Visualizing the AAI Data Model

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AAI in ONAP

- AAI delivered 13 Microservices in the Dublin release helm charts
- CRUD Microservices
  - Resources
  - Traversal
  - Graphadmin
  - Schema Service
- User Interface
  - Sparky (AAIUI)
  - Search Data Service
  - Data Router
  - Elasticsearch
- TOSCA Processing
  - Model Loader
  - Babel
- Other (future looking)
  - Gizmo
  - Champ
  - Spike

AAI in ONAP

- AAI has additional microservices that are not included in the Demo helm charts
  - Graphgraph
  - Cacher
  - Chameleon
  - Gallifrey

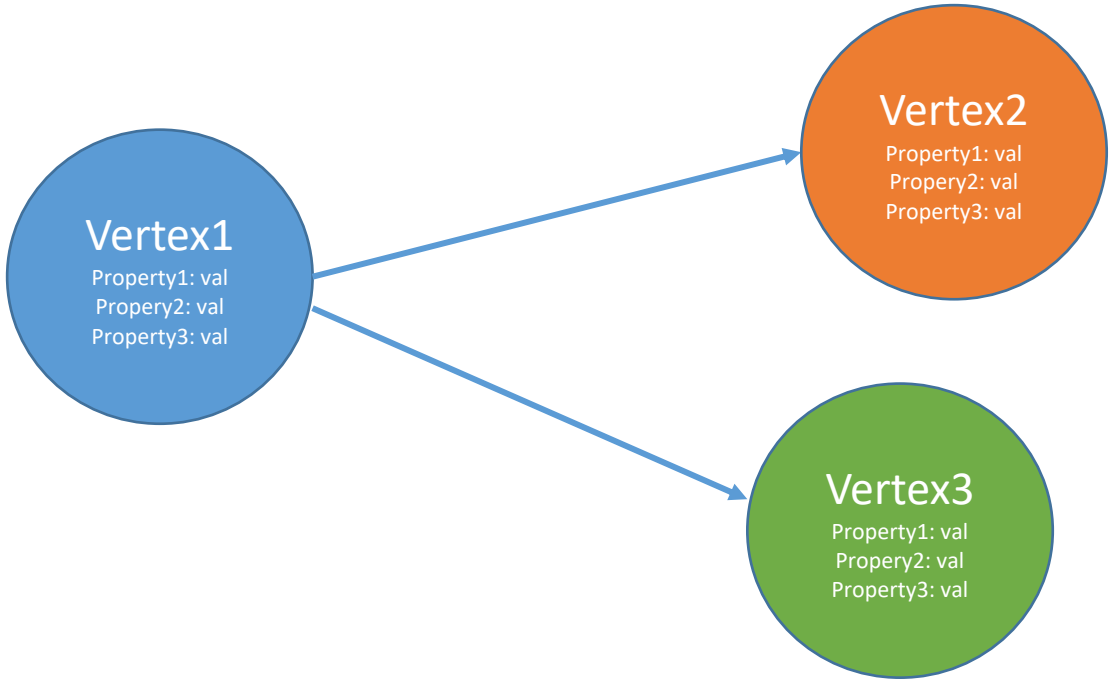
- During the Dublin release, the modeling subcommittee requested an initiative to reverse engineer the AAI data model
- To that end, the community has produced several different but complementary views of the AAI data model

AAI In ONAP

- This presentation will cover the following:
  - AAI Graph Basics
  - The AAI Data Model Browser
  - GraphGraph
  - PlantUML
  - Papyrus
  - Custom Queries
  - DSL Queries

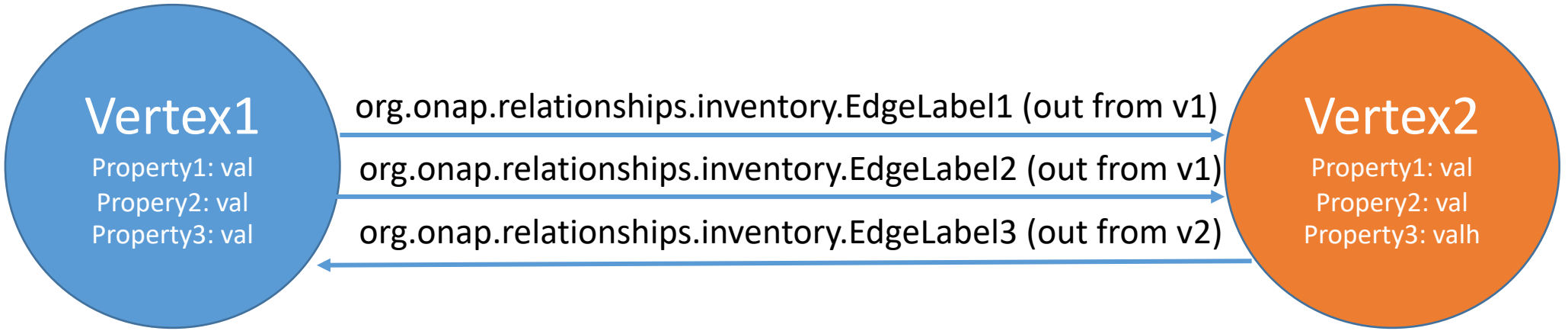
AAI Graph Basics

- A&AI uses Janusgraph for persistence which is a property graph model, where a graph is a set of vertices with edges between them.
- JanusGraph stores graphs in adjacency list format which means that a graph is stored as a collection of vertices with their adjacency list.



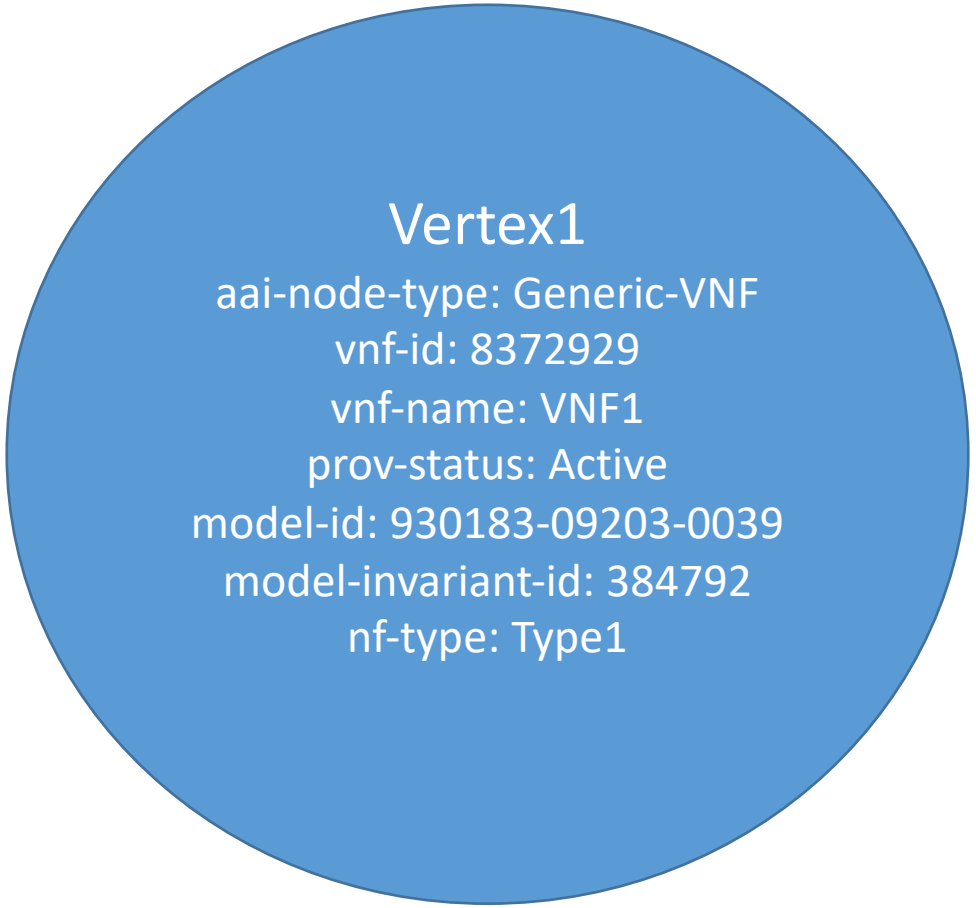
AAI Graph Basics

- The adjacency list of a vertex contains all of the vertex's incident edges (and properties).



