Open-Multinet Ontologies – Their Hierarchy and Tooling

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Outline

- Introduction
- Open-Multinet (OMN) Hierarchy
- OMN Ontologies
- Tools
  - OMN Converters
  - FITeagle
  - Semantic Orbit Measurement Library (OML)
- Use-cases
- Outlook

Introduction

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Issues in Federated ICT Infrastructure with Different Administrative Domains

- Currently XML is used to describe heterogeneous resources
- Arbitrary extensions to define more than links, nodes and further information are required
- XML is extensible but
  - no rule on how and in which part of the tree the extensions can be applied
  - the semantics have to be encoded in the parsing code (no reusability)

- APIs used for provisioning, monitoring and control use various data models (e.g. SFA, OMSP and FRCP)

Issues in Federated ICT Infrastructure with Different Administrative Domains

- Users can't find resources without knowing how the information was embedded
- Users have a hard time using different models in different APIs
- Developers have to hard code knowledge about the XML structure
- Developers have to hard code handovers between APIs
- Infrastructure owners are bound to the resource specification of a given federation
- Federators have to ensure that each infrastructure pushes "correct" information
- The union of two tree structures is not a tree anymore → how to merge?
- With n domains in a federation, $O(n^2)$ transformations need to be implemented

- There is a need for a canonical model

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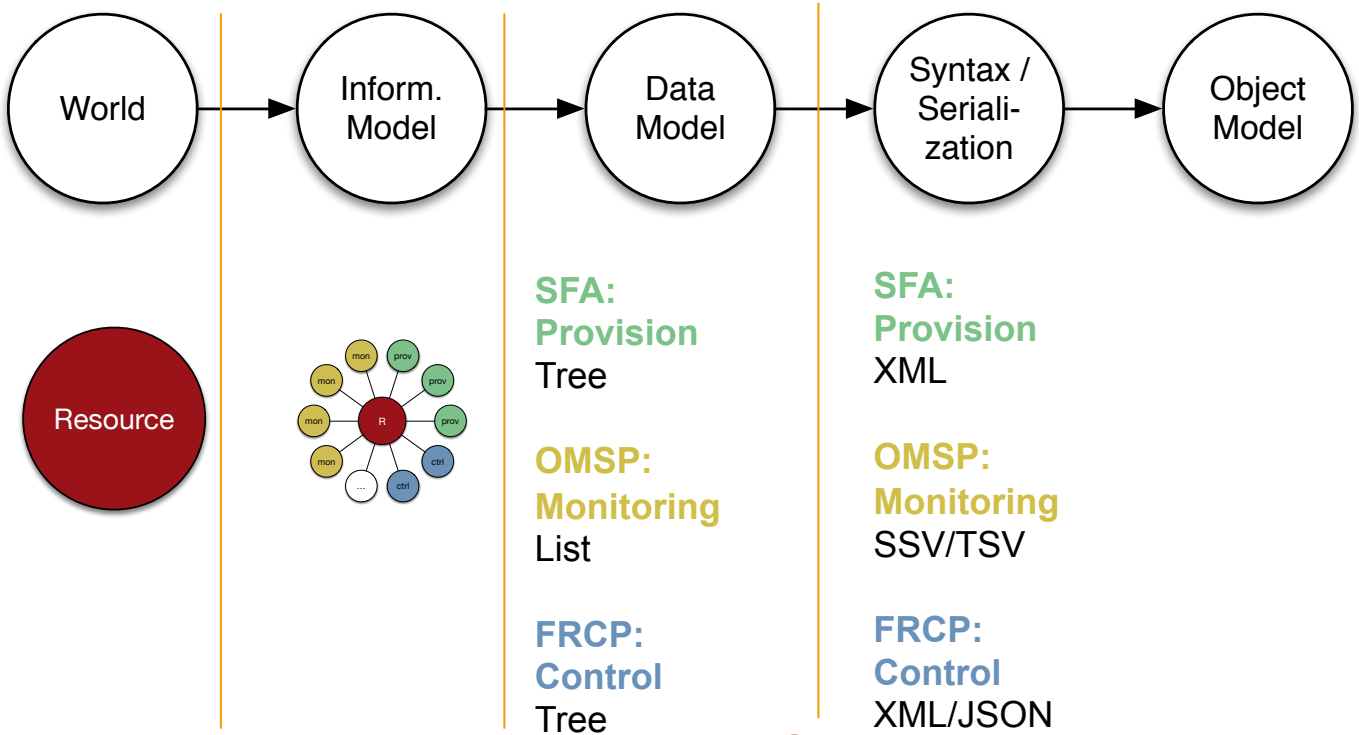
Information Modelling in GENI/FIRE Context



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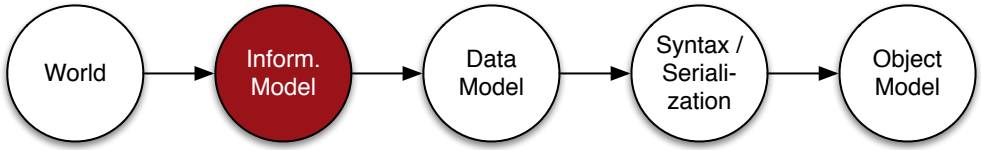
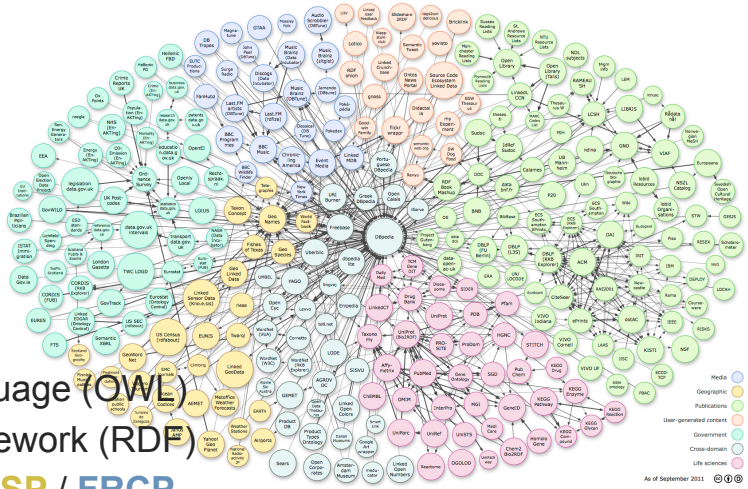
Adopting Semantic Web Research





Exploit work from the Semantic Web

1. Formal information models (ontologies) in Web Ontology Language (OWL)
2. Labeled directed graphs using the Resource Description Framework (RDF)
3. Serialize them as we like (XML, JSON, Turtle, …) → **SFA** / **OMSP** / **FRCP**
4. Find information like cloud connectivity information with SPARQL Protocol And RDF Query Language (SPARQL)
5. Automatically reason over the information to infer knowledge and overcome interoperability issues using the Semantic Web Rule Language (SWRL).

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Advantages

Tools : re-use implementations & ontologies

Linking : combine resource information (from various tools / APIs)

Validation : detect error early and explain them

Inference : express e.g. equality of resources

Queries : discover resources or complex paths (this scales!)

(usually just declarative, i.e. no code needed)

Filling the Gap

❶ Defined a set of high-level vocabularies and integration concepts

❷ Focused on integrating work from existing approaches

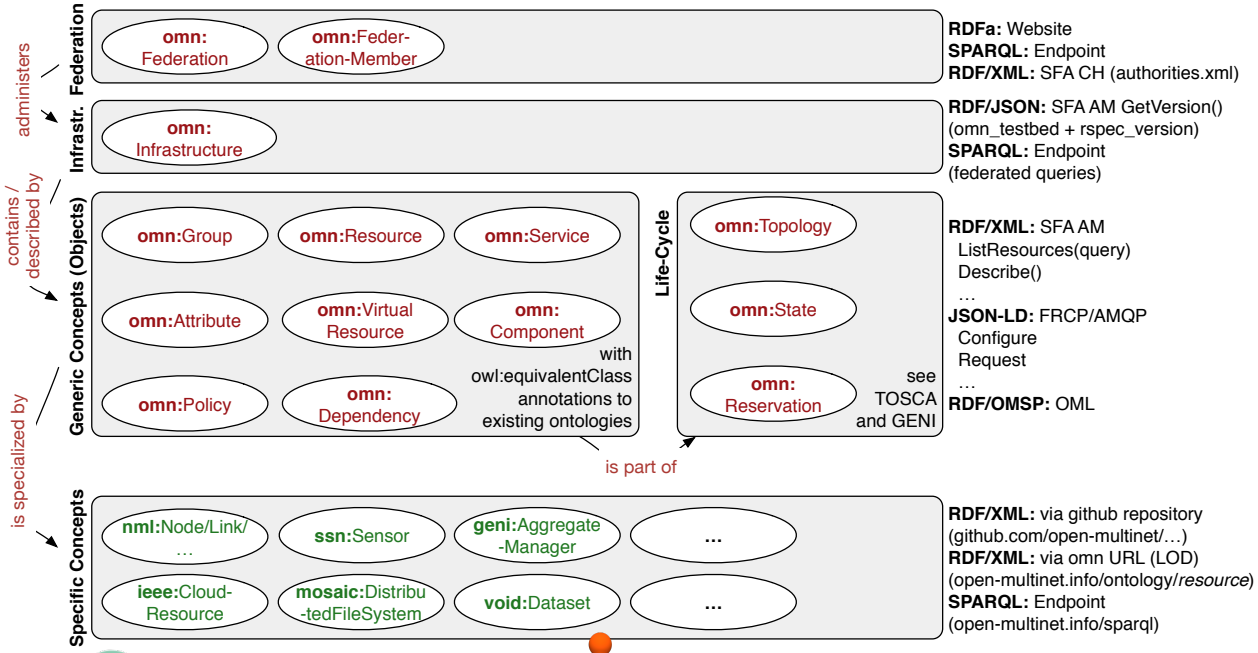
❸ Defined a formal information model for federated infrastructure management

❹ Implemented a translation mechanisms and examples to ease transition

Integration Concepts

❶ Defined a set of high-level vocabularies and integration concepts.

