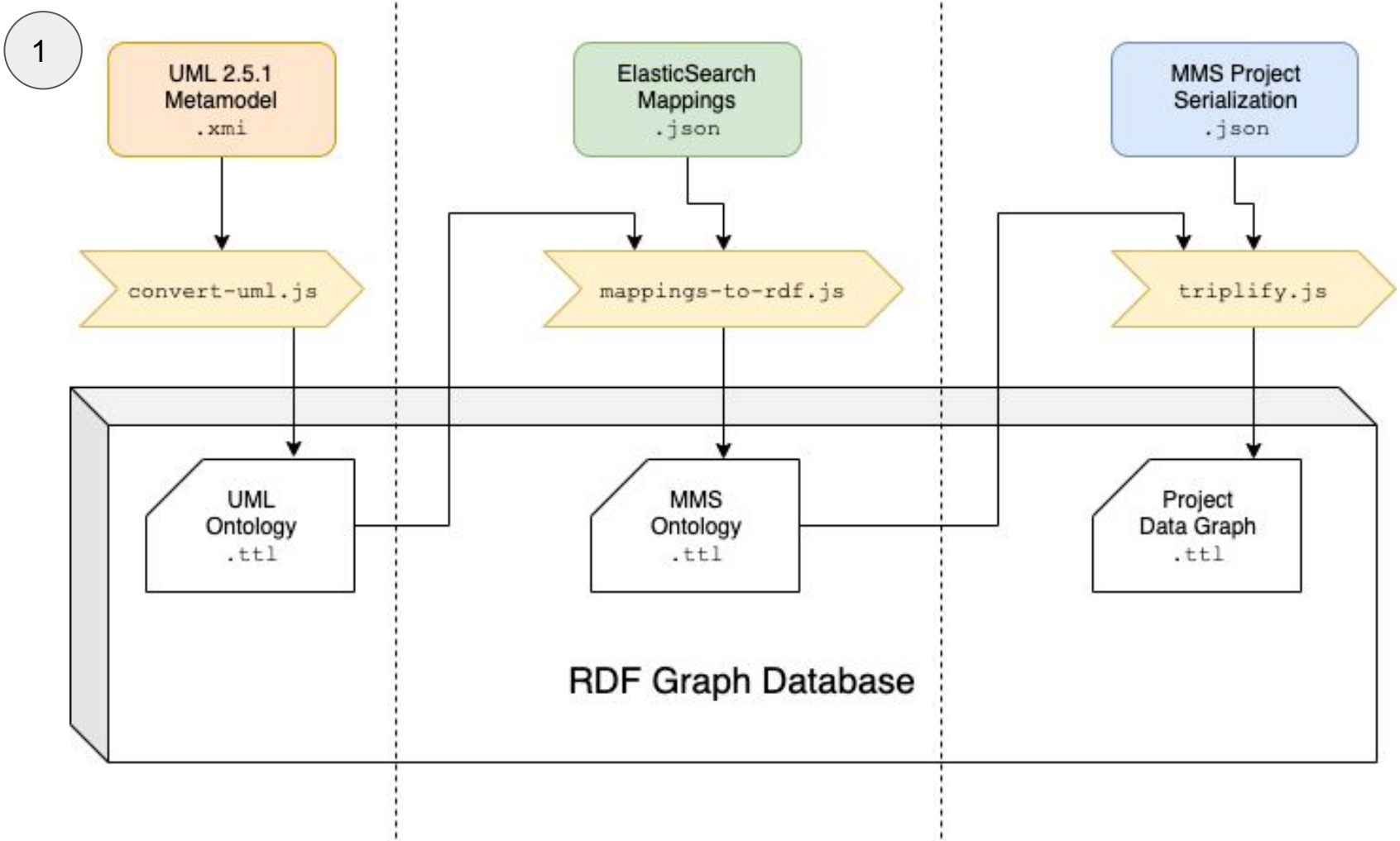
MMS in RDF

Blake Regalia


1
UML 2.5.1
Metamodel
.xmi
ElasticSearch
Mappings
.json
MMS Project
Serialization
.json
convert-uml.js
mappings-to-rdf.js
triplify.js
UML
Ontology
.ttl
MMS
Ontology
.ttl
Project
Data Graph
.ttl
RDF Graph Database

UML Metamodel Excerpt: ‘Nodes’