AAI Graph Basics

- A vertex is the fundamental unit of the graph and represents an object. Vertex can have properties to describe the object.



AAI Graph Basics

- An edge is a connection between two vertices that expresses a relationship between them. An edge can have a multiplicity, direction, and properties.

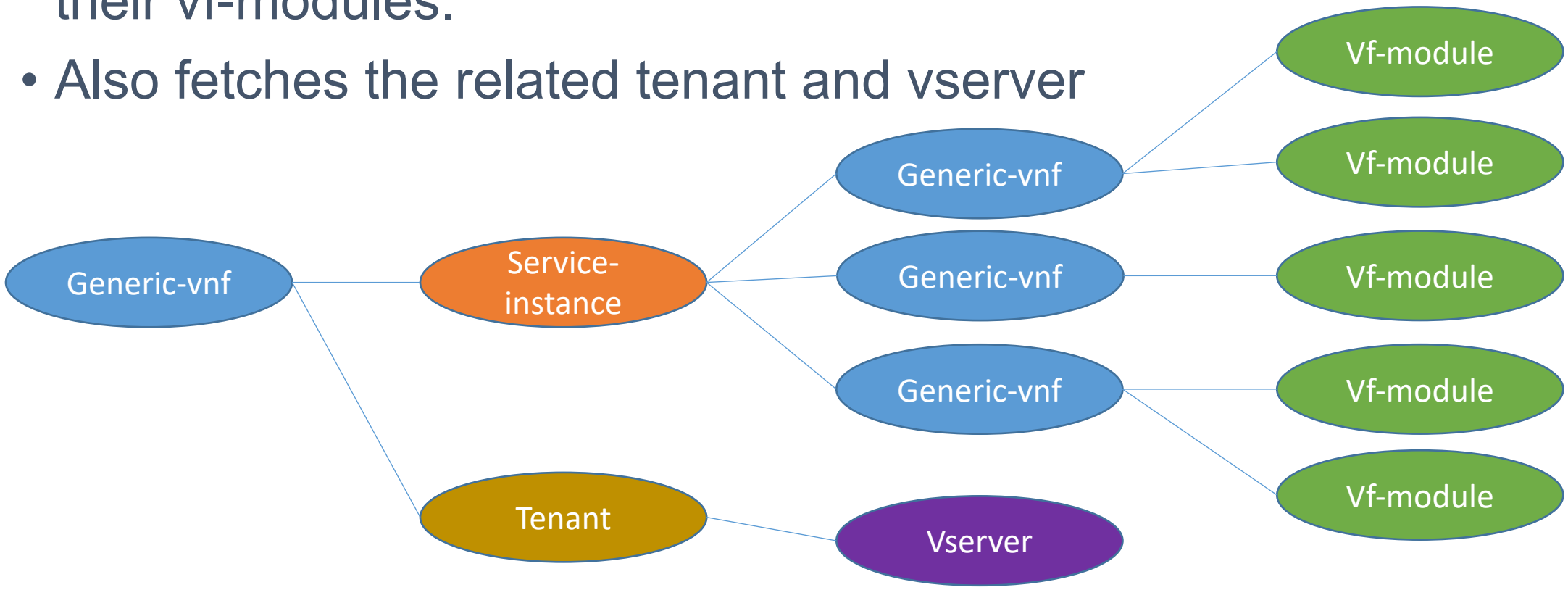
```
{
        "from": "vf-module",
        "to": "generic-vnf",
        "label": "org.onap.relationships.inventory.BelongsTo",
        "direction": "OUT",
        "multiplicity": "MANY2ONE",
        "contains-other-v": "!${direction}",
        "delete-other-v": "!${direction}",
        "prevent-delete": "NONE",
        "default": "true",
        "description":""
},
```

AAI Graph Basics

- Traversal is the process of analyzing a graph's structure.
- Traversals discover and return information about edges, vertices, and their properties.
- In graph databases, the relationship is a primary component of the data model and traversing from vertex to edge to vertex and beyond is the primary mechanism for querying the data within the model.

AAI Graph Basics

- Traversal Example: A custom query that starts at a generic-vnf, follows the edge to the service-instance, then gets all connected vnfs and their vf-modules.
- Also fetches the related tenant and vserver

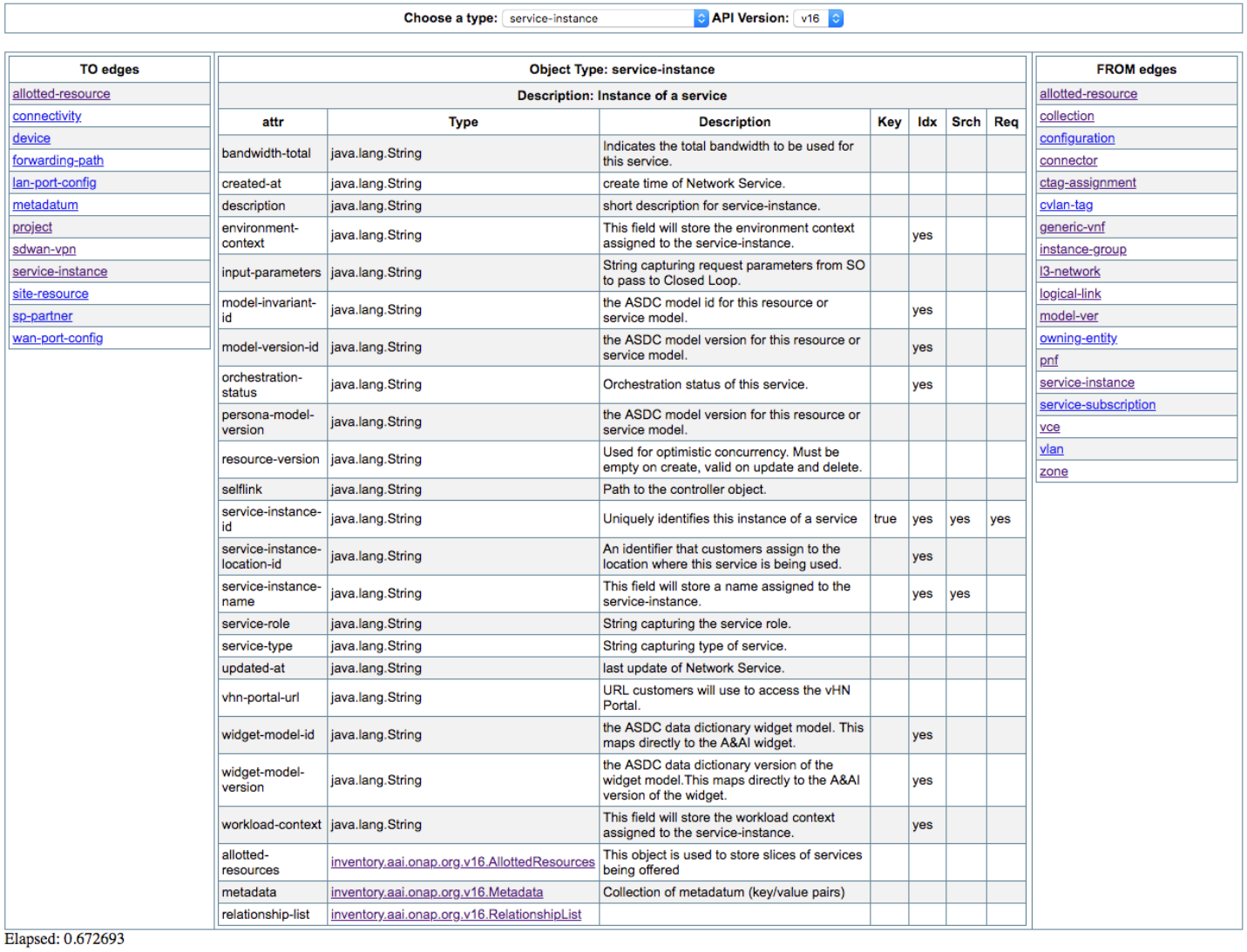


AAI Data Model

- AAI uses a Graph Database based on JanusGraph / Titan
- AAI's APIs are driven by its data model
- EclipseLink MOXy is the foundation of the AAI schema
- Types and their attributes are defined in OXM (Object to XML Mapping)
- Relationships – cousin and parent edges – are defined in a custome Edge Rules configuration (JSON)
- Nested objects and object reuse means that we have a huge number of endpoints
- Visualizing the data model is difficult
- Visualization from the swagger API is a messy eyechart
- Visualization without filtering out operational objects is also difficult

