Semantic resource descriptions in ORCA

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Welcome!

- 1:30 PM Cluster-D ORCA NDL-OWL resource representations: current capabilities and roadmap – I.Baldine, Y.Xin
- 2:30 PM ORBIT: a view on ontological resource representations – M.Ott
- 2:50 PM Break
- 3:00 PM ProtoGENI RSpec evolution – R. Ricci
- 3:30 PM ViSE: the view of resource representation – D.Irwin
- 3:45 PM KanseiGenie resource representation requirements – Hongwei Zhang
- 4:00 PM Open discussion: the future of GENI resource representations

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Resource representations in GENI

- Used by elements of control frameworks
- Used by experimenter tools
- Visualizations, performance measurements etc. etc.
- Have a lifecycle
  - Current state of the substrate
  - Request specification
  - Slice specification
  - ‘As-built’ manifest

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Overview

- RDF primer
- Differences between formats and languages
- NDL-OWL introduction
- NDL in ORCA
- Future vision

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RDF Primer

- RDF represents information about resources
- Resources are identified by URIs
- Intended to be processed by many different applications
- Applications share common vocabularies
- Emphasis on common toolsets:
  - Parsers
  - Query engines
  - Inference engines

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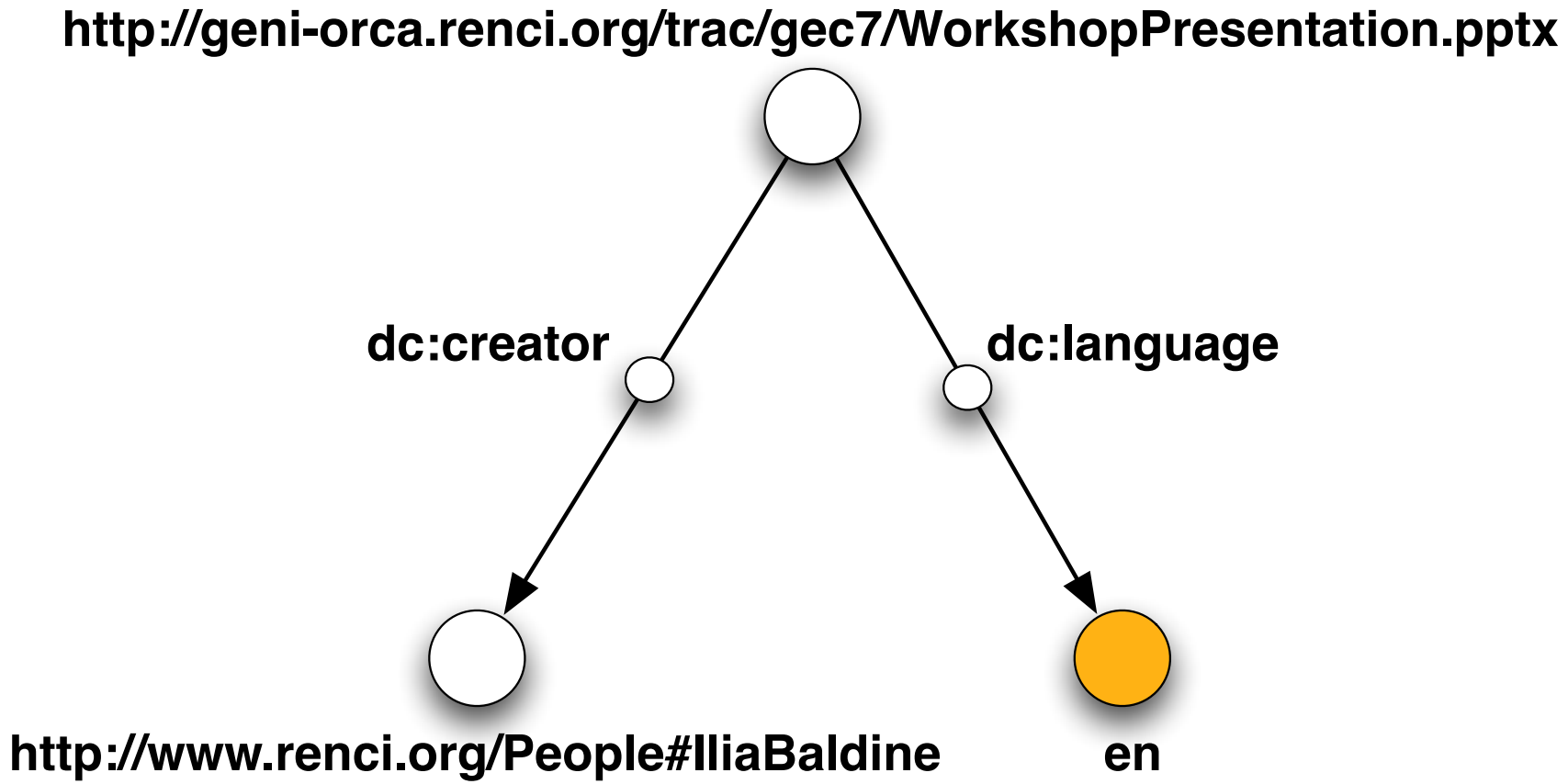
RDF Primer