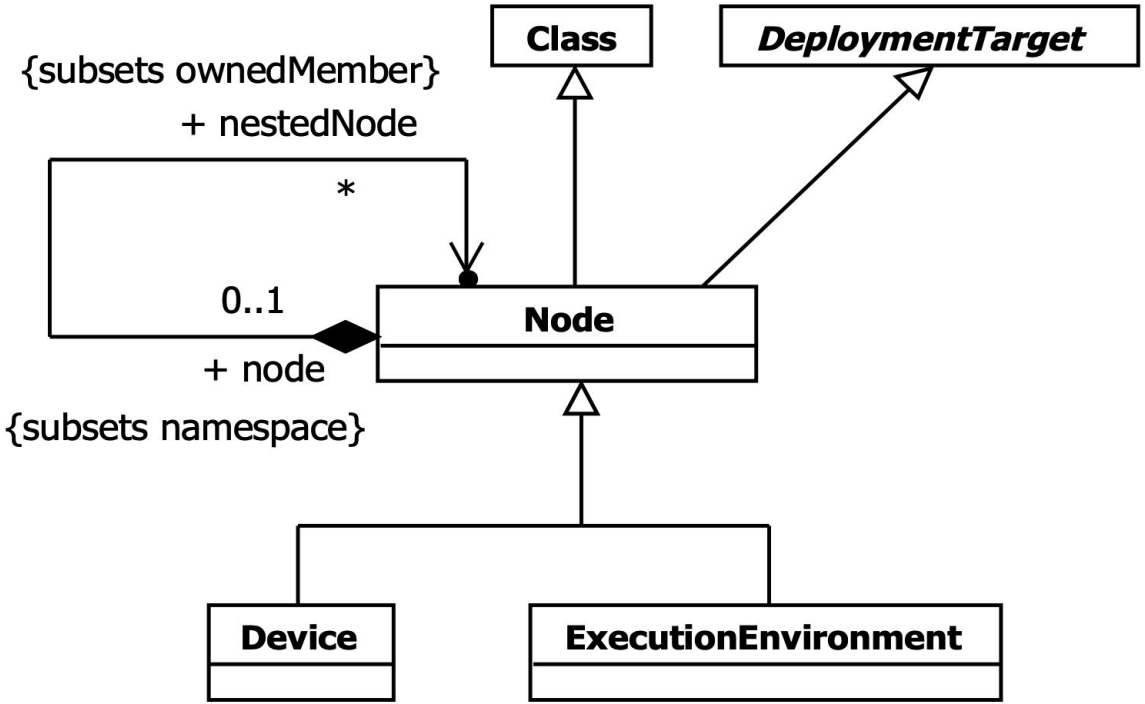
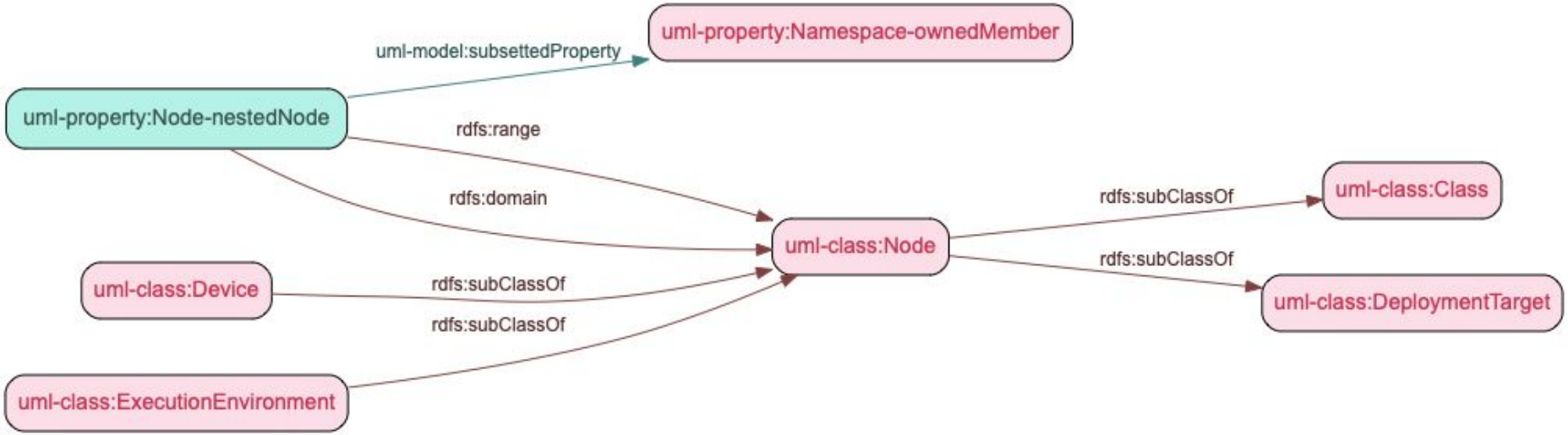
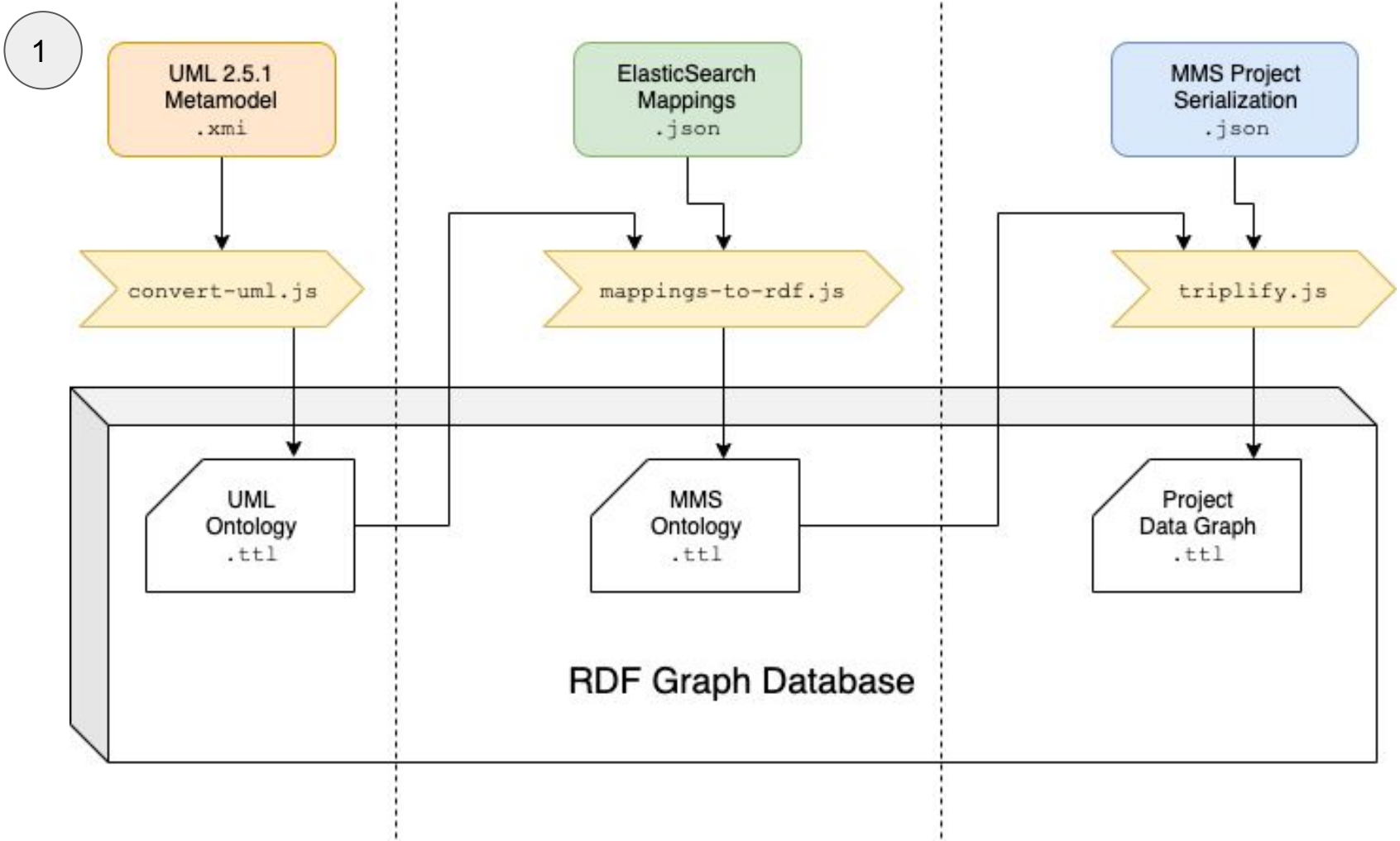