Model Browser

- Table-based view of the AAI data model
- Allows users to browse all installed versions of the AAI data model
- Provides navigation to browse nodes to which AAI has a



Choose a type: service-instance **API Version:** v16

TO edges
allotted-resource
connectivity
device
forwarding-path
lan-port-config
metadatum
project
sdwan-vpn
service-instance
site-resource
sp-partner
wan-port-config

Object Type: service-instance

Description: Instance of a service

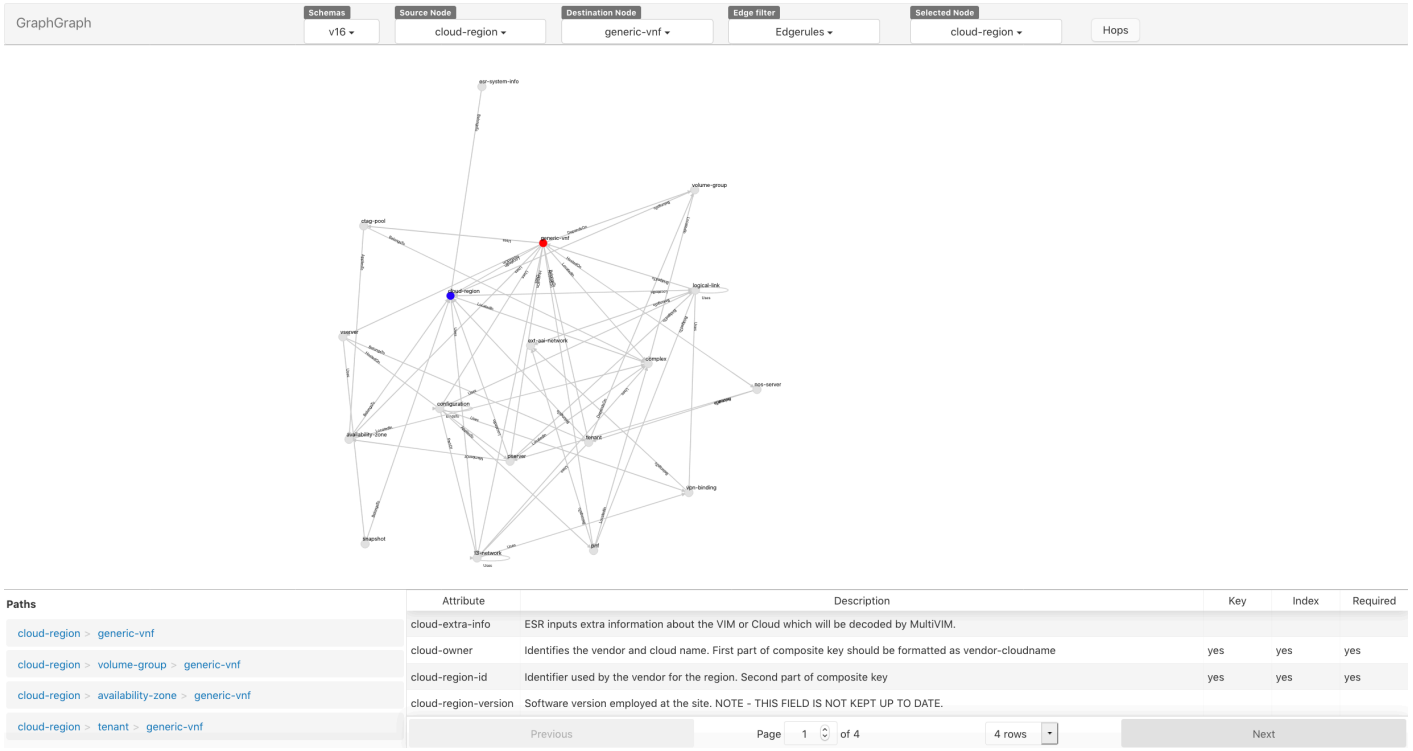
attr	Type	Description	Key	Idx	Srch	Req
bandwidth-total	java.lang.String	Indicates the total bandwidth to be used for this service.				
created-at	java.lang.String	create time of Network Service.				
description	java.lang.String	short description for service-instance.				
environment-context	java.lang.String	This field will store the environment context assigned to the service-instance.		yes		
input-parameters	java.lang.String	String capturing request parameters from SO to pass to Closed Loop.				
model-invariant-id	java.lang.String	the ASDC model id for this resource or service model.		yes		
model-version-id	java.lang.String	the ASDC model version for this resource or service model.		yes		
orchestration-status	java.lang.String	Orchestration status of this service.		yes		
persona-model-version	java.lang.String	the ASDC model version for this resource or service model.				
resource-version	java.lang.String	Used for optimistic concurrency. Must be empty on create, valid on update and delete.				
selflink	java.lang.String	Path to the controller object.				
service-instance-id	java.lang.String	Uniquely identifies this instance of a service	true	yes	yes	yes
service-instance-location-id	java.lang.String	An identifier that customers assign to the location where this service is being used.		yes		
service-instance-name	java.lang.String	This field will store a name assigned to the service-instance.		yes	yes	
service-role	java.lang.String	String capturing the service role.				
service-type	java.lang.String	String capturing type of service.				
updated-at	java.lang.String	last update of Network Service.				
vhn-portal-url	java.lang.String	URL customers will use to access the vHN Portal.				
widget-model-id	java.lang.String	the ASDC data dictionary widget model. This maps directly to the A&AI widget.		yes		
widget-model-version	java.lang.String	the ASDC data dictionary version of the widget model.This maps directly to the A&AI version of the widget.		yes		
workload-context	java.lang.String	This field will store the workload context assigned to the service-instance.		yes		
allotted-resources	inventory.aai.onap.org.v16.AllottedResources	This object is used to store slices of services being offered				
metadata	inventory.aai.onap.org.v16.Metadata	Collection of metadatum (key/value pairs)				
relationship-list	inventory.aai.onap.org.v16.RelationshipList					

FROM edges
allotted-resource
collection
configuration
connector
ctag-assignment
cvlan-tag
generic-vnf
instance-group
l3-network
logical-link
model-ver
owning-entity
pnf
service-instance
service-subscription
vce
vlan
zone