- RDF is declarative
- RDF is represented as triples
  - <subject> <predicate> <object>
- Trivial example
  1. http://geni-orca.renci.org/trac/gec7/WorkshopPresentation.pptx
  2. dc:creator
  3. http://www.renci.org/People#IliaBaldine
- dc is a shorthand for
  - http://purl.org/dc/elements/1.1/
  - Dublin Core Metadata Initiative (DMCI)
- An open organization engaged in the development of interoperable metadata standards that support a broad range of purposes and business models

RDF Graphs


http://geni-orca.renci.org/trac/gec7/WorkshopPresentation.pptx
dc:creator
dc:language
http://www.renci.org/People#IliaBaldine
en

RDF Representations

- NTriples

  <http://geni-orca.renci.org/trac/gec7/WorkshopPresentation.pptx> dc:creator http://www.renci.org/People#IliaBaldine .

- Turtle: Terse RDF Triple Language
  - Extension of NTriples
  - @prefix, @base and other shorthand notation
- RDF-XML

```
<rdf:RDF>
<rdf:Description rdf:about=
   http://geni-orca-renci.org/trac/gec7/WorkshopPresentation.pptx>
  <dc:creator rdf:resource="http://www.renci.org/People#IliaBaldine>
</rdf:Description>
</rdf:RDF>
```

SPARQL Queries/subgraph extractions

- SPARQL query

SELECT ?doc

WHERE {

?doc dc:creator

http://www.renci.org/People#IliaBaldine .

}

Returns *http://geni-orca.renci.org/trac/gec7/WorkshopPresentation.pptx*

Inferences

- Inference engines use rulesets to add new statements into the model
  - Simple example