Figure 19.11 Nodes

UML ‘Nodes’ Represented in RDF



```
uml-class:Node xmi:type uml:Class ;
    xmi:id "Node" ;
    xmi:packagedElementOf uml-class:Deployments .

uml-class:Node rdfs:comment "A Node is computational resource upon which artifacts may be deployed for
    execution. Nodes can be interconnected through communication paths to define network structures."@en .

uml-class:Node rdfs:subClassOf uml-class:Class .

uml-class:Node rdfs:subClassOf uml-class:DeploymentTarget .

uml-property:Node_nestedNode xmi:type uml:Property ;
    xmi:id "Node-nestedNode" ;
    xmi:ownedAttributeOf uml-class:Node ;
    rdfs:label "Node-nestedNode" ;
    uml-model:name "nestedNode" ;
    rdfs:domain uml-class:Node ;
    uml-model:compositeAggregation true ;
    rdfs:range uml-class:Node .

uml-property:Node_nestedNode uml-model:subsettedProperty uml-property:Namespace_ownedMember .

uml-property:Node_nestedNode rdfs:comment "The Nodes that are defined (nested) within the Node."@en .

uml-property:Node_nestedNode uml-model:lowerValue uml-property:Node_nestedNode_upperValue .

uml-property:Node_nestedNode_upperValue xmi:type uml:LiteralUnlimitedNatural ;
    xmi:id "Node-nestedNode-_upperValue" ;
    uml-model:value "*" .
```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.ttl
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Ontology
.ttl
Project
Data Graph
.ttl
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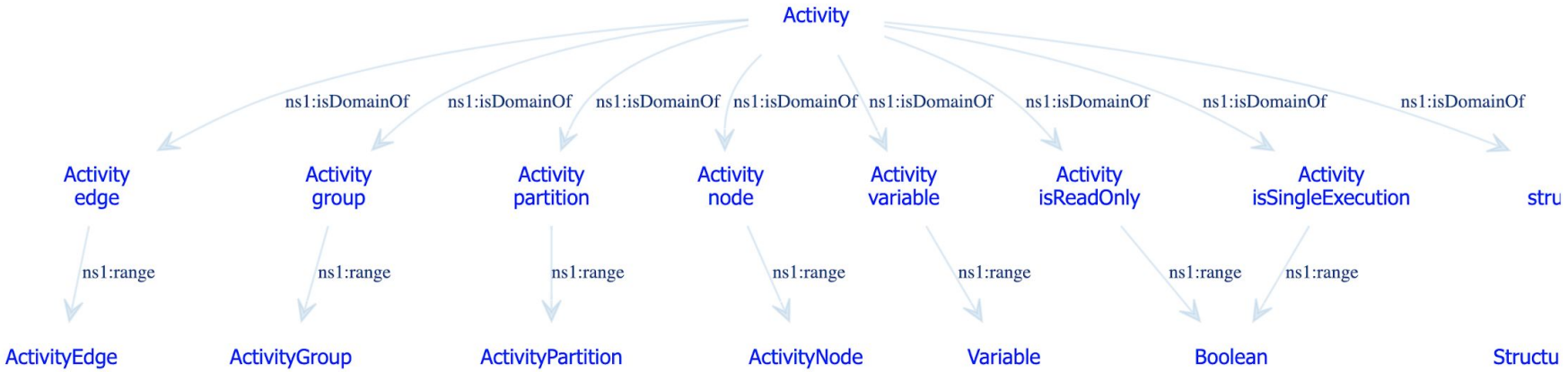
Query UML model for range of all properties that belong to an Activity

In [3]:

```
%display diagram

construct {
    ?domain :isDomainOf ?property .
    ?property :range ?range .
} from mms-graph:vocabulary {
    ?property xmi:type uml:Property ;
              rdfs:domain ?domain ;
              rdfs:range ?range .
    values ?domain {
        uml-class:Activity
    }
}
```

