not at all ... 5=absolutely)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

* I was able to make sense of the R2RML mappings (1=not at all ... 5=absolutely)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

* I found SML to be easily readable (1=not at all ... 5=absolutely)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

* I found R2RML to be easily readable (1=not at all ... 5=absolutely)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

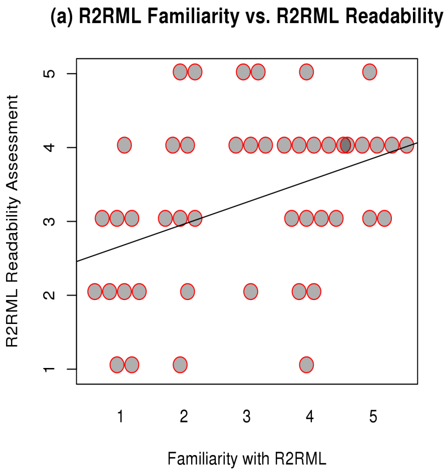
* I could imagine using SML for solving RDB2RDF mapping tasks
(1=not at all ... 5=absolutely)

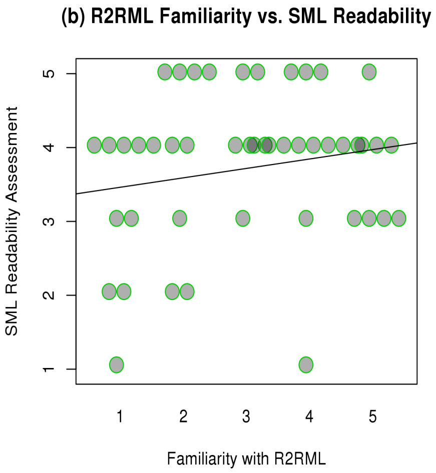
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

*
Which of the languages did you prefer over the other?
1=strong preference for R2RML, 2=weak preference for R2RML
3=indifferent
4=weak preference for SML, 5=strong preference for SML

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

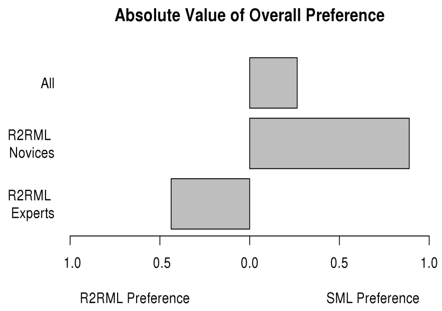
User Study - Results: Readability

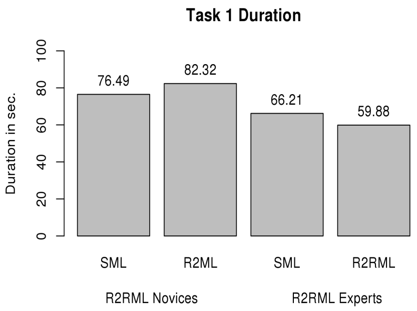




- Readability of SML better than R2RML for novices.

User Study - Results: Preference





- Novice = Self assessment in R2RML familiarity <= 3
- Expert = Self assessment in R2RML familiarity >= 4

Conclusions and Future Work

- We introduced the novel Sparqlification Mapping Language (SML) and showed how it relates to R2RML
- Evaluation shows a favor in SML by RDB2RDF novices, providing evidence that SML could simplify RDB2RDF mapping.
- We provided tooling to bridge the gap between SML and R2RML

Future Work

- More testing of the converters (WIP)
- Possibly streamline some language features, such as
    - Usage SPARQL 1.1's **strdt** and **strlang** in favor of **plainLiteral** and **typedLiteral**
    - Introduction of a **FROM QUERY** syntax instead of interpreting content of triple quotes as an SQL query.

The End - Questions/Feedback?

SML Resources: `http://sml.aksw.org`

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