Elapsed: 0.672693

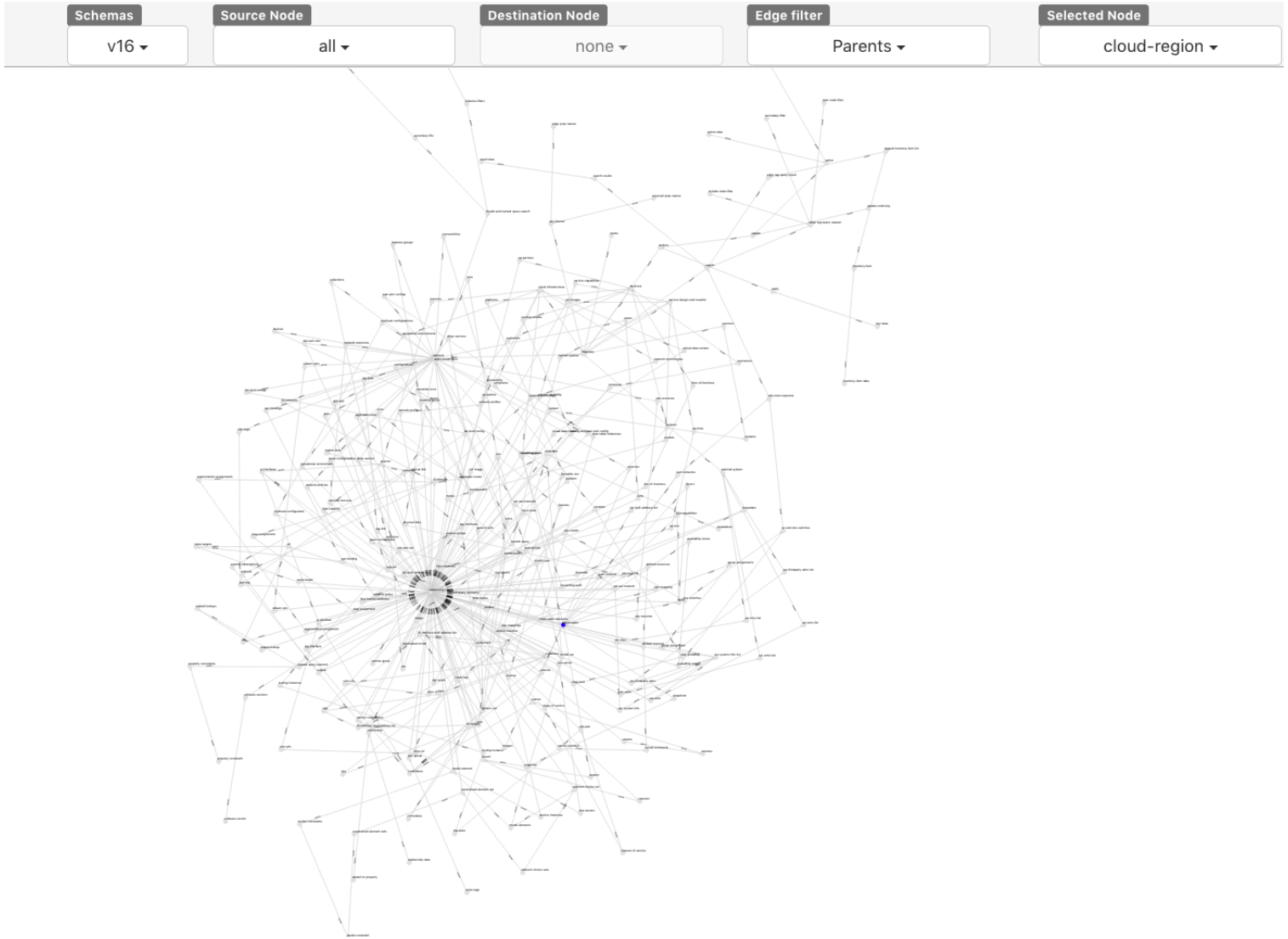
GraphGraph

- Pavel Paroulek has developed “Graphgraph” for the Frankfurt release of AAI
- Graphgraph examines the AAI schema and presents it in a User interface using React UI
- Graphgraph displays multiple dynamic views for understanding types and relationships in AAI



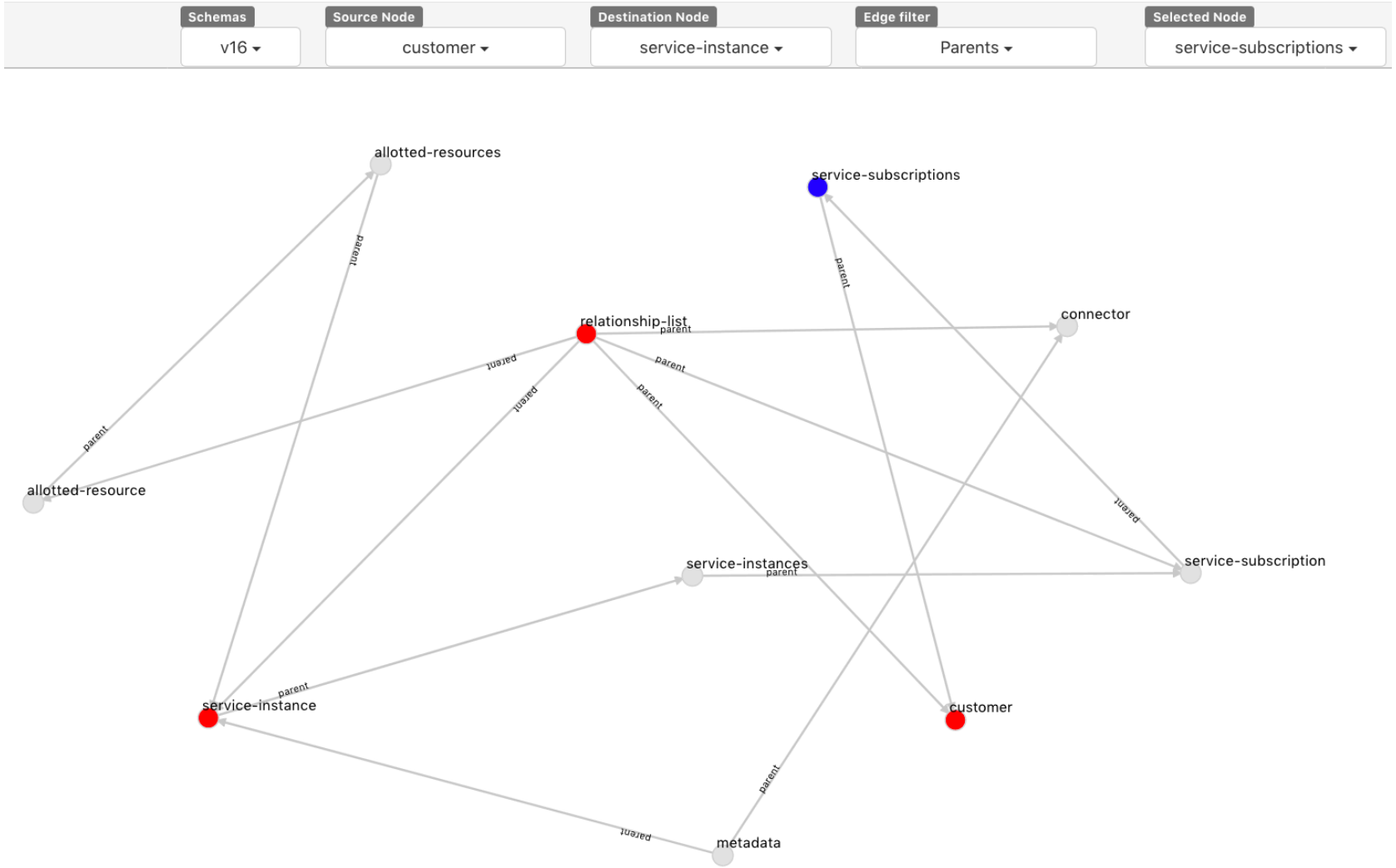
GraphGraph

- Graphgraph allows a very high view of the graph that shows the complexity of the schema and all the various ways the hierarchy can be arranged.



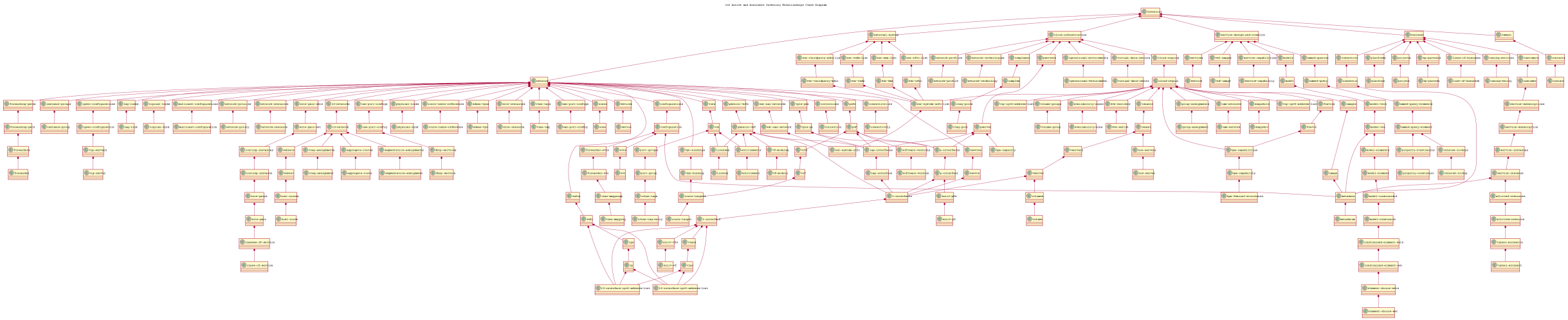
GraphGraph

- Graphgraph allows a user to zoom into a specific set of types and see how they are related
- In this example, you can visualize how the customer / service-subscription / service-instance objects are related