Display: svg



%3

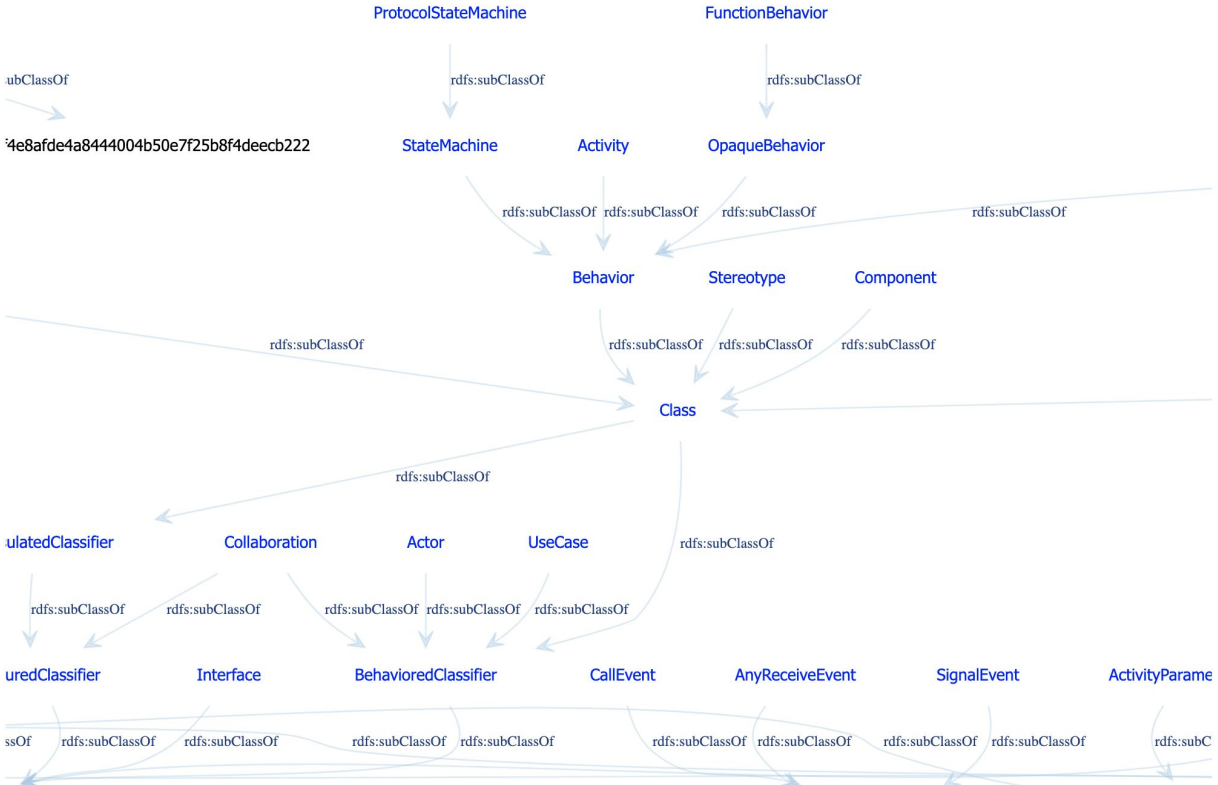
Construct diagram of UML metamodel class hierarchy

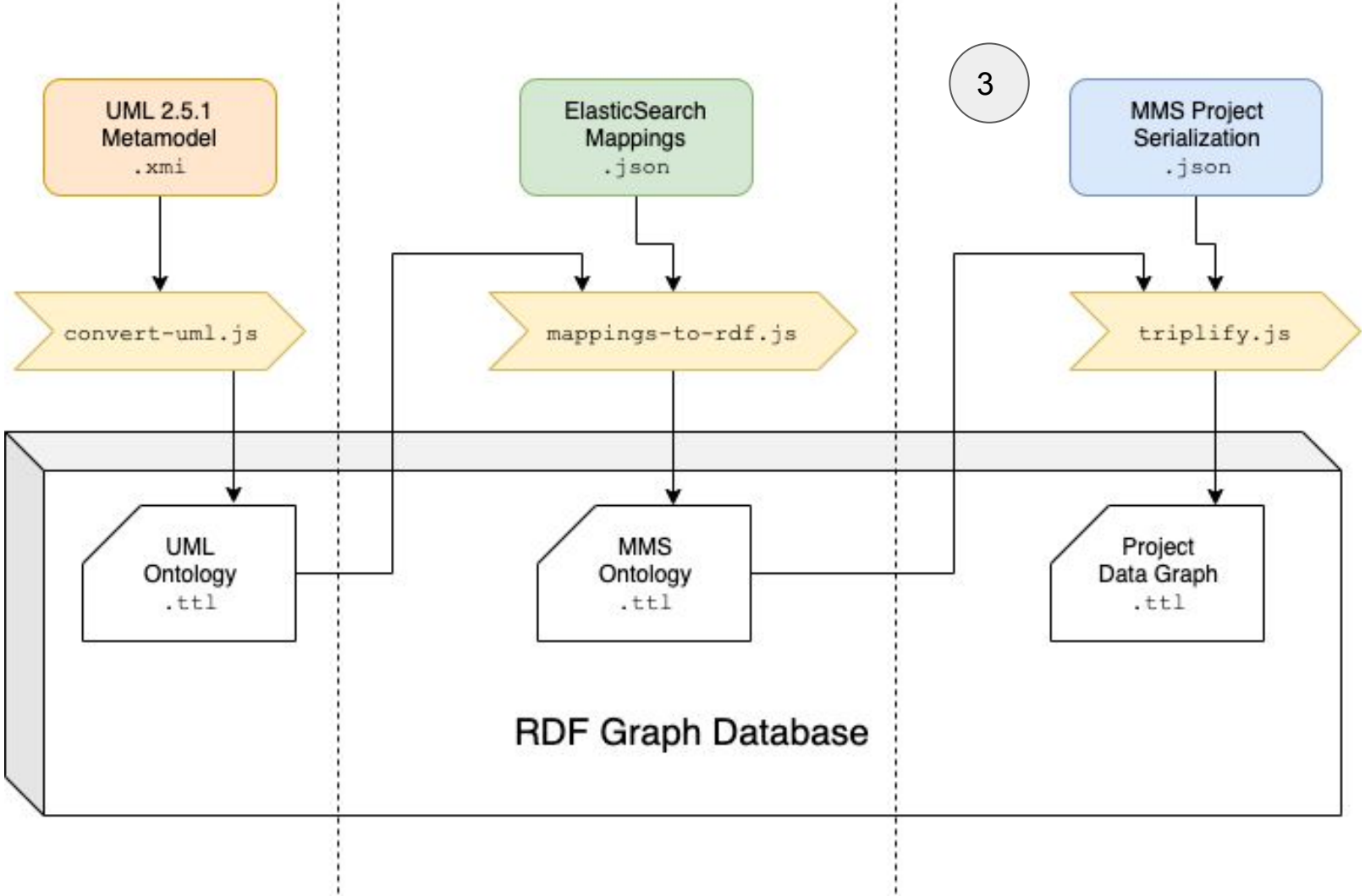
In [4]:

```
%display diagram

construct {
    ?class rdfs:subClassOf ?super .
} from mms-graph:vocabulary {
    ?class rdfs:subClassOf ?super .
}
```