Integration into SFA, FRCP, OMSP, TOSCA, ETSI NFV, …



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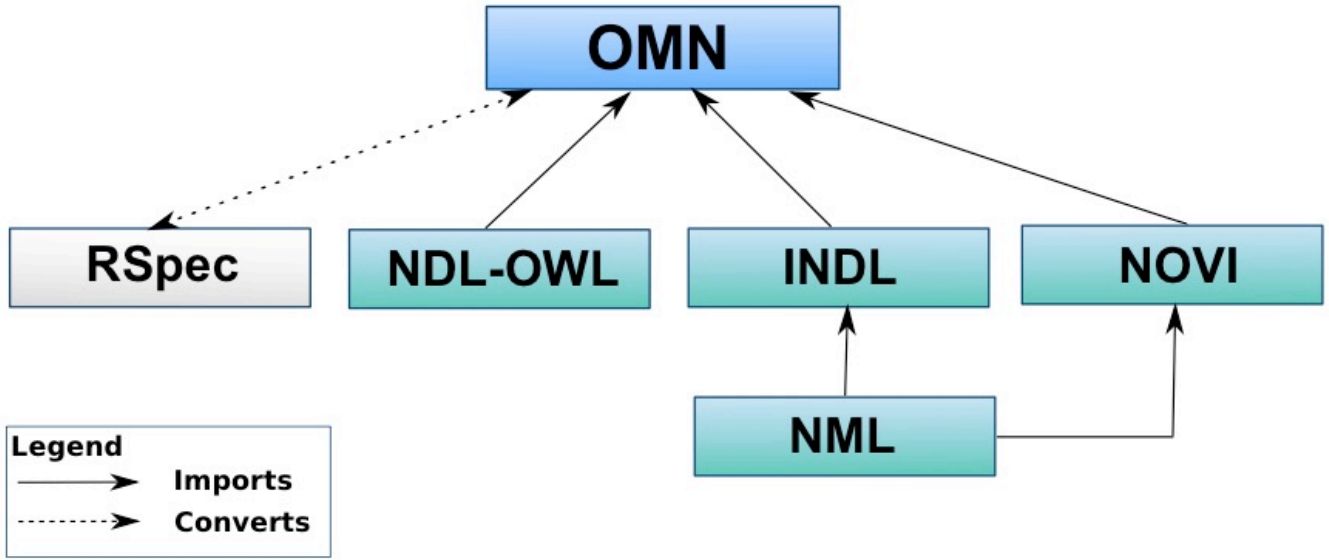
Reusability of Existing Ontologies

❷ Focused on integrating work from existing approaches

Integration of NML, INDL, NOVI, MOMENT, NDL-OWL, RDFS, OWL, DC, FOAF, ...



Information Model for Federated Infrastructure

❸ Defined a formal information model for federated infrastructure management

The Open-Multinet Ontology Set

http://open-multinet.info

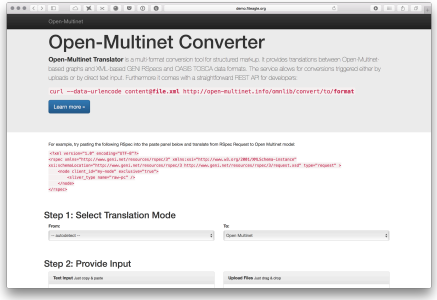
W3C Community Group on Federated Infrastructures

https://www.w3.org/community/omn/

Information Model for Federated Infrastructure

❹ Implemented a translation mechanisms and examples to ease transition

- A translation mechanism (Java, CLI, WS, ...), resource queries, AM and semantic OML implementation



FITeagle
Future Internet Testbed Management

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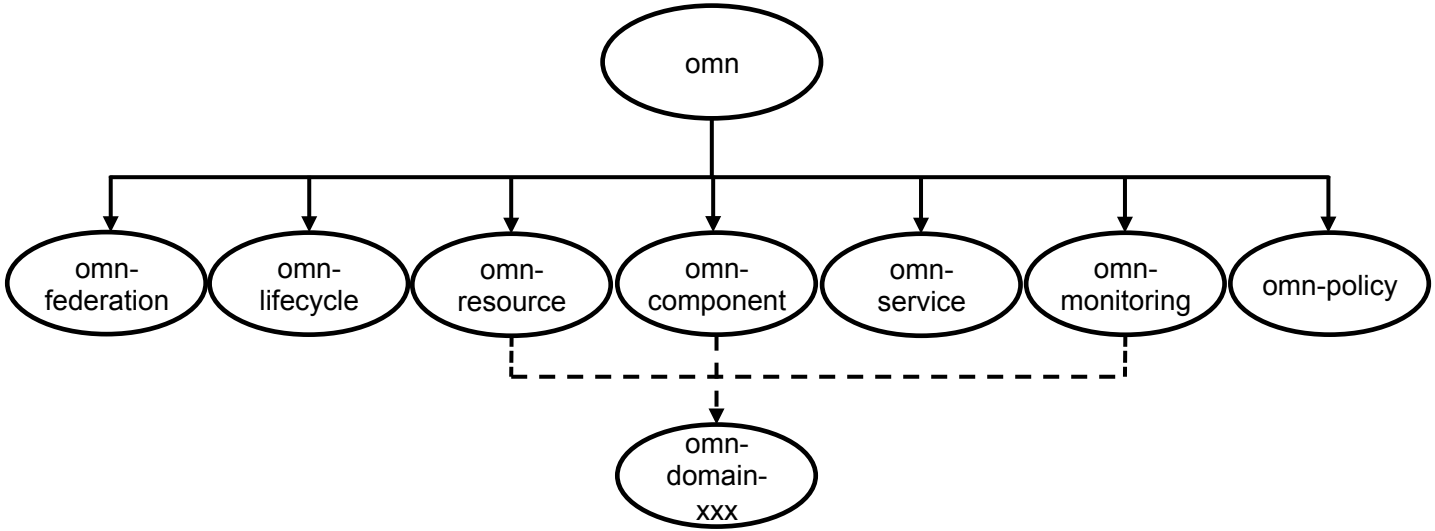
OMN Hierarchy

OMN Ontology Hierarchy



OMN Ontologies

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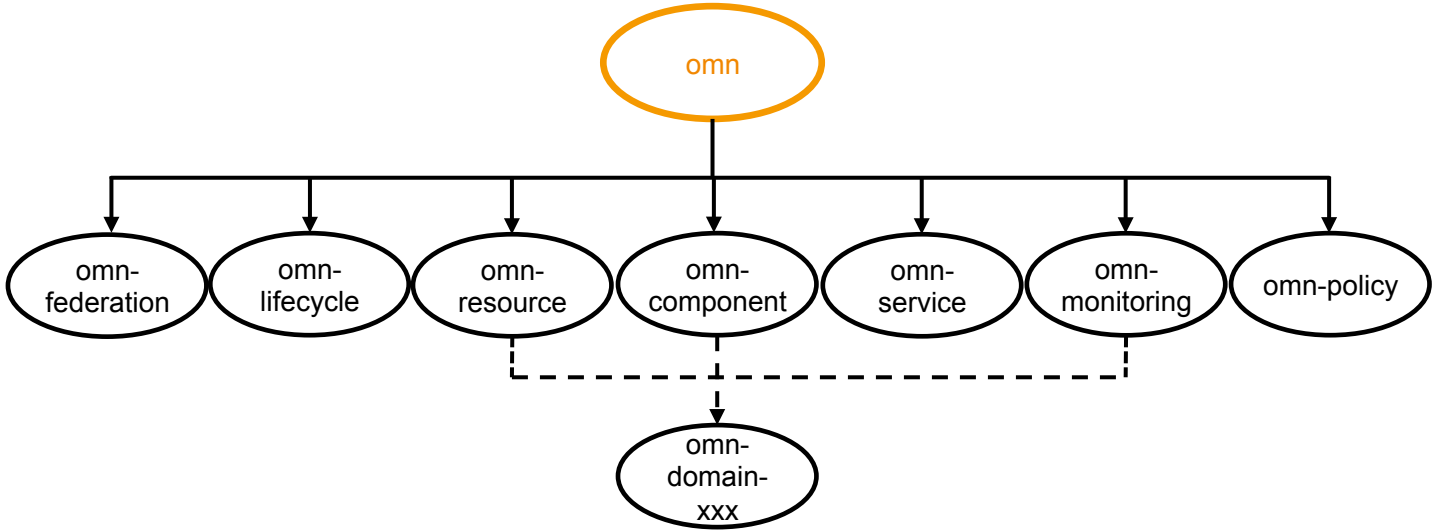
OMN Upper Ontology



OMN Upper Ontology

- Defines basic concepts and properties that are re-used and specialized in the subjacent ontologies
- Classes:
  - Attribute, Component, Resource, Service, Dependency, Environment, Group, Topology, Layer, Reservation, ..
- Object Properties:
  - adaptableFrom/adaptableTo, adaptsFrom/adaptsTo, dependsOn, relatesTo, fromDependency, hasAttribute, hasComponent, hasGroup, hasResource, hasService, hasReservation, isAttributeOf, isComponentOf, isGroupOf, isResourceOf, isReservationOf, toDependency, withinEnvironment, ..
- Datatype Properties:
  - hasEndpoint, hasURI, isReadonly, sequenceNumber, ..