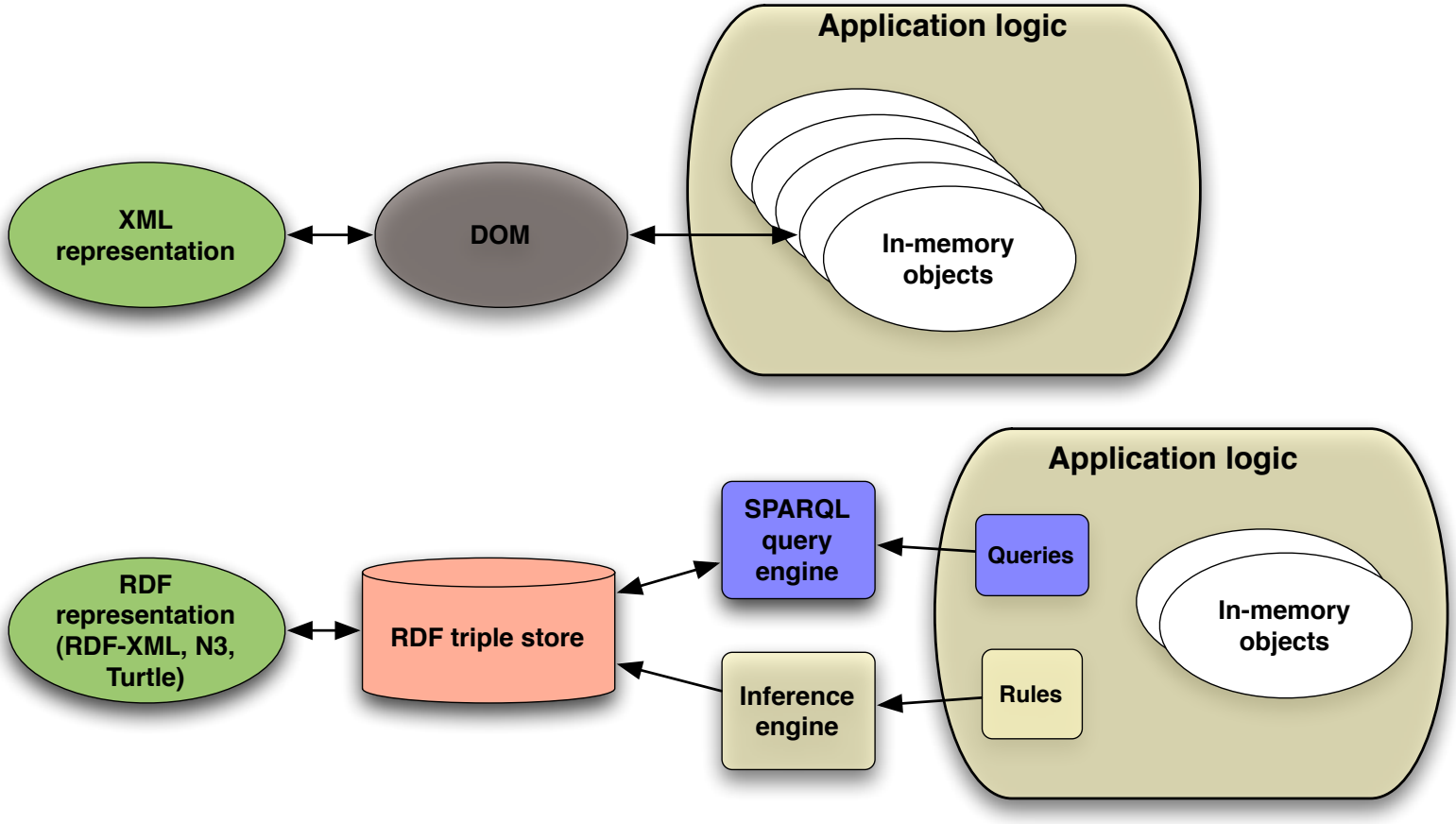
  A is_connected B

  B is_connected C

  - By indicating transitivity of *is_connected* predicate to the inference engine, the engine would automatically insert rule

  A is_connected C

Formats vs. languages



Multi-layered network representations

- Multi-layered network is not a single graph
- It is an embedding of graphs of higher level networks into graphs of lower level networks
  - Done by selecting proper layer adaptations
  - The lower level graphs may evolve over time
- NDL and NDL-OWL allow to describe layer adaptations based on ITU G.805 (connection-oriented), G.809 (connectionless) abstractions
- Besides connectivity, other metadata should be expressed
  - Human-readable labels
  - Coordinates
  - Administrative relationships

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Applying RDF/OWL to resource descriptions

- Abstract Data model
  - NDL-OWL is a data model first
  - Based on ITU-G.805 and GMPLS
    - Topology (node + link), Layer adaptation, switching capability,
    - Capacity, Labels, ….
  - Dynamic model update based on new system state
- Language choice
  - Model representation
  - Semantic richness
  - Tool kits
- Decide on the abstractions first, RDF/OWL helps reflect abstractions in a standardized way

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NDL – the original Network Description Language

- Created at UVA SNE group (http://www.science.uva.nl/research/sne/ndl
- Based on G.805 (for transport networks) and the concept of layer adaptations
- Uses RDF as foundation
- Used to describe GLIF facility
- Tools for path planning and visualization

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NDL example

<#gi3/1:fiber> <rdf:type> <ndl:Interface>.
<#gi3/1:fiber> <rdf:type> <wdm:FiberNetworkElement>.
<#gi3/1:fiber> <wdm:polish> <wdm:PC>.
<#gi3/1:fiber> <wdm:connector> <wdm:LC-connector>.
<#gi3/1:fiber> <wdm:WDM> <#gi3/1:lamda>.
<#gi3/1:lamda> <rdf:type> <ndl:Interface>.
<#gi3/1:lamda> <rdf:type> <wdm:LambdaNetworkElement>.
<#gi3/1:lamda> <wdm:wavelength> "1310.0"^^http://www.w3.org/2001/XMLSchema#float.
<#gi3/1:lamda> <wdm:eth1000base-X> <#gi3/1:Ethernet>.
<#gi3/1:ethernet> <rdf:type> <nd:Interface>.
<#gi3/1:ethernet> <rdf:type> <eth:EthernetNetworkElement>.
<#gi3/1:ethernet> <eth:frameSize> <eth:FrameSize:1500>.