Display: svg

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.ttl
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.ttl
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Model Element Data

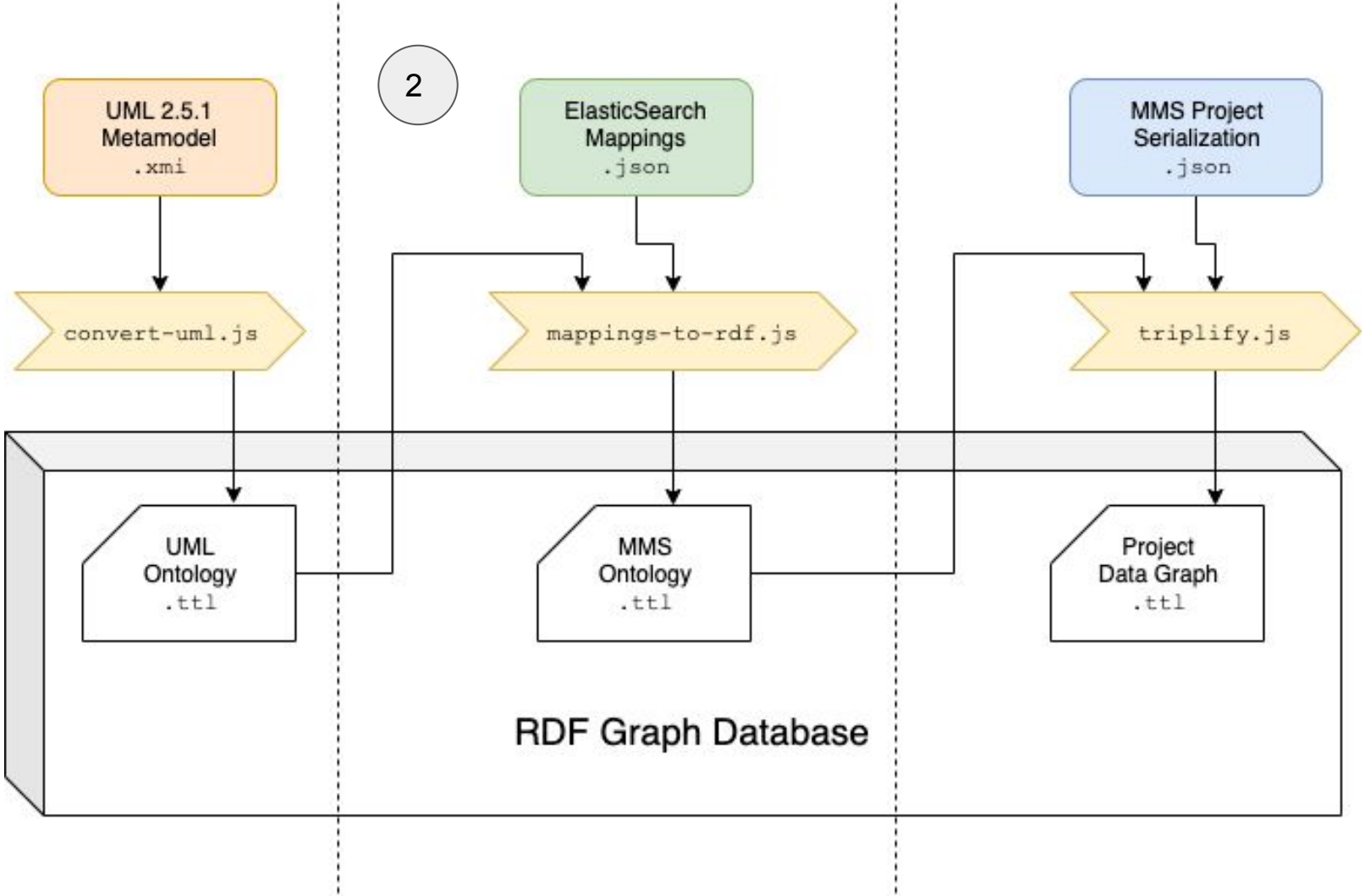
The input data source is MMS' serialization of model elements in JSON.

Keys of JSON objects represent either:

- some **UML property** -- such as the keys "isAbstract" or "targetIds".
- or some **derived property** including metadata about the commit such as: *who and when created or last modified the element, the commit id, the branch*, etc.

Need to have **knowledge** of serialization's structure in order to **transform model element data into RDF** in a way that is conformant with generated UML ontology.

```
      "_inRefIds": [
        "master"
      ],
      "structuredNodeInputIds": [],
      "localPreconditionIds": [],
      "bodyPartIds": [
        "_18_0_6_876026b_1494866664018_615922_183752",
        "_18_0_6_876026b_1494866989432_632113_183800",
        "_18_0_6_876026b_1494869500672_400531_183955"
      ],
      "_elasticId": "bf0002eb-3965-42ac-bd2f-0fc9db5fb793",
      "structuredNodeOutputIds": [],
      "nameExpression": null,
      "packageImportIds": [],
      "edgeIds": [
        "_18_0_6_876026b_1494867441408_836874_183823",
        "_18_0_6_876026b_1494869500681_910063_183957",
        "_18_0_6_876026b_1494869610935_433369_183994"
      ],
      "variableIds": [],
      "inStructuredNodeId": null,
      "_refId": "master",
      "id": "_18_0_6_876026b_1494866614221_588750_183735",
      "_modifier": "rkarbanAdmin",
      "outgoingIds": [],
      "clientDependencyIds": [],
      "handlerIds": [],
      "inActivityId": null,
      "mdExtensionsIds": [],
      "incomingIds": [
        "_18_0_6_876026b_1494865902273_651463_183694"
      ],
```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.ttl
Project
Data Graph
.ttl
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Deriving ‘MMS Ontology’: a UML Ontology Extension

Keeping the UML Ontology as is, **define a new RDF property** for each ‘relation’ that arises from applying the ElasticSearch mapping template.