OMN Upper Ontology

Relationship example

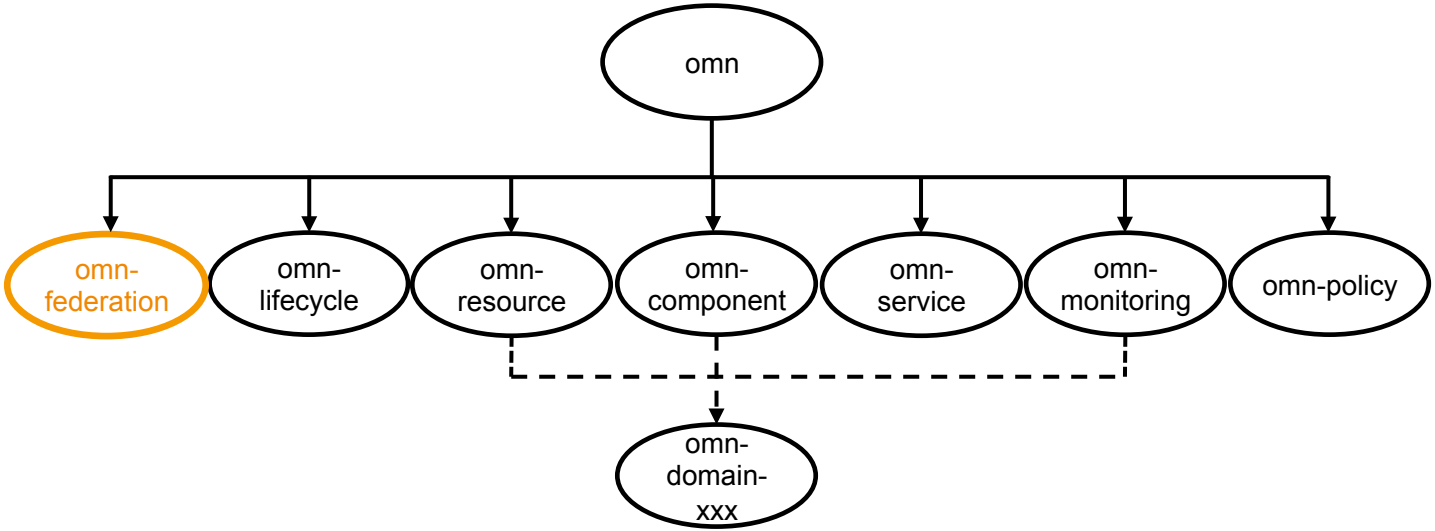
```
###  http://open-multinet.info/ontology/omn#hasService

:hasService rdf:type owl:ObjectProperty ;

            rdfs:label "has service"@en ;

            rdfs:comment "a service that this resource contains - e.g. a Hadoop instance within a reserved topology"@en ;

            rdfs:range :Service ;

            rdfs:domain [ rdf:type owl:Class ;
                          owl:unionOf ( :Group
                                        :Resource
                                        :Service
                                      )
                        ] .
```

OMN Upper Ontology

Examples on similarity concepts defined in other ontologies

```
###  http://open-multinet.info/ontology/omn#Service

:Service rdf:type owl:Class ;

        rdfs:label "Service"@en ;

        rdfs:comment "An Entity that has an API/capability to use it, it may depend on an omn:Resource"@en ,
                     "Examples: Aggregate Manager, Portal, Measurement Service, Hadoop, Broker, ..."@en ;

        rdfs:seeAlso novi:Service ,
                     nml:Service ,
                     gr:ProductOrService,
                     dctype:Service,
                     schema:Service,
                     service:Service,
                     owl-s:Service .
```

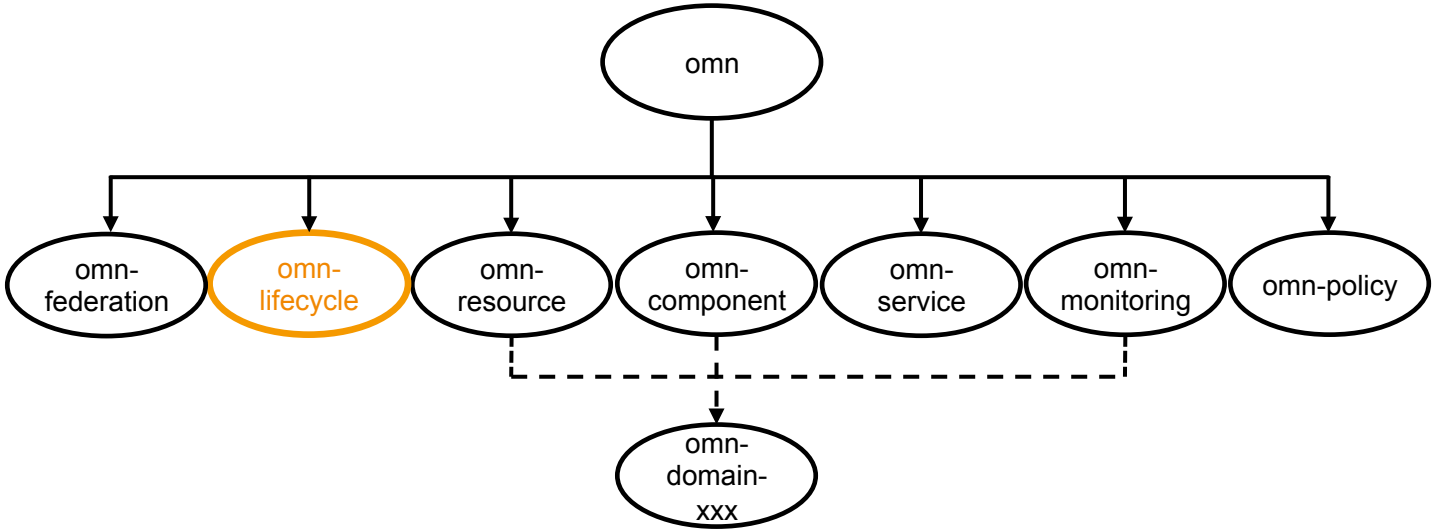
OMN Federation Ontology



OMN Federation Ontology

- Classes:
  - Federation, FederationMember, Infrastructure, (foaf:Organization)
- Object Properties:
  - administers, hasFederationMember, isAdministeredBy, hasFederationMember, isAdministeredBy, partOfFederation

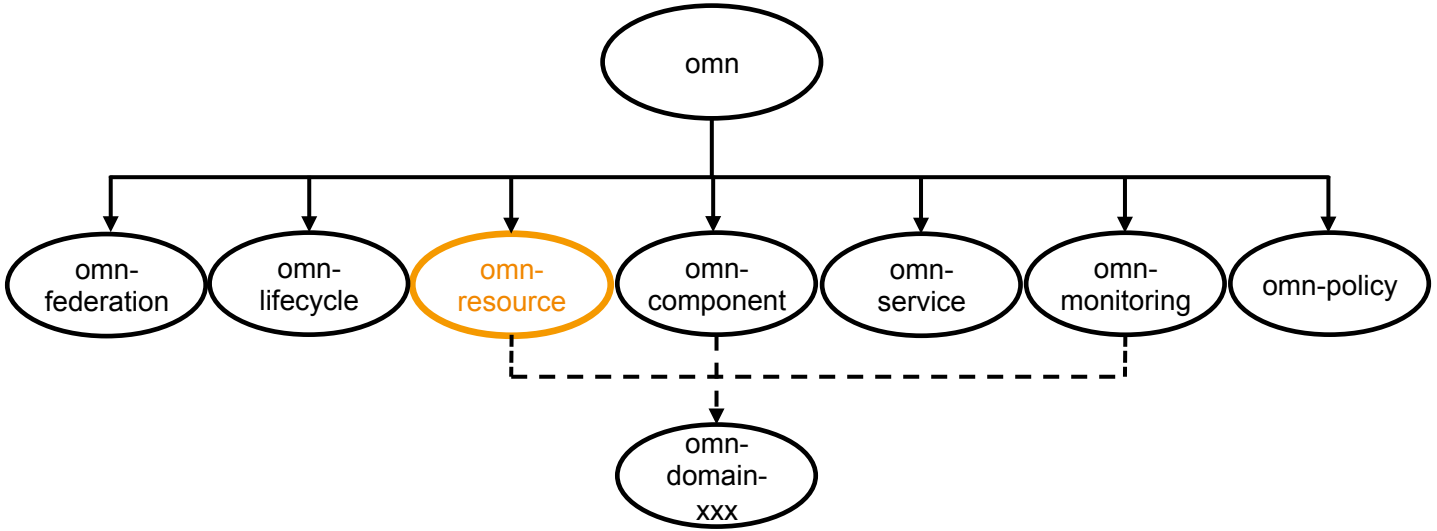
OMN Lifecycle Ontology



OMN Lifecycle Ontology

- Classes:
  - Action, Active, Allocated, Cleaned, Confirmation, Error, Failure, Initialized, Installed, Manifest, NotReady, NotYetInitialized, Offering, Opstate, Pending, Preinit, Provisioned, Ready, Removing, Request, ReservationState, Success, Restart, Start, Started, State, Stop, Stopped, Stopping, Wait Unallocated, Reload, UpdatingUsers, UpdateUsersCancel, UpdateUsers, Uncompleted, Updating, ...
- Object Properties:
  - hasReservationState, hasState, hasStartState, hasNext, hasType, hasStateName, hasWait, hasAction, usesService, serviceIsUsedBy, canImplement, canBeImplementedBy, implementedBy, implements, isReservationStateOf, isStateOf, parentOf, childOf, …
- Datatype Properties:
  - hasAuthenticationInformation, hasID, hasComponentID, hasRole, hasOriginalID, hasComponentName, hasComponentManagerName, hasSliverID, hasSliverName, hasLinkName, resourceId, creator, startTime, expirationTime, creationTime, managedBy, …