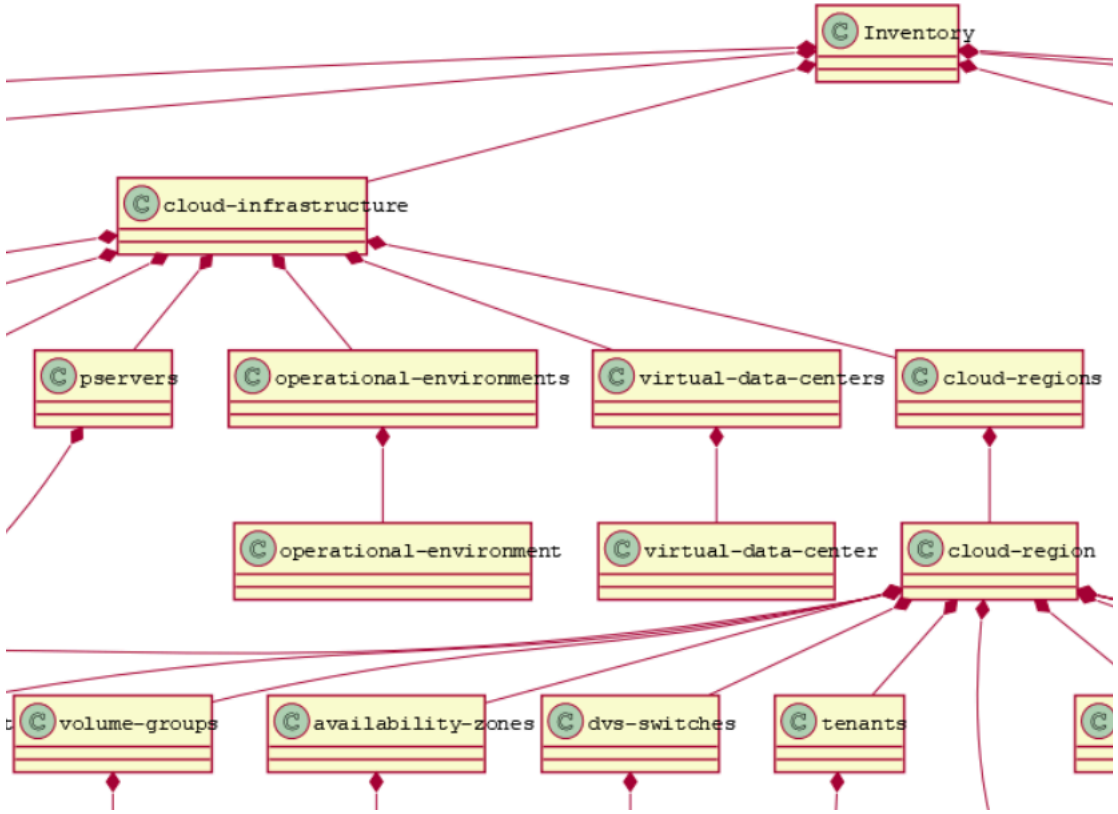
Plant UML – Schema View

- Keong Lim has developed a sequence of steps to parse the AAI data model and create Plant UML diagrams
- Below is an example schema which shows a heirarchical view of the OXM data, and shows the nesting / inheritance in the AAI schema



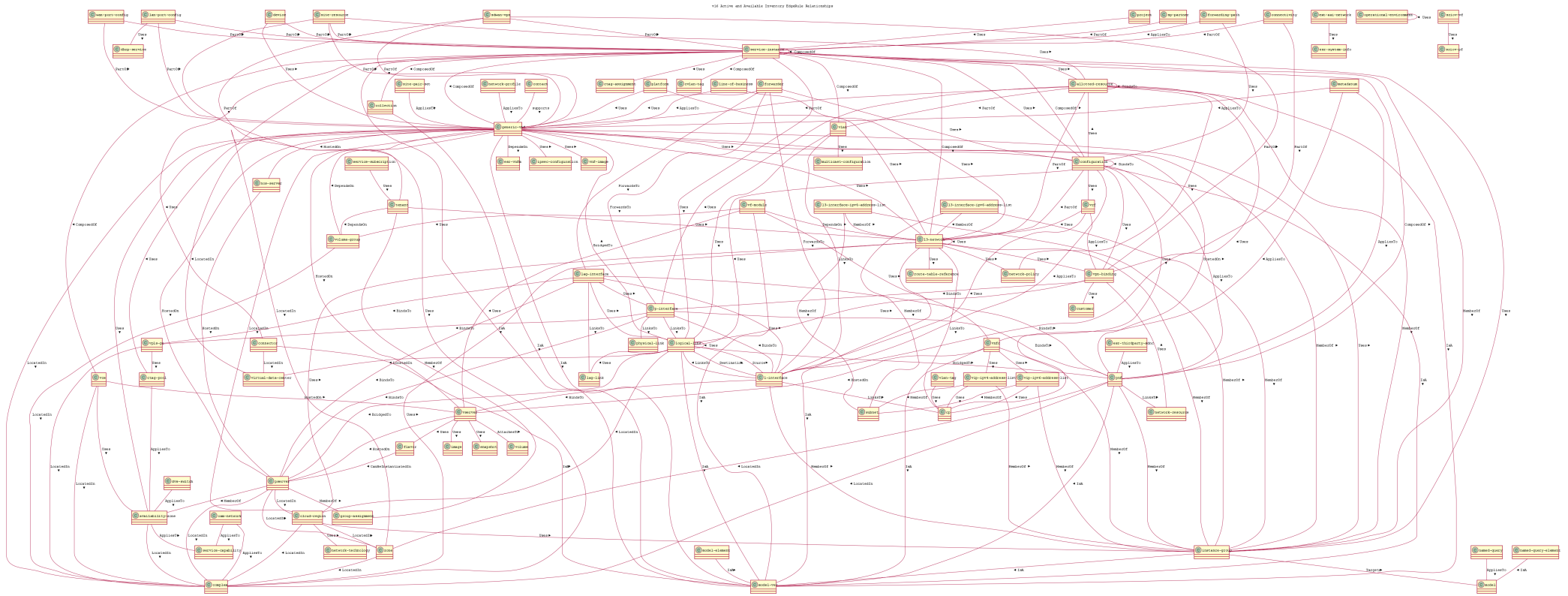
Plant UML – Schema View

- This provides an excellent visualization of the schema and the way objects are nested w/ BelongsTo relationships
- Inventory is the top node and the root of the schema, and the all the types are connected it.
- In this example, you can see how the AAI URIs are created, a tenant's URI is:
- /aai/vX/cloud-infrastructure/cloud-regions/cloud-region/{cloud-owner}/{cloud-region-id}/tenant/{tenant-id}