A ‘relation’ in this case represents either:

- a **direct alias** of a UML property -- e.g., ‘Transition-source’ => ‘sourceVertex’
- a **reification** of a UML property to contain either a **set or list** of objects.
- or a **derived property** (such as metadata about the commit) that does not exist in the UML metamodel.

Directly Aliasing UML Properties

```
# In the original UML ontology...
uml-property:Transition_source xmi:type uml:Property ;
    xmi:id "Transition-source" ;
    rdfs:label "Transition-source" ;
    rdfs:comment "Designates the originating Vertex (State or Pse
    xmi:ownedAttributeOf uml-class:Trans
    uml-model:name "source" ;
    rdfs:domain uml-class:Transition ;
    rdfs:range uml-class:Vertex .

uml-property:DirectedRelationship_sour
    xmi:id "DirectedRelationship-source"
    rdfs:label "DirectedRelationship-so
    rdfs:comment "Specifies the source
    xmi:ownedAttributeOf uml-class:Dire
    uml-model:name "source" ;
    rdfs:domain uml-class:DirectedRelat
    rdfs:range uml-class:Element .
```

```
# In the derivative MMS ontology...
mms-property:sourceVertex a mms-ontology:UmlObjectPrope
    mms-ontology:key "sourceId" ;
    rdfs:label "sourceVertex" ;
    rdfs:comment "The Vertex that is the source of this
    rdfs:domain uml-class:Transition ;
    rdfs:range uml-class:Vertex ;
    mms-ontology:umlPropertySource uml-property:Transiti

mms-property:sourceElement a mms-ontology:UmlObjectProp
    mms-ontology:key "sourceId" ;
    rdfs:label "sourceElement" ;
    rdfs:comment "The Element that is the source of this
    rdfs:domain uml-class:DirectedRelationship ;
    rdfs:range uml-class:Element ;
    mms-ontology:umlPropertySource uml-property:Directed
```

Reified UML Properties to Sets/Lists

```
# In the original UML ontology...
uml-property:InstanceSpecification_slot xmi:type uml:Property ;
    xmi:id "InstanceSpecification-slot" ;
    xmi:ownedAttributeOf uml-class:InstanceSpecification ;
    rdfs:label "InstanceSpe
    uml-model:name "slot" ;
    rdfs:domain uml-class:I
    uml-model:compositeAggr
    rdfs:range uml-class:Sl
```

```
# In the derivative MMS ontology...
mms-property:slots a mms-ontology:UmlObjectProperty ;
    mms-ontology:key "slotIds" ;
    rdfs:label "slots" ;
    rdfs:comment "List of Slots that belong to this InstanceS
    rdfs:domain uml-class:InstanceSpecification ;
    rdfs:range mms-class:SlotsList ;
    mms-ontology:listItemRange uml-class:Slot ;
    mms-ontology:umlPropertySource uml-property:InstanceSpec

mms-class:SlotsList a owl:Class ;
    mms-ontology:category mms-class:ElementList ;
    rdfs:subClassOf [
        rdf:type owl:Class ;
        owl:intersectionOf (
            rdf:List
            [
```

Reified UML Properties to Sets/Lists cont’d

The **need for a container** is inferred from the “Ids” suffix of the mapping key label.

A **new class is created** (e.g., “SlotsList”) which defines a **list of elements** that **must be** of the given **type** (e.g., “Slot”).

Together with the **range** of the **reified property**, these assertions will enable **validation** of instance data in the eventual project graph.

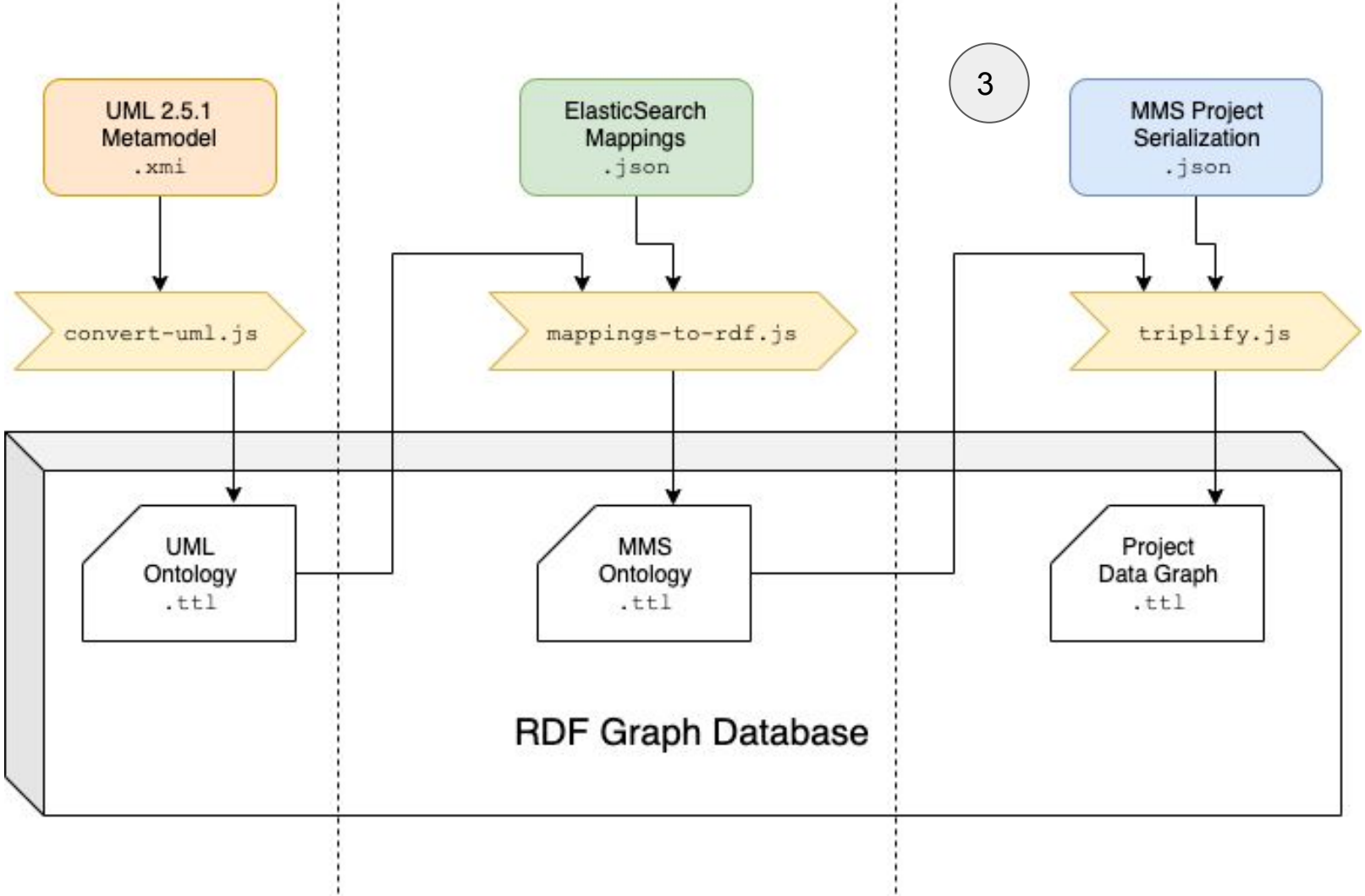
Derived Properties

```
# Derived properties that describe commit metadata
mms-property:created a mms-ontology:DerivedDatatypeProperty ;
    mms-ontology:key "_created" ;
    rdfs:label "created" ;
    rdfs:comment "Based on the key '_created'"@en ;
    rdfs:domain mms-class:Element ;
    rdfs:range xsd:dateTime ;
    mms-ontology:mappingDomain mms-class:Element .

mms-property:creator a mms-ontology:DerivedObjectProperty ;
    mms-ontology:key "_creator" ;
    rdfs:label "creator" ;
    rdfs:comment "Based on the derived property '_creator'."@en ;
    rdfs:domain mms-class:Element ;
    rdfs:range mms-class:User ;
    mms-ontology:mappingDomain mms-class:Element .
```