OMN Resource Ontology



OMN Resource Ontology

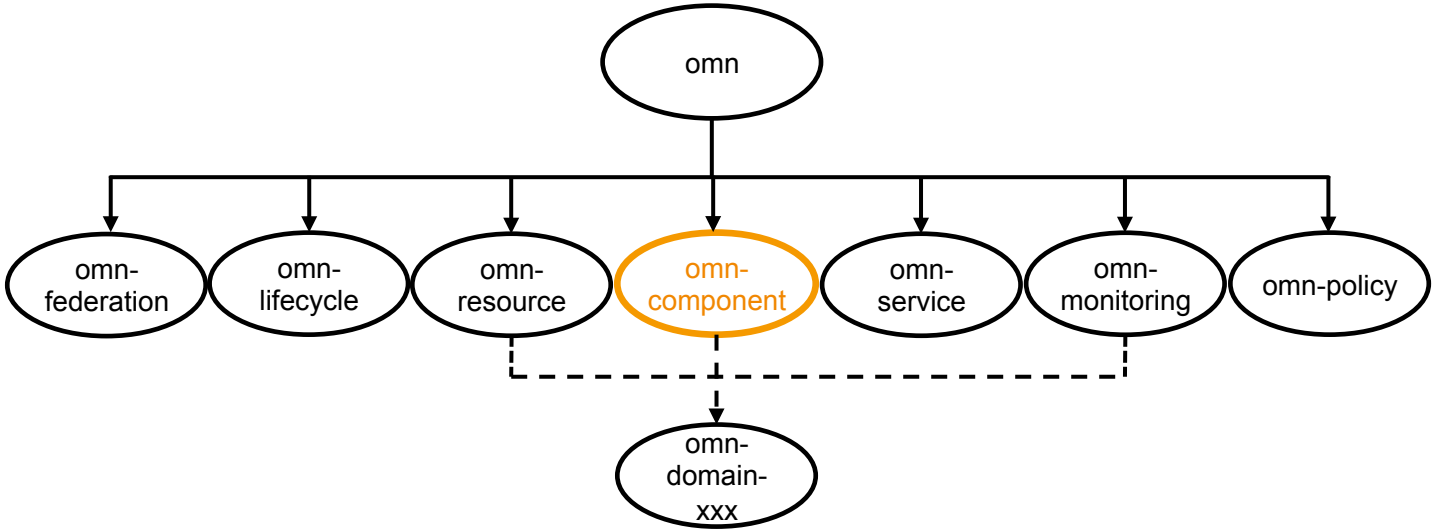
- Classes:
  - Cloud, Hop, Interface, IPAddress, Link, LinkProperty, NetworkObject, Node, Openflow, Path, SliverType, Stitching, …
- Object Properties:
  - hasInterface, isInterfaceOf, hasIPAddress, isIPAddressOf, isSink, isSource, hasSink, hasSource, hasSliverType, hasProperty, isPropertyOf, requiredBy, requires, ...
- Datatype Properties:
  - isAvailable, isExclusive, address, netmask, type, country, macAddress, clientId, …

OMN PC Ontology

PC is a special resource concept

- omn:PC is-a omn:Node, omn:Node is-a omn:Resource
- Classes:
  - Available, Controller, Datapath, DiskImage, FeatureDescription, HardwareType, OpenStack, Packet, PC, SharedVlan, VM, VMServer, …
- Object Properties:
  - hasDiskImage, hasAvailable, isDiskImageOf, hasHardwareType, isHardwareTypeOf, …
- Datatype Properties:
  - hasCapacity, hasDiskimageDescription, diskimageDefault, hasDlVlan, hasDiskimageOS, hasDlVlan, hasDiskimageVersion, emulabNodeTypeStatic, hasLatency, hasPacketLoss, lastUpdateTime, hasNextHop, hasVMID, hasUseGroupName, hasCPU, …

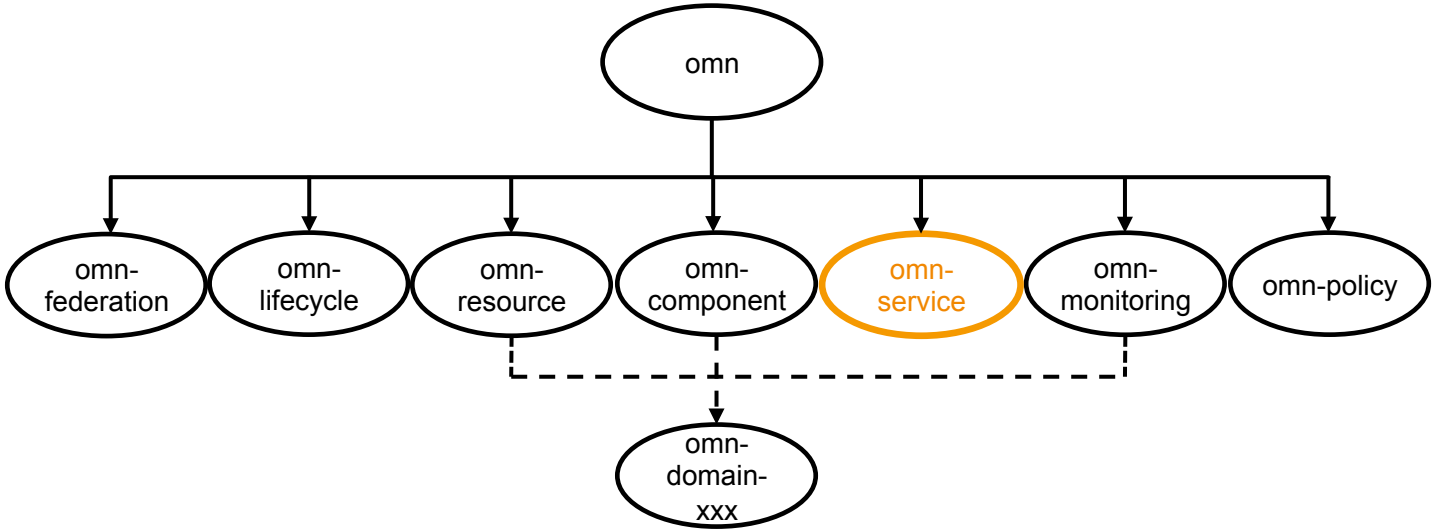
OMN Component Ontology



OMN Component Ontology

- Classes:
  - ProcessingComponent, StorageComponent, MemoryComponent, CPU, ..