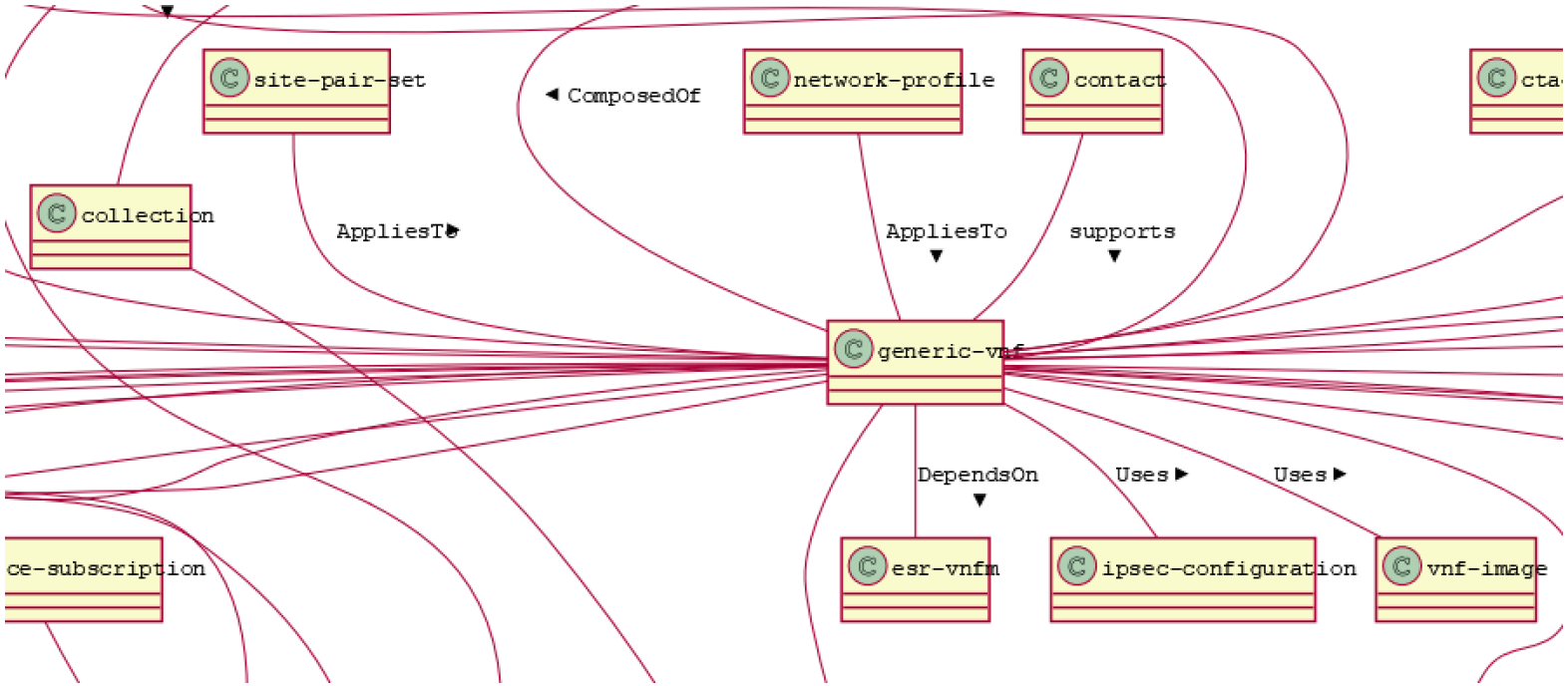
Plant UML – Edges View

- This chart shows how nodes are connected – as “cousin” edges
- These relationships are critical for traversals and a represented in the REST api in relationship-list objects



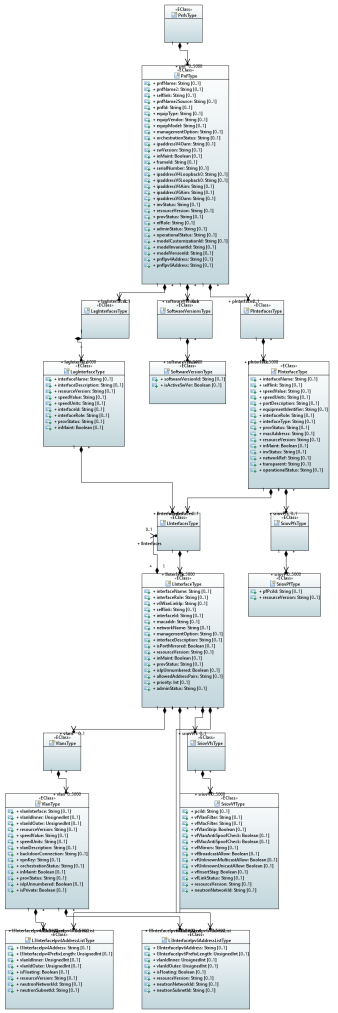
Plant UML – Edges View

- In this example, you can see that generic-vnf can be connected to a large number of other object types.



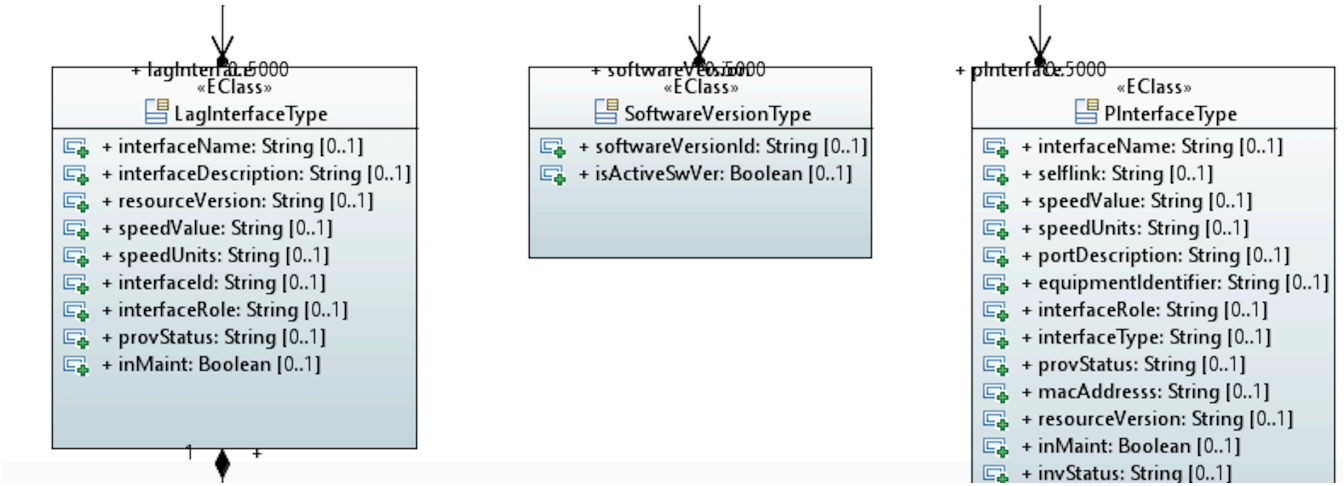
Papyrus

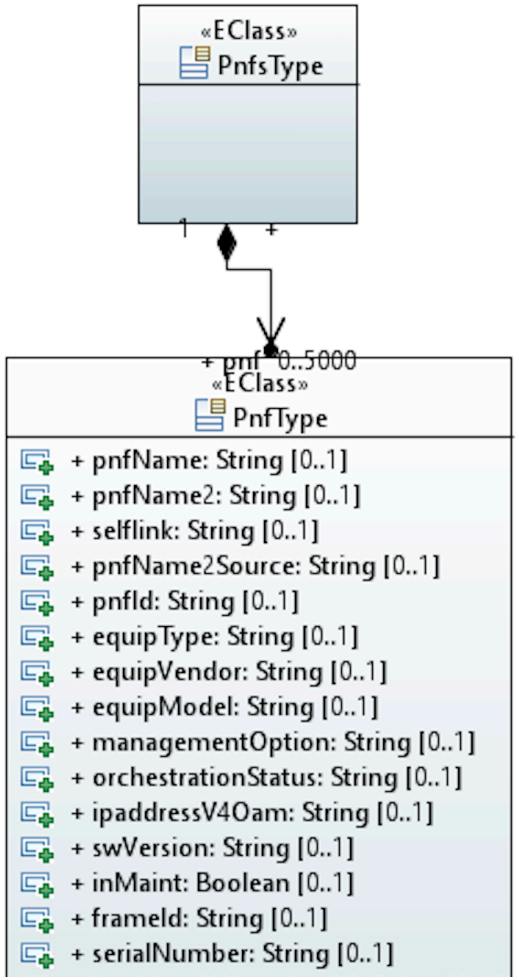
- Jacqueline Beaulac and Michela Bevilacqua have reverse engineered the AAI data model into papyrus UML
- To the right is the diagram for the PNF object and the objects that it contains



Papyrus

- Looking closer you can see that it shows the relationships and heirarcy of the various types
- It also shows the attributes of each type, the type of each attribute and their cardinality