Derived Properties cont’d

Integrating **commit metadata** into the graph (alongside model element data) will allow users to write queries based on arbitrary constraints from **both the instance-data-level as well as the metadata-level** (...plus the metamodel level).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.ttl
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Ontology
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Project
Data Graph
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Converting Model Element Data to RDF

Triplifier script ingests MMS' serialization of the project and **queries** generated **MMS ontology** in order to **transform each element** to a set of **RDF triples**.

Each non-derived key of an object represents some specific UML property, but the label of the key **does not uniquely identify** the property. It also depends on the **type** of the element.

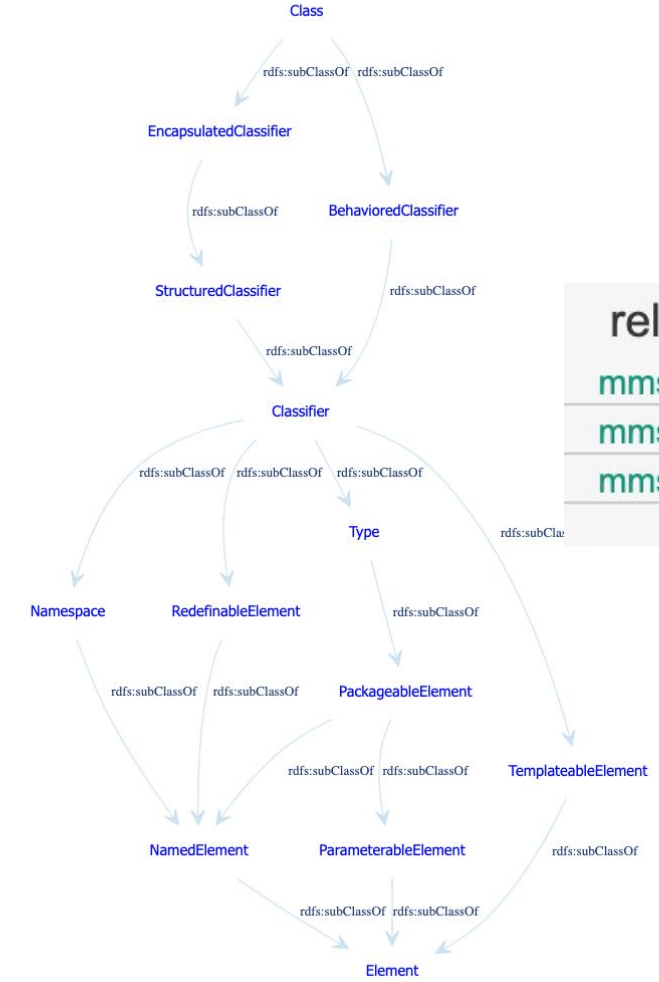
Properties that are candidates for “targetId” key

relation	domain
mms-property:targetInputPinFromSendObjectAction	uml-class:SendObjectAction
mms-property:targetInputPinFromDestroyObjectAction	uml-class:DestroyObjectAction
mms-property:targetElement	uml-class:DirectedRelationship
mms-property:targetVertex	uml-class:Transition
mms-property:targetActivityNode	uml-class:ActivityEdge
mms-property:targetInputPinFromCallOperationAction	uml-class:CallOperationAction
mms-property:targetInputPinFromSendSignalAction	uml-class:SendSignalAction

Properties that are candidates for “isAbstract” key

relation	key	class
mms-property:isAbstractClassifier	"isAbstract"	uml-class:Classifier
mms-property:isAbstractBehavioralFeature	"isAbstract"	uml-class:BehavioralFeature
mms-property:isAbstractClass	"isAbstract"	uml-class:Class