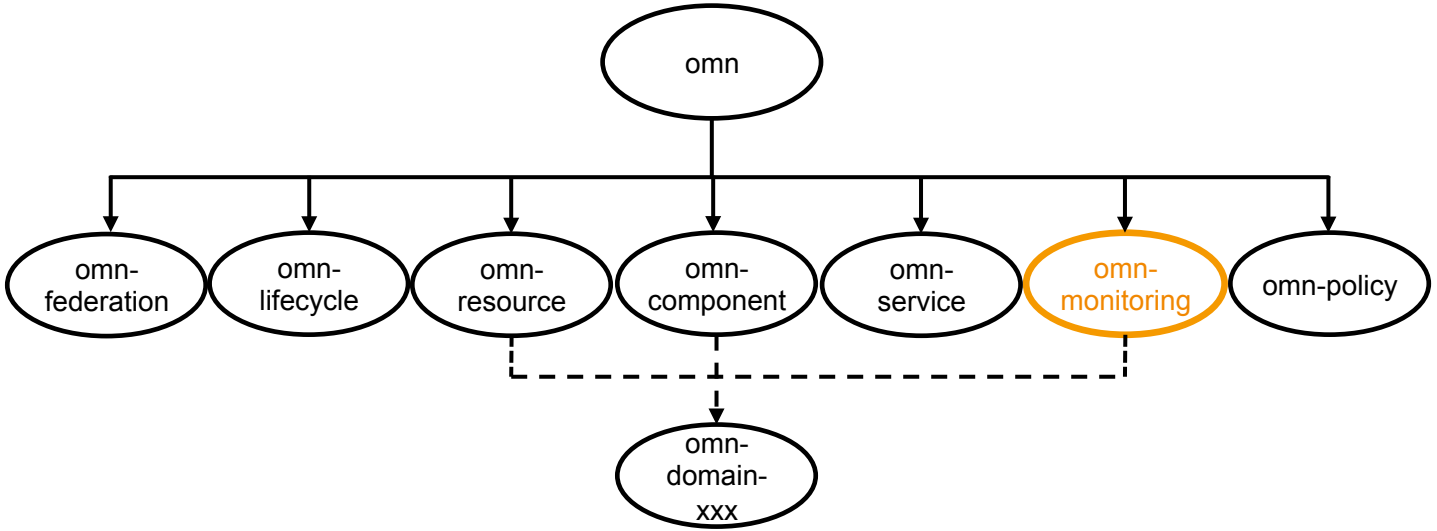
OMN Service Ontology



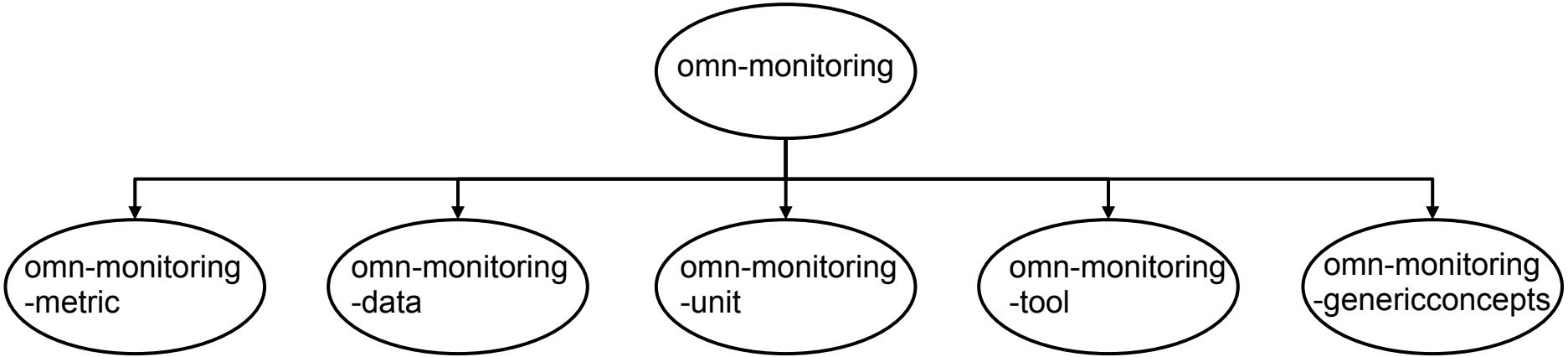
OMN Service Ontology

- Classes:
  - PostBootScript, ExecuteService, InstallService, LoginService, …
- Datatype Properties:
  - authentication, command, hostname, installPath, port, shell, shell, url, username, publickey, postBootScriptType, postBootScriptText, …

OMN Monitoring Ontology



OMN Monitoring Ontology



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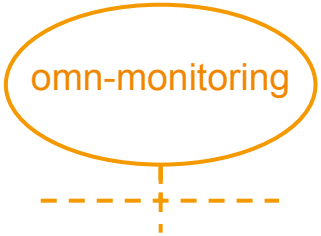
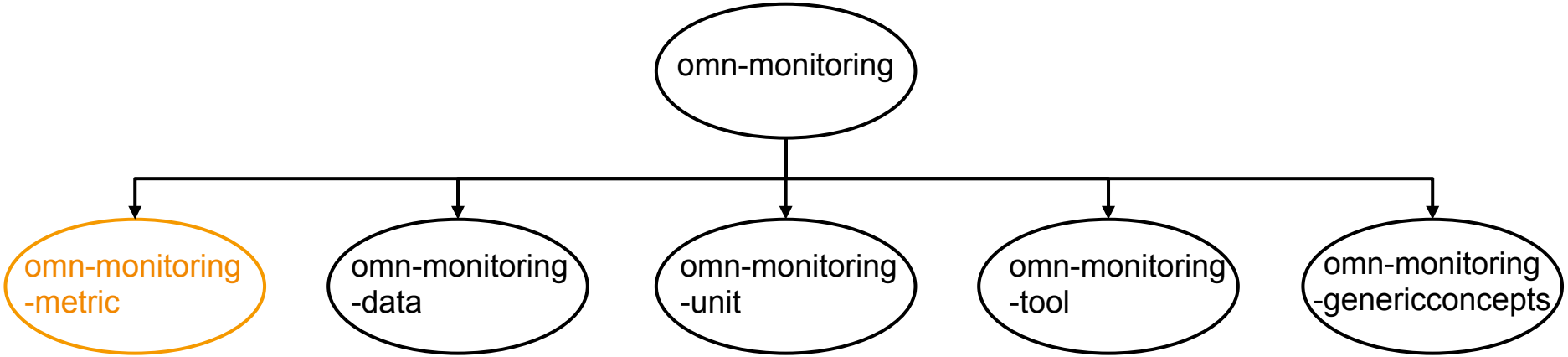


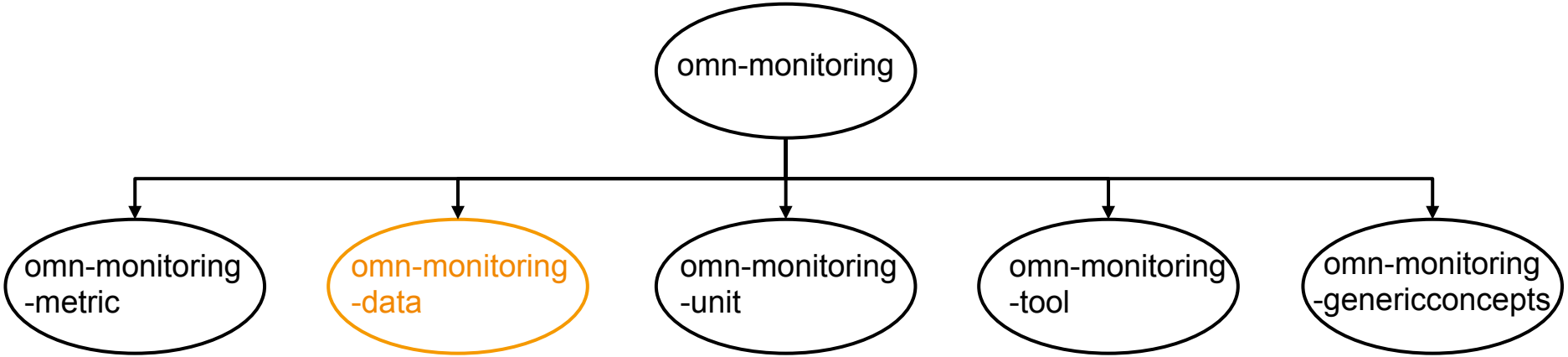
- Classes:
  - Data, Metric, Unit, Tool, Lifetime, , Measurement, ActiveMeasurement, PassiveMeasurement, MonitoringService, InfrastructureHealthMonitoring, InfrastructureResourceMonitoring, SLAMonitoring, FirstLevelSupport, …
- Object Properties:
  - isMeasurementMetricOf, hasMeasurementMetric, isMeasurementOf, measuredBy, measuresMetric, monitors, hasMetricAttribute, hasUnit, sentBy, sendTo, sentFrom, retrievedBy, retrievedFrom, pushesDataTo, pushedBy, ...
- Datatype Properties:
  - isRequested, isOffered, endTime, startTime, requiresUsername, requiresPassword, …

OMN Monitoring Ontology



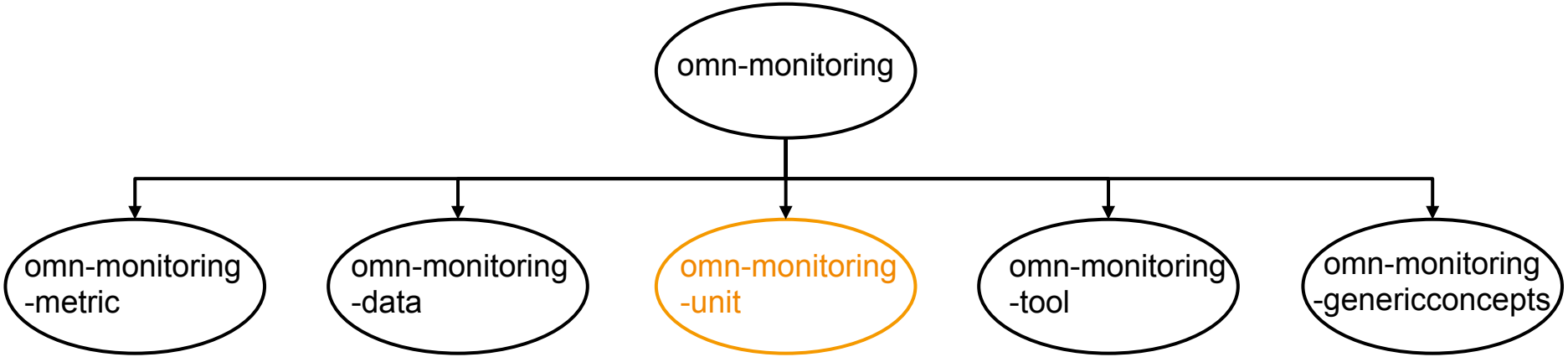
- Classes: CPUUtilization, CPUload, MemoryUtilization, Delay FreeMemory, Availability, RSSILevel, SNR, …
- Object Properties: canBeCalculatedFrom
- Datatype Properties: hasFrequency, statusValue