Custom Queries

- Custom queries represent a sophisticated graph traversal mechanism which allows clients to develop and deploy stored queries to make processing complex services and ONAP deployments faster and more efficient
- There is a proposal to add custom queries to graph graph so that they can be visualized – Volunteers?
- https://wiki.onap.org/display/DW/Custom+Queries

Custom Query

- Stored-queries with required/optional properties and query parameters
- PUT request on the query API
- https://<host>:8446/aai/v$/query?format={format}&<optional-query-parameters>
- Payload with start-node and query-name.
- Start-node -> URI or an array of URIs or Nodes API
- Format = id / simple / pathed / resource / resource_and_url / graphson / count / console
- Optional Query parameters: nodesOnly, subgraph

Custom Query Input

```
{     "start": ["{namespace}/{resource}"],
      "query" : "query/{query-name}"
}

{
      "start" : ["{namespace}/{resource}"]
}

{     "start": ["{namespace}/{resource}"],
      "query" : "query/{query-name}?prop1=value1&prop2=value2"
}
```

Custom Query Example – Closed Loop

Closed-loop: Start with vserver and retrieve data required for closed-loop action (replaces a closed-loop-named-query)

```
{
      "start" : "/cloud-infrastructure/cloud-regions/cloud-region/{cloud-owner}/{cloud-region-
      id}/tenants/tenant/{tenant-id}/vservers/vserver/{vserver-id}",
     "query" : "query/closed-loop"
}
```

Traversal to use : vserver

vserver > generic-vnf

generic-vnf > model-ver

model-ver > model

generic-vnf > service-instance

service-instance > model-ver

model-ver > model

service-instance > generic-vnf

generic-vnf > vf-module

vf-module > model-ver

model-ver > model

vserver > tenant

tenant > cloud-region

Custom Query - Related-to

Related-to: Start with any starting node and the query returns all related nodes of a requested node-type with optional edge-type

```
{
          "start":["..."],
          "query":"query/related-to?startingNodeType={node-type}&relatedToNodeType={node-type}"
}

OR

{
          "start":["..."],
          "query":"query/related-to?startingNodeType={node-type}&relatedToNodeType={node-type}&edgeType={edge-type}"
}
```

Traversal to use : {starting-node-type} > {related-node-type}

Stored-queries.json

```
{
    "related-to":{
      "query":{
        "required-properties":["startingNodeType","relatedToNodeType"],
        "optional-properties":["edgeType"]
      },
      "stored-query":"builder.createEdgeTraversal(edgeType, startingNodeType, relatedToNodeType).store('x').cap('x').unfold().dedup()"
}
```

Custom Query Syntax continued..

Get generic-vnfs from pserver: Start with pserver hostname or fqdn and retrieve the generic-vnfs related to it. This query also supports pre-filtering the vnf results using optional parameters.

```
{
    "start":[“nodes/pservers?hostname=<hostname>"],
    "query":"query/genericVnfs-fromPserver?vnfType={}"
}
OR
{
    "start":[“nodes/pservers?fqdn=<fqdn> "],
    "query":"query/genericVnfs-fromPserver?vnf-type={}&nf-function={}”
}
```

Traversal to use : pserver > generic-vnf
pserver > vserver > generic-vnf

Custom Query – genericVnfs-fromPserver

```
{
   "genericVnfs-fromPserver":
     {
      "query":{
          "optional-properties":["vnfType","nfFunction","nfRole","nfNamingCode"]
               },

       "stored-query":"builder.union(
                           builder.newInstance().createEdgeTraversal(EdgeType.COUSIN, 'pserver', 'generic-vnf'),
                           builder.newInstance().createEdgeTraversal(EdgeType.COUSIN, 'pserver', 'vserver').
                                     createEdgeTraversal('vserver','generic-vnf'))
                           .getVerticesByProperty('vnf-type',vnfType)
                           .getVerticesByProperty('nf-function',nfFunction)
                           .getVerticesByProperty('nf-role',nfRole)
                           .getVerticesByProperty('nf-naming-code',nfNamingCode)
                          .store('x').cap('x').unfold().dedup()"
                     }
          }
```

Formats

- **Id** : Resource link includes the vertex Id

```
"results": [
    {
      "resource-type": "generic-vnf",
      "resource-link": "/aai/v$/resources/id/2388112"
    }
```

- **pathed**: Resource link includes the uri of the vertex

```
"results": [
    {
      "resource-type": "generic-vnf",
      "resource-link": “/aai/v$/network/generic-vnfs/generic-vnf/lab20105v"
    }
```

- **resource** : Same format as resources API response payload with depth=1
- **resource_and_url** : resource format plus the pathed url
- **graphson**: Results in graphson format
- **count**: Provides count of objects in the query

Formats

- **simple** : node-type, graph vertex id, pathed url, object properties, and directly related objects in the graph are all returned.

```
results": [
        {
            "id": "739696712",
            "node-type": "generic-vnf",
            "url": "https://<host>:8443/aai/v$/network/generic-vnfs/
                   generic-vnf/85f60b5e-6eff-49c8-9a79-550ee9eb4806",
            "properties": {
                "vnf-type": "WX",
                "vnf-name": “ONAPPHLPA0703UJWX01"
            },
            "related-to": [
                {
                    "id": "739700808",
                    "node-type": "license",
                    "url": "https://onap:8443/aai/v10/
                               network/generic-vnfs/generic-vnf/
                               85f60b5e-6eff-49c8-9a79-550ee9eb4806/
                               licenses/license/ONAP-M/
                             VONAP-81"
                }
            ]
        }
```

DSL Queries (Bring Your Own Query)

- DSL (Bring Your Own Query) is new feature being delivered in Frankfort that will allow users to specify ad-hoc queries that will make AAI more flexible and robust than previous versions
- Like with custom queries, there is a proposal to add DSL queries to the graph graph views

DSL Query

- BYOQ : A simple DSL to describe a graph traversal query
- provides the abstraction to translate to underlying graph language(gremlin, cypher)
- BYOQ language was built using Antlr4 (AAIDSL.g4) .
- 2-step translation which gets translated first to our A&AI internal DSL and next to underlying graph query language using Groovy
- BYOQ UI (part of Sparky UI) is under development, where users can build queries and retrieve the results
- Formats and query parameters similar to custom queries
- PUT request on the DSL API

  https://<host>:8446/aai/v$/dsl?format={format}&<optional-query-parameters>

DSL Example

- Input Payload

```
{
  "dsl" : "  customer('global-customer-id','8310000058863-16102016-aai1539')
             > service-subscription > service-instance
             > connector* > virtual-data-center* > generic-vnf* "

}
```

Starting with a customer object, traverse through service-subscriptions and service-instances, and traverse any edges to connector objects. Store the connectors and any connected virtual data centers and their generic vnfs, and return the set.

DSL Syntax

Node Query (Filter based on properties or negation)
node* (‘key’,value’) (‘key2’,’value2’)…. * → store(x) or ‘Select *’
node* !(‘key’,value’) (‘key2’,value2’)…. ‘!’ → neq or negation

Example:
cloud-region*('cloud-owner',‘onap-rs1')('cloud-region-id',‘onap3')

Traversal with Node Query
node1(‘key1’,value1’) > node2 > node3* (‘key3’,value3’)

Example:
cloud-region ('cloud-owner',‘onap')('cloud-region-id',ONAP25') > availability-zone*

Where clause (Filter based on traversal)
node1* (> node2(‘key’,’value’))
node1* (‘key1’,’value1’) (> node2!(‘key2’,’value’))

Example
pnf* (> complex('physical-location-id',‘ONAPDATA'))

DSL Syntax

Traversal Query with union

- node1(‘key’,’value’)+ > [node2> node3* , node3*]
- For a Topology view , when you want to view a sub-set of nodes from NODE1

Example:

```
cloud-region('cloud-owner',‘onap-rs1')('cloud-region-id',’onap3') >
[
  complex*('state','NJ'),
   l3-network*('network-type','tst-EXAMPLE_BASIC_NETWORK’)
]
```