Display: svg



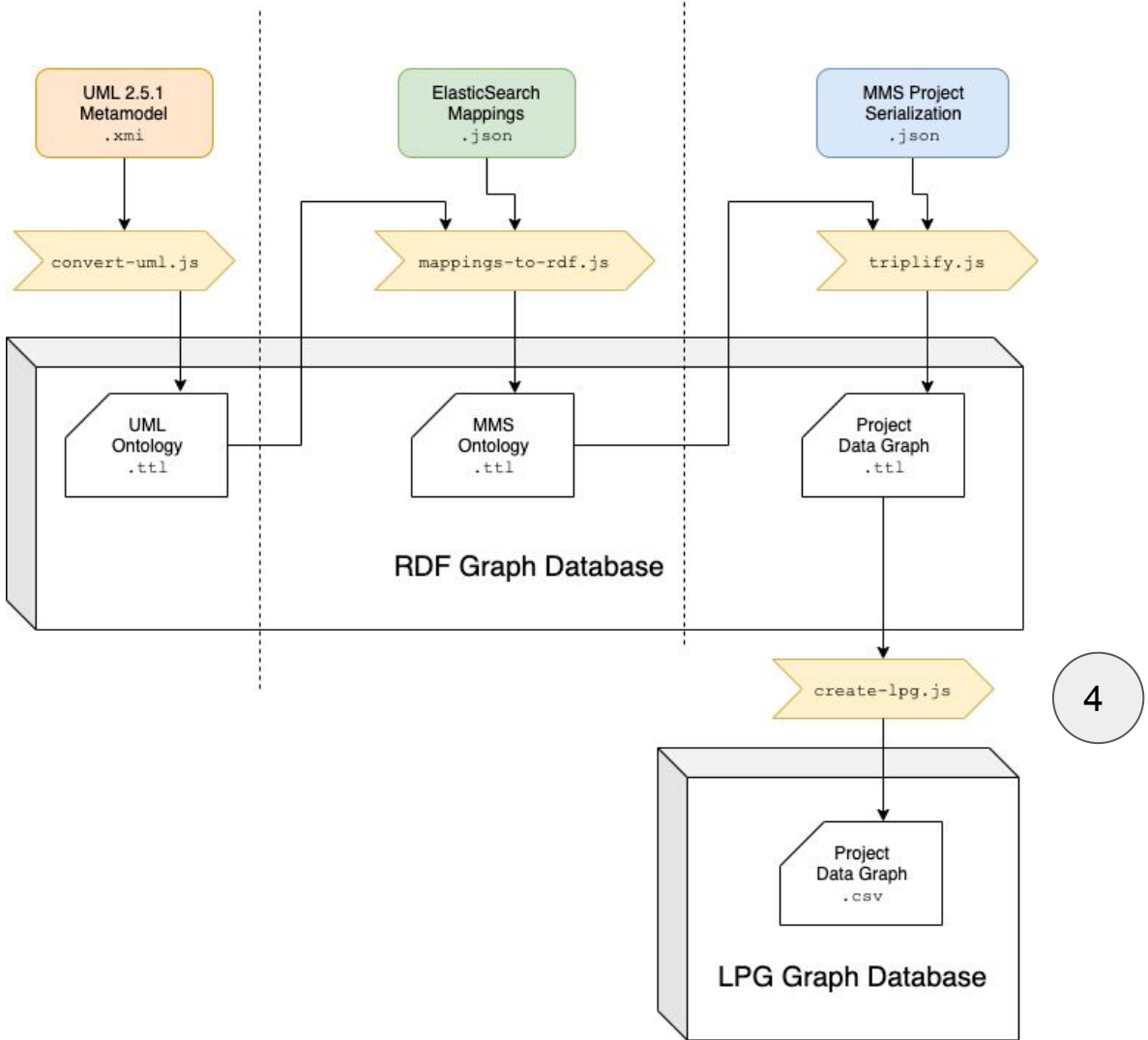
However, “Class” is a also subclass of “Classifier”...

Which relation should be used?

relation	domain
mms-property:isAbstractClassifier	uml-class:Classifier
mms-property:isAbstractBehavioralFeature	uml-class:BehavioralFeature
mms-property:isAbstractClass	uml-class:Class

Need to choose the property with the domain that is most specific to the given element type.

```
select * from mms-graph:vocabulary {
    ?property a ?propertyType ;
        mms-ontology:key ?keyLabel ;
        rdfs:domain ?propertyDomain ;
        rdfs:range ?propertyRange .

    ?propertyType rdfs:subClassOf* mms-ontology:Property .

    ?propertyDomain (^rdfs:subClassOf)* mms-class:Signal .


    # select property with most specific domain class
    filter not exists {
        ?subProperty a ?subPropertyType ;
            mms-ontology:key ?keyLabel ;
            rdfs:domain ?subPropertyDomain .

        ?subPropertyType rdfs:subClassOf* mms-ontology:Property .

        ?subPropertyDomain (^rdfs:subClassOf)* mms-class:Signal .

        filter(?subProperty != ?property)

        ?subPropertyDomain rdfs:subClassOf+ ?propertyDomain .
    }

    values ?keyLabel {
        "isAbstract"
    }
}
```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Ontology
.ttl
MMS
Ontology
.ttl
Project
Data Graph
.ttl
RDF Graph Database
create-lpg.js
Project
Data Graph
.csv
LPG Graph Database

Labeled Property Graph

A **shortcoming** of the SPARQL query language is that it **does not facilitate graph traversal** queries, such as answering the question: *“what is the shortest path between these two nodes?”*

Gremlin is a graph traversal query language for labeled property graphs (LPGs).

The RDF graph-based data model **cannot be mapped** to LPGs without making some sacrifices (i.e., the transformation will inevitably be lossy).

For example, the **ontology and metamodel are omitted** from transformation since definitions for properties cannot link to the edges which instantiate them.

Labeled Property Graph cont’d

Instead, **only the project data graph** is converted to LPG as **best they can**.

Containers such as sets/lists of objects present a challenge; edges in LPGs can only have a single value so ordered lists must be reified as ad-hoc linked lists.

The **linking of datatype nodes** within RDF literals is lost in the transformation.

Cannot query for things that are a **subClass of A**, nor relations that are **subProperties of P**. Likewise, all inherent reasoning capability is lost.