OMN Monitoring Ontology



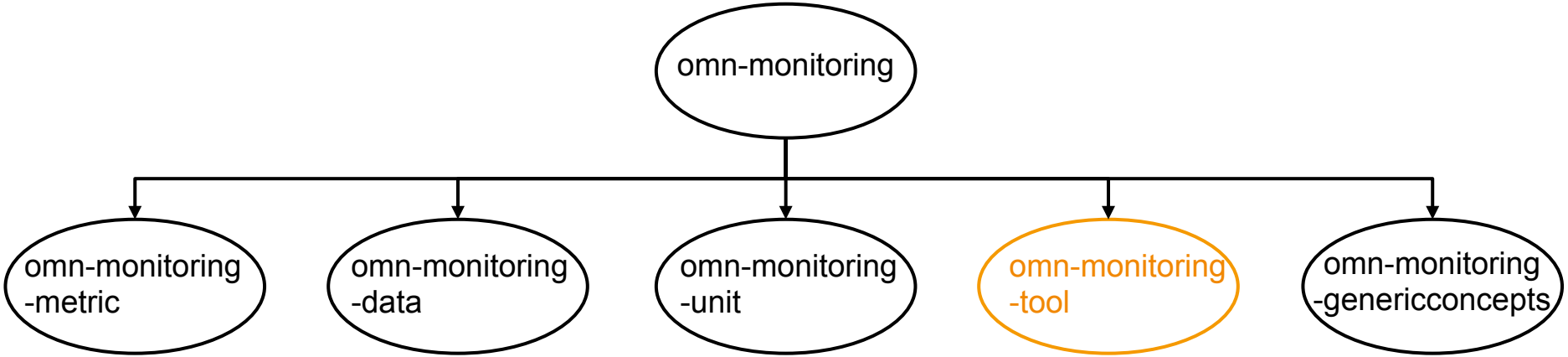
- Classes: MeasurementData, ConfigurationParameter, SimpleMeasurement, StatisticalMeasurement, DataFormat, XMLFormat, BinaryFormat, ..
- Object Properties: dataFormat, hasMeasurementData, isMeasurementDataOf, isStatisticalMeasurementOf, …
- Datatype Properties: hasMeasurementDataValue, hasTimestamp, isRequired, …

OMN Monitoring Ontology



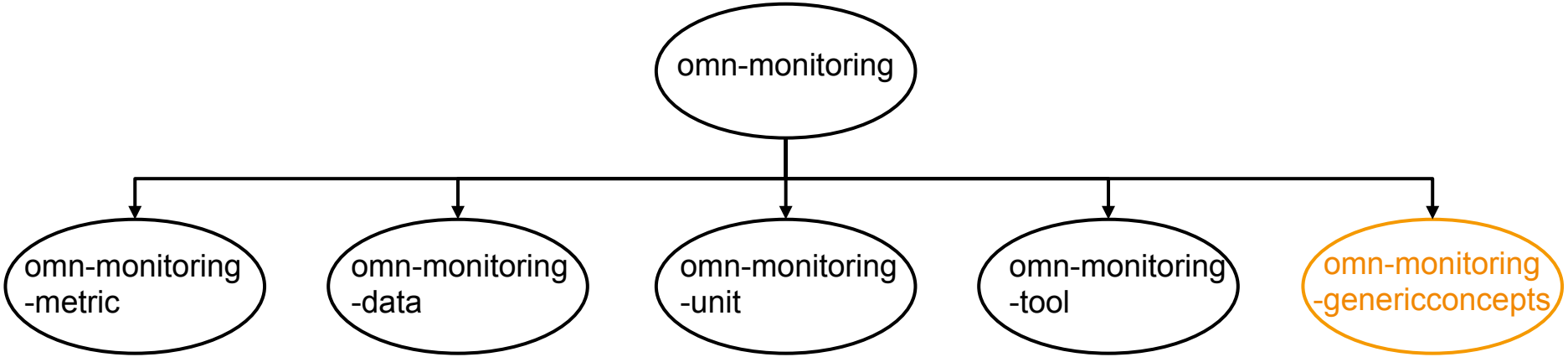
- Classes: BaseUnit, N_aryUnit, UnaryUnit, Dimension, BaseDimension, DerivedDimension, Prefix, BinaryPrefix, DecimalPrefix, Countable, Frequency, GeoPosition, MeasurementLevel, RatioLevel, TimeInterval, …
- Object Properties: defaultUnit, derivedFrom, hasPrefix, …
- Datatype Properties: base, exponent, hasValue, offset, scale, …

OMN Monitoring Ontology



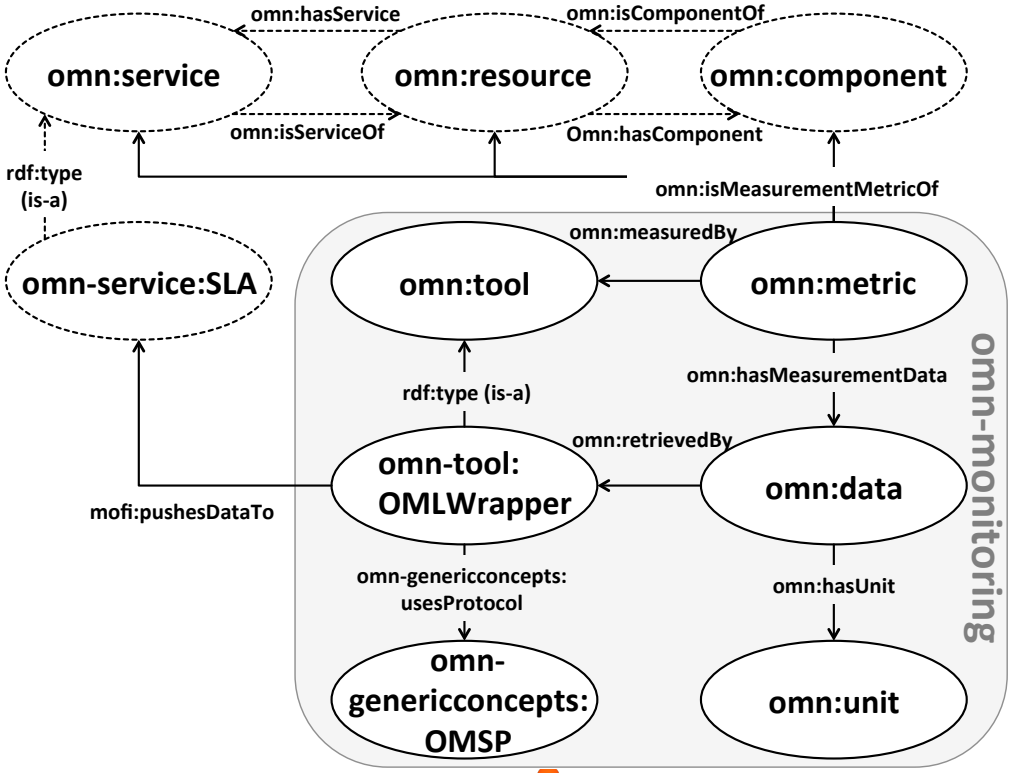
- Classes: MonitoringTool, CaptureTool, Collector, Adapter, Exporter, MeasurementTool, VisualizationTool, GUI, API, Filter, DataBroker, CommunicationParadigm, Centralized, Distributed, CollectionEndpoint, Database, SQL, …
- Individuals: Zabbix, Nagios, OMLWrapper, OMLServer, PostgreSQL, JenaFuseki, OMSPEndpoint, SPARQLEndpoint, Manifold, …
- Object Properties: communicationParadigm, dataAccessProvided, usesDataBroker, reportesDataAbout, convertsDataFrom, convertsDataTo, …

OMN Monitoring Ontology

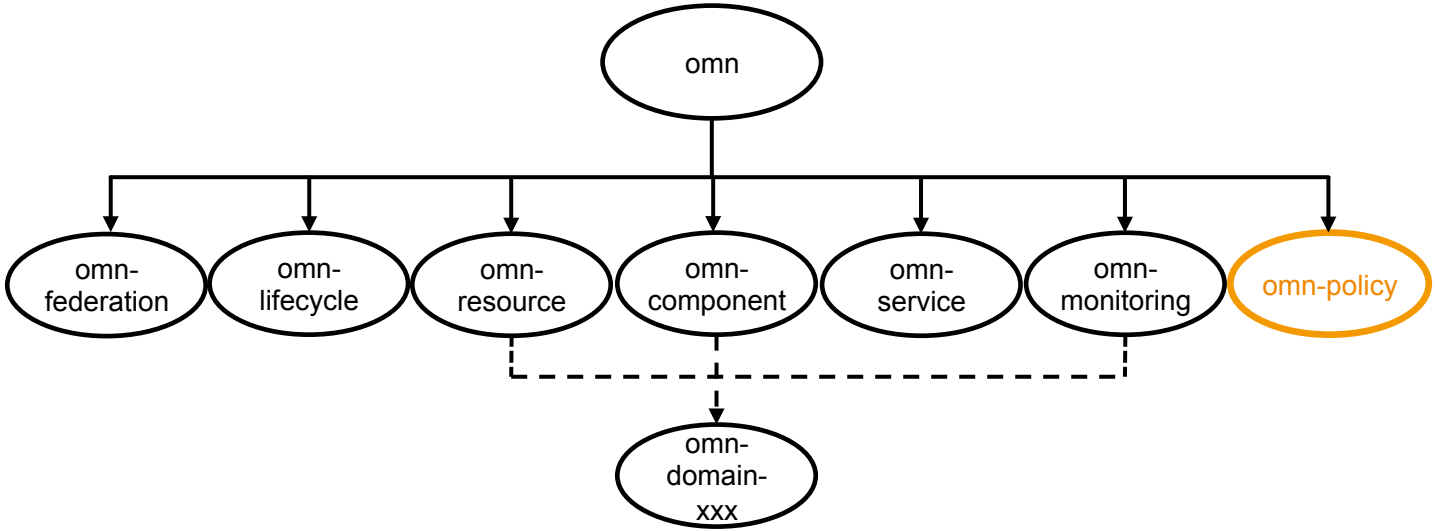


- Classes: MonitoringDomain, Protocol, Query, SingleQuery, BatchQuery, Location, LogicalLocation, PhysicalLocation, ApplicationProtocol, TransportProtocol, AuthenticationMethod, Event, ConditionalNotSatisfiedEvent, EventAtMeasurementPhase, ToolUnavailableEvent, NoToolConfiguredToMeasureMetric, …
- Object Properties: locatedAt, usesProtocol, query, …
- Datatype Properties: latitude, longitude, …