Best Practices for CQ and BYOQ

- Verify that the start element or the start node has (this is the preferred order)
  - URI
  - Keys
  - Unique indexed properties
  - Indexed properties
- Run cq2gremlin API in traversal (https://<host>:8446/aai/cq2gremlin) and get the gremlin equivalent. Run a profile on the gremlin equivalent to make sure the gremlin query is optimal
- GraphGraph or Schema Service could help with the shortest path to define the optimal traversal for the custom query
- Do not start a query with a union . Union queries do not use indexes

Best Practices for CQ and BYOQ

- Use subgraph=* sparingly. It tries to get the related edge for every vertex returned by your custom query. It would get very expensive if the vertex has too many related edges(like cloud-region)
- Use groupCount sparingly or in UI queries. Not for use by clients in application.
- groupCount by a property is equivalent of a full table scan. The only index that it uses is aai-node-type which is a low cardinality index
- Frequently used DSL queries should be encouraged to be converted to custom-queries since the start-node in a custom query has a URI which is uniquely indexed in the graph
- Run a count on the query and verify if the traversal can be reversed to get the optimal query

Rest Layer

- Rest Consumer classes are the entry point for all Rest endpoints in the microservice
- Validates the request and completes the preprocessing required for the request
- Applies query parameters (depth, nodesOnly) to the request
- Formats the response payload – calls core library to transform response payloads

- QueryConsumer : REST layer for custom query API (/query)
- DSLConsumer : Rest layer for DSL queries(/dsl)
- RecentsAPIConsumer: Rest layer for recents API (/recents)
- SearchProvider : Rest layer for nodes and generic query(/search)
- ModelAndNamedQueryRestProvider: Rest layer for model query and named query (/model)

- Separate consumer class for each endpoint
- Register in JerseyConfiguration.java(`org.glassfish.jersey.server.ResourceConfiguration`)

Query Builder

Gremlin QueryBuilder

- Provides abstraction from the A&AI schema and from the underlying graph query language
- Converts the A&AI internal DSL to gremlin

Key Methods

- getVerticesByProperty(key,value) → has('key','value')
- getVerticesByProperty(key, MissingOptionalParameter value)
- getVerticesByProperty(key) → has('key')
- createEdgeTraversal(EdgeType, nodeType1, nodeType2)
  - Find if edgerule exists between the nodeTypes. If yes, finds the direction for the traversal .out().has('aai-node-type','nodeType2') or .in().has('aai-node-type','nodeType2')
- createEdgeTraversalWithLabels(EdgeType, nodeType1, nodeType2, List<> labels)

  .out('edgelabel').has('aai-node-type','nodeType2') or .in('edgelabel').has('aai-node-type','nodeType2')

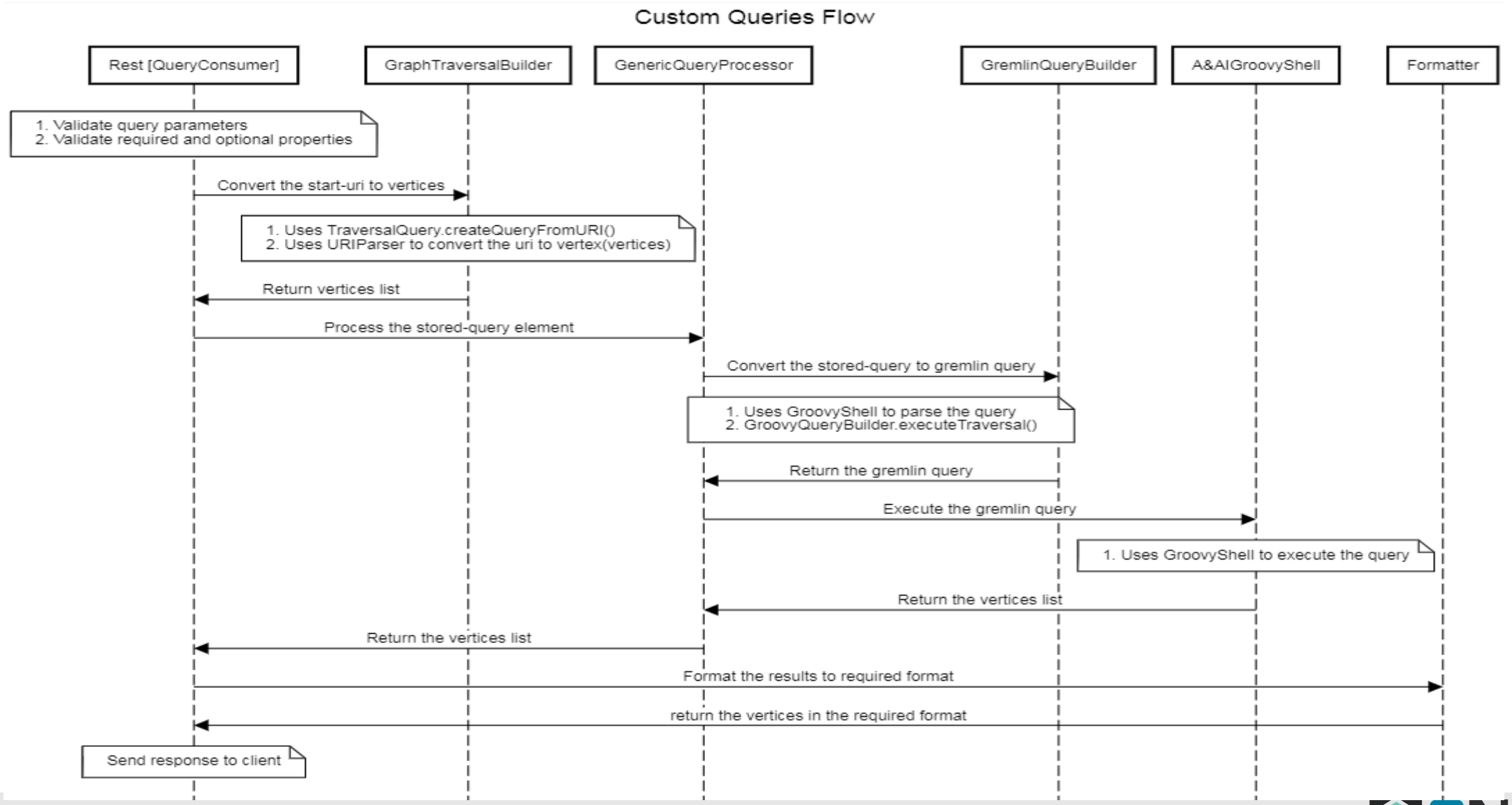
Implemented constructs

- Union, where, has, hasNot, select, or , store, cap, unfold, dedup, emit, repeat, both, tree, by, path

Query Builder Internals

- { "start" : ["cloud-infrastructure/cloud-regions/cloud-region/{cloud-owner}/{cloud-region-id}"],
  "query" : "query/availabilityZoneAndComplex-fromCloudRegion"
  }
- builder.union(builder.newInstance().createEdgeTraversal(EdgeType.TREE, 'cloud-region', 'availability-zone').store('x'),builder.newInstance().createEdgeTraversal(EdgeType.COUSIN, 'cloud-region', 'complex').store('x')).cap('x').unfold().dedup()
- g.V(vertices).has('aai-node-type', 'cloud-region').has('cloud-owner', ‘onap').has('cloud-region-id', ‘ONAP25').union(__.in('org.onap.relationships.inventory.BelongsTo').has('aai-node-type', 'availability-zone').store('x'),__.out('org.onap.relationships.inventory.LocatedIn').has('aai-node-type', 'complex').store('x')).cap('x').unfold().dedup()
- GraphStep([],vertex), HasStep([aai-node-type.eq(cloud-region)]), StoreStep(x), HasStep([aai-node-type.eq(service-subscription)]), StoreStep(x), StoreStep(x), VertexStep(OUT,[usesL3Network],vertex), HasStep([aai-node-type.eq(l3-network)]), StoreStep(x), VertexStep(IN,[uses],vertex), HasStep([aai-node-type.eq(cloud-region)]), StoreStep(x), SideEffectCapStep([x]), UnfoldStep]
- CQ2Gremlin : API that will help you verify the gremlin for your custom query

Custom Queries Flow



DSL Queries Flow