OMN Monitoring Ontology

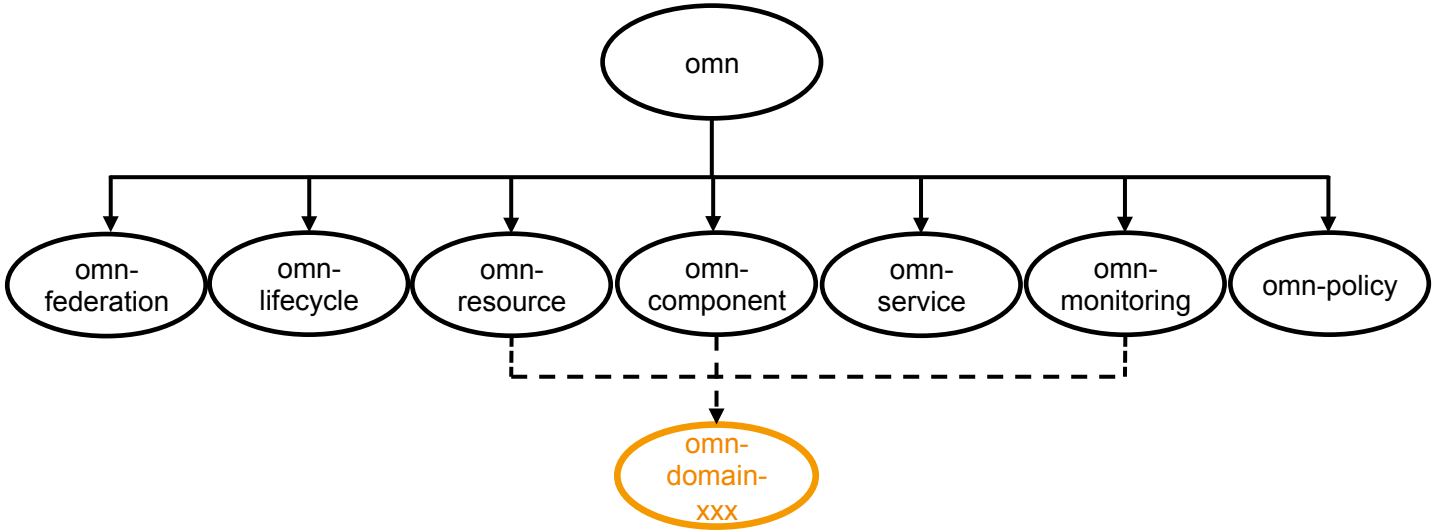


OMN Policy Ontology



Future work …

OMN Domain-specific Ontologies



Specific concepts related to domains like Cloud, Wireless, SDN ….

OMN Tools

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Converter

- Multi-format conversion tool for structured markup
- Provides translations between data formats
  - OMN-based graphs and XML-based GENI Rspecs
  - OMN-based graphs and OASS TOSCA
- Conversions triggered by
  - upload or
  - direct input
- Includes REST API for developers

Open-Multinet

Open-Multinet Converter

Open-Multinet Translator is a multi-format conversion tool for structured markup. It provides translations between Open-Multinet-based graphs and XML-based GENI RSpecs and OASIS TOSCA data formats. The service allows for conversions triggered either by uploads or by direct text input. Furthermore it comes with a straightforward REST API for developers:

```
curl --data-urlencode content@file.xml http://demo.fiteagle.org/omnlib/convert/to/format
```

Learn more »

For example, try pasting the following RSpec into the paste panel below and translate from RSpec Request to Open Multinet model:

```
<?xml version="1.0" encoding="UTF-8"?>
<rspec xmlns="http://www.geni.net/resources/rspec/3" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.geni.net/resources/rspec/3 http://www.geni.net/resources/rspec/3/request.xsd" type="request" >
    <node client_id="my-node" exclusive="true">
        <sliver_type name="raw-pc" />
    </node>
</rspec>
```

Step 1: Select Translation Mode

From: -- autodetect --

To: Open Multinet (Turtle)

Step 2: Provide Input

Text Input Just copy & paste

Paste document below:

Upload Files Just drag & drop

Select a file (RSpec, TOSCA, OMN) from your computer:

Choose File no file selected

Or drag and drop the file below:

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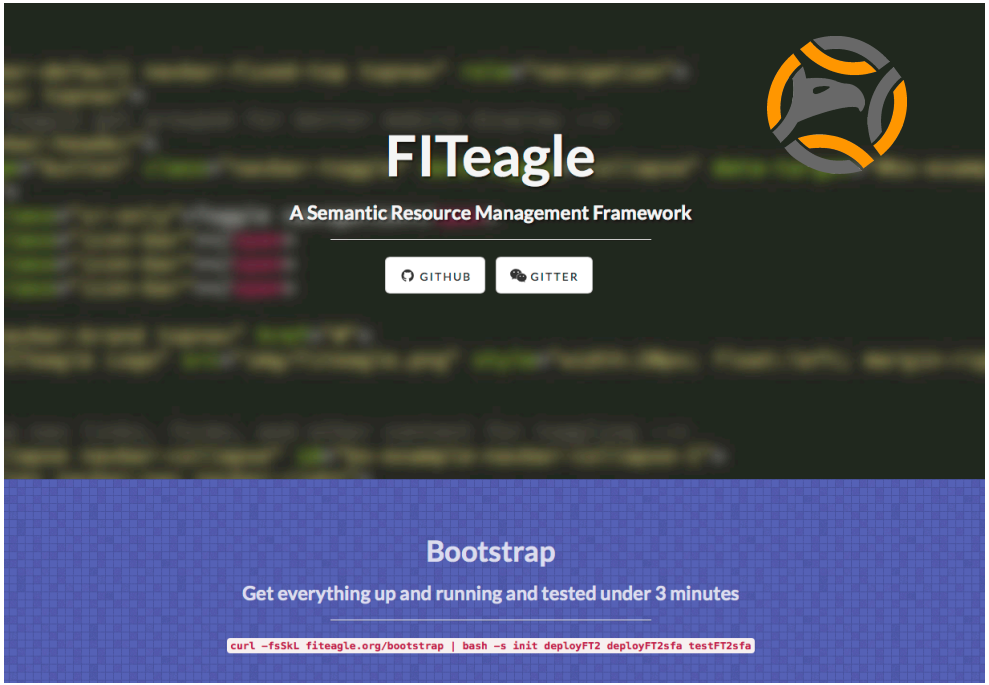
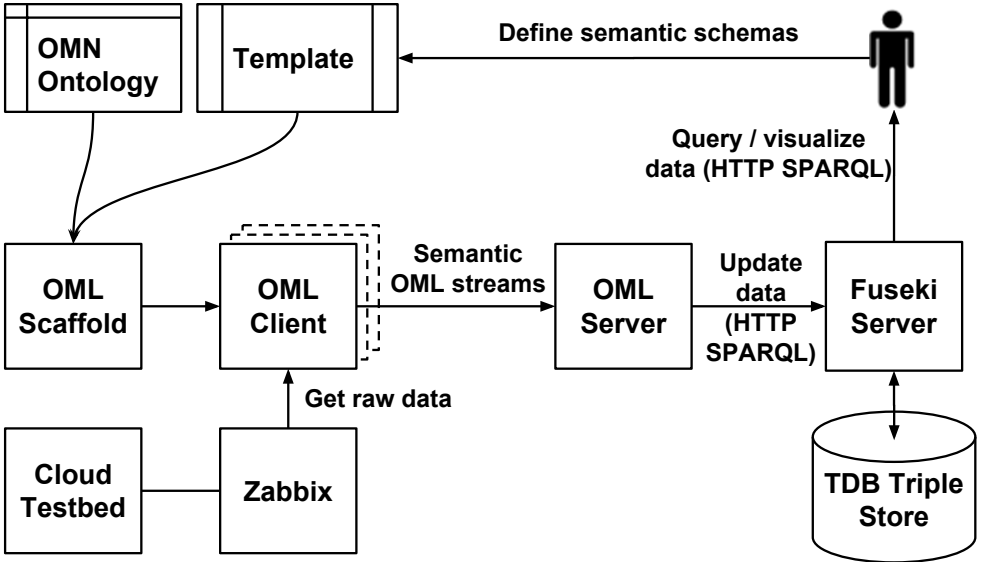
Semantic AM (FITeagle)

http://fiteagle.github.io

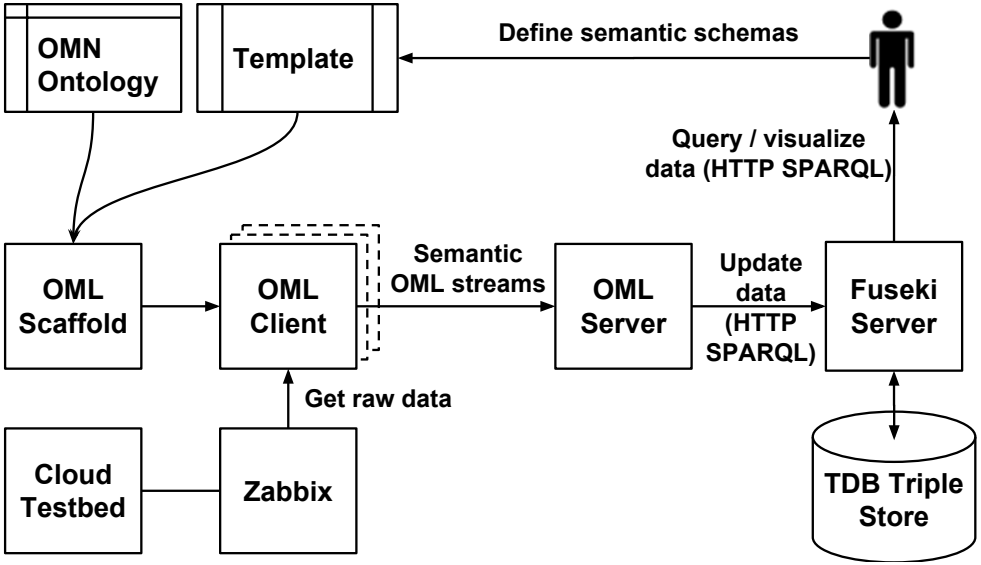
- Semantic- and microservices-based resource management toolkit for federated testbeds
- Based on the J2EE implementation WildFly
- Supports experimentation protocols
  - Currently: SFA and OMSP

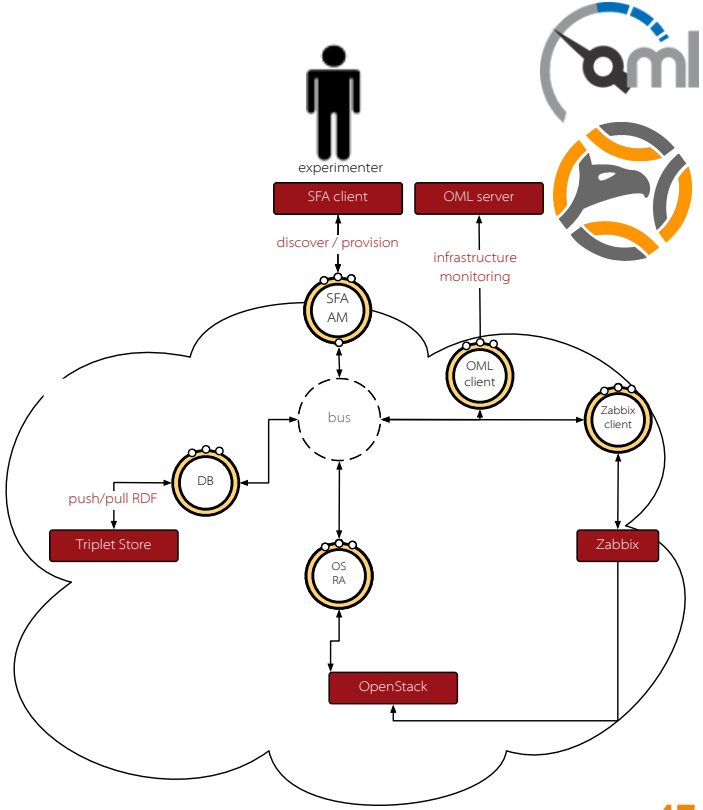


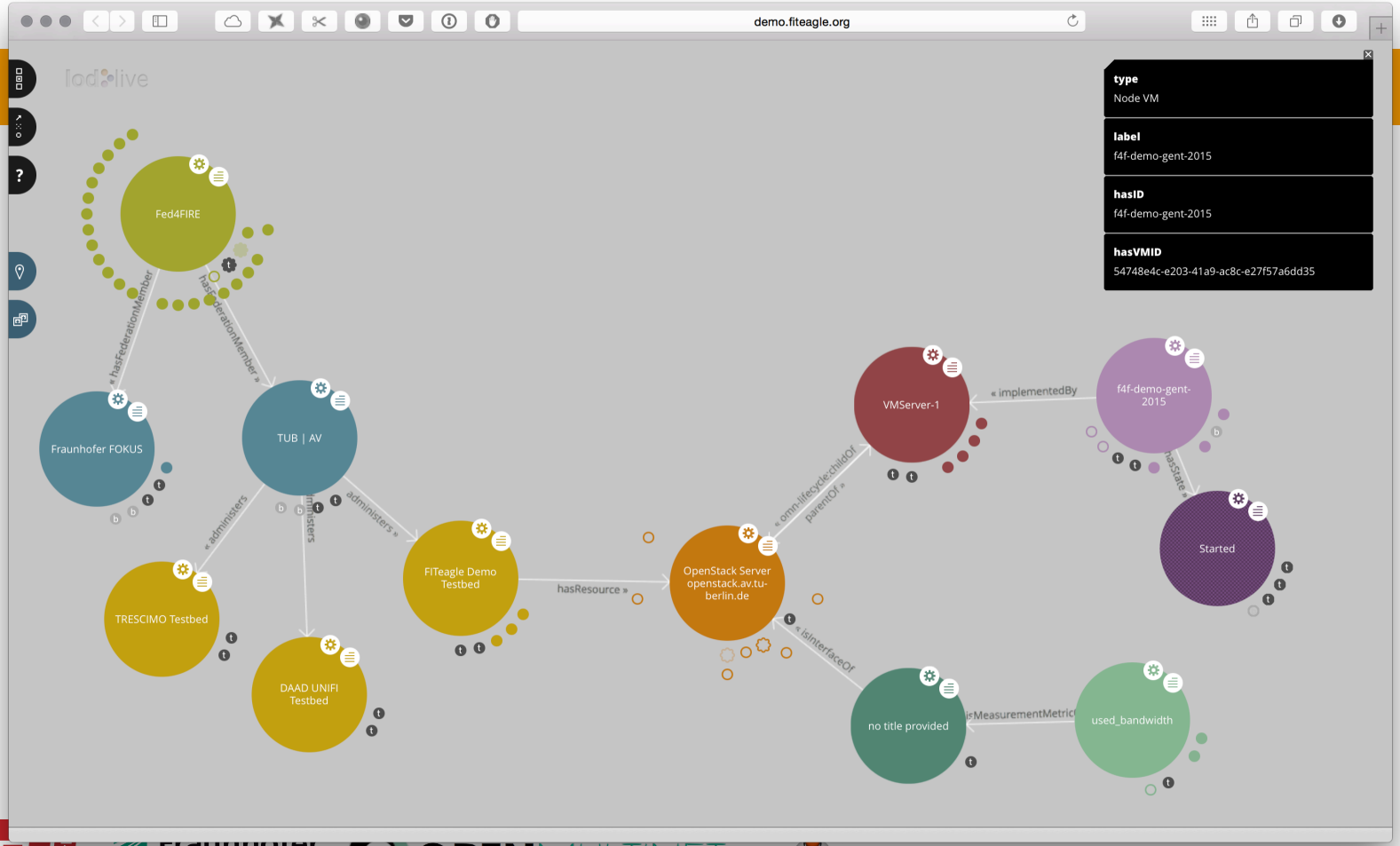
Semantic OML



Semantic OML & FITeagle Integration







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Use-cases

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Use-cases

- Two use-cases of OMN ontologies within the context of FI experimentation are to be discussed
  - Lifecycle experimentation (discussed in the following presentation)
  - Monitoring (discussed tomorrow in the monitoring session)

Outlook

Outlook

Current Status

- OMN ontologies are
  - encoded via OWL2 and serialized via RDF/XML and Turtle
  - automatically checked every time a new concept or relation is added or modified using Apache Jena Eyeball inspectors and also validated manually via other validators such as the OntOlogy Pitfall Scanner (OOPS)
  - implemented in FITeagle, Semantic OML, and SFA- and TOSCA-related converters
  - publically available along with their implementations:
    - https://www.w3.org/community/omn/
    - https://github.com/open-multinet/playground-rspecs-ontology
    - https://github.com/FITeagle
    - https://github.com/alhazmi/semantic-oml

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Outlook

Dissemination Activities

- Used suitable vocabularies to describe meta information about our ontologies
- Human readable documentation
- Machine readable serializations
- Permanent identifier (https://w3id.org/omn) is registered
- OMN namespace (http://prefix.cc/omn) is registered
- the source code & issue tracker are publicly available
- OMN has been submitted to Semantic Web search engines: Swoogle and Watson
- Established the Open-Multinet Forum
- Created the W3C Federated Infrastructures Community Group
- 4 related papers are published

Also Important Step Towards Covering Further Domains

Federated Testbeds	Federated Clouds	Federated Networks	Federated IoT	Federated Big Data

Thanks for your attention!

Questions?

Contact:
Web: http://open-multinet.info
https://www.w3.org/community/omn/
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