NDL-OWL

- OWL has stronger support for classes, attributes and constraints
  - There are *classes* and *individuals*
  - Properties (datatype and object)
  - Instances
  - Operations (unions, intersections, complements, cardinality constraints)
- RDF makes no distinctions between classes and individuals
- NDL-OWL uses NDL schema as a basis and extends it

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NDL-OWL example (1/2)

```
<rdf:Description rdf:about="http://geni-orca.renci.org/owl/ben.rdf#UNC/Cisco/6509">
      <rdfs:label>6509</rdfs:label>
      <ndl:hostName>6509-1.UNC.ben</ndl:hostName>
      <ndl:managementIP>192.168.203.7</ndl:managementIP>
      <ndl:hasSwitchMatrix rdf:resource="#UNC/Cisco/6509/EthernetSwitchingMatrix"/>
      <ndl:hasInterface rdf:resource="#UNC/Cisco/6509/GigabitEthernet/1/2/ethernet"/>
…
      <ndl:hasInterface rdf:resource="#UNC/Cisco/6509/TenGigabitEthernet/3/1/fiber" />
  </rdf:Description>

<dtn:FiberNetworkElement rdf:about="#UNC/Cisco/6509/TenGigabitEthernet/3/1/fiber">
      <rdf:type rdf:resource="&ndl;Interface"/>
      <dtn:WDM rdf:resource="#UNC/Cisco/6509/TenGigabitEthernet/3/1/lambda" />
      <ndl:linkTo rdf:resource="&t1B3;fiber"/>
      <ndl:interfaceOf rdf:resource="http://geni-orca.renci.org/owl/ben.rdf#UNC/Cisco/6509"/>
  </dtn:FiberNetworkElement>

<ndl:Interface rdf:about="#UNC/Cisco/6509/TenGigabitEthernet/3/1/lambda">
      <rdf:type rdf:resource="&dtn;LambdaNetworkElement"/>
      <dtn:TenGbase-R rdf:resource="#UNC/Cisco/6509/TenGigabitEthernet/3/1/ethernet" />
  </ndl:Interface>
```

NDL-OWL example (2/2)

```
<ethernet:EthernetNetworkElement rdf:about="#UNC/Cisco/6509/TenGigabitEthernet/
    3/1/ethernet">
    <rdf:type rdf:resource="&ndl;Interface"/>
    <rdfs:label rdf:datatype="&xsd;string"
        >tengigabitethernet 3/1</rdfs:label>
    <ethernet:availableVLANSet rdf:resource="#UNC/Cisco/6509/availableVLANSet" />
  </ethernet:EthernetNetworkElement>

<layer:LabelSet rdf:about="#UNC/Cisco/6509/availableVLANSet">
      <collections:element rdf:resource="#UNC/Cisco/6509/availableVLANSet/1" />
  </layer:LabelSet>

  <layer:LabelRange rdf:about="#UNC/Cisco/6509/availableVLANSet/1">
    <layer:lowerBound rdf:resource="#UNC/Cisco/6509/VLANLabel/100"/>
    <layer:upperBound rdf:resource="#UNC/Cisco/6509/VLANLabel/200"/>
  </layer:LabelRange>
```

Other statements in NDL-OWL

- Domains are collections of PoPs (to facilitate interdomain path computation and stitching)
- PoPs are collection of Devices
- Device is a broad class of resource subtypes
  - Network devices
  - Computational devices
- Devices have interfaces with adaptations

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Common tools used in ORCA-BEN

- Protégé (http://protege.stanford.edu/)
  - Maintains ontologies (schemas and models)
  - Converts to appropriate formats
- Jena (http://jena.sourceforge.net/)
  - RDF triple store
  - Inference engine
  - SPARQL engine
- MIT Tabulator (http://www.w3.org/2005/ajar/tab)
  - Javascript-based RDF triple store and SPARQL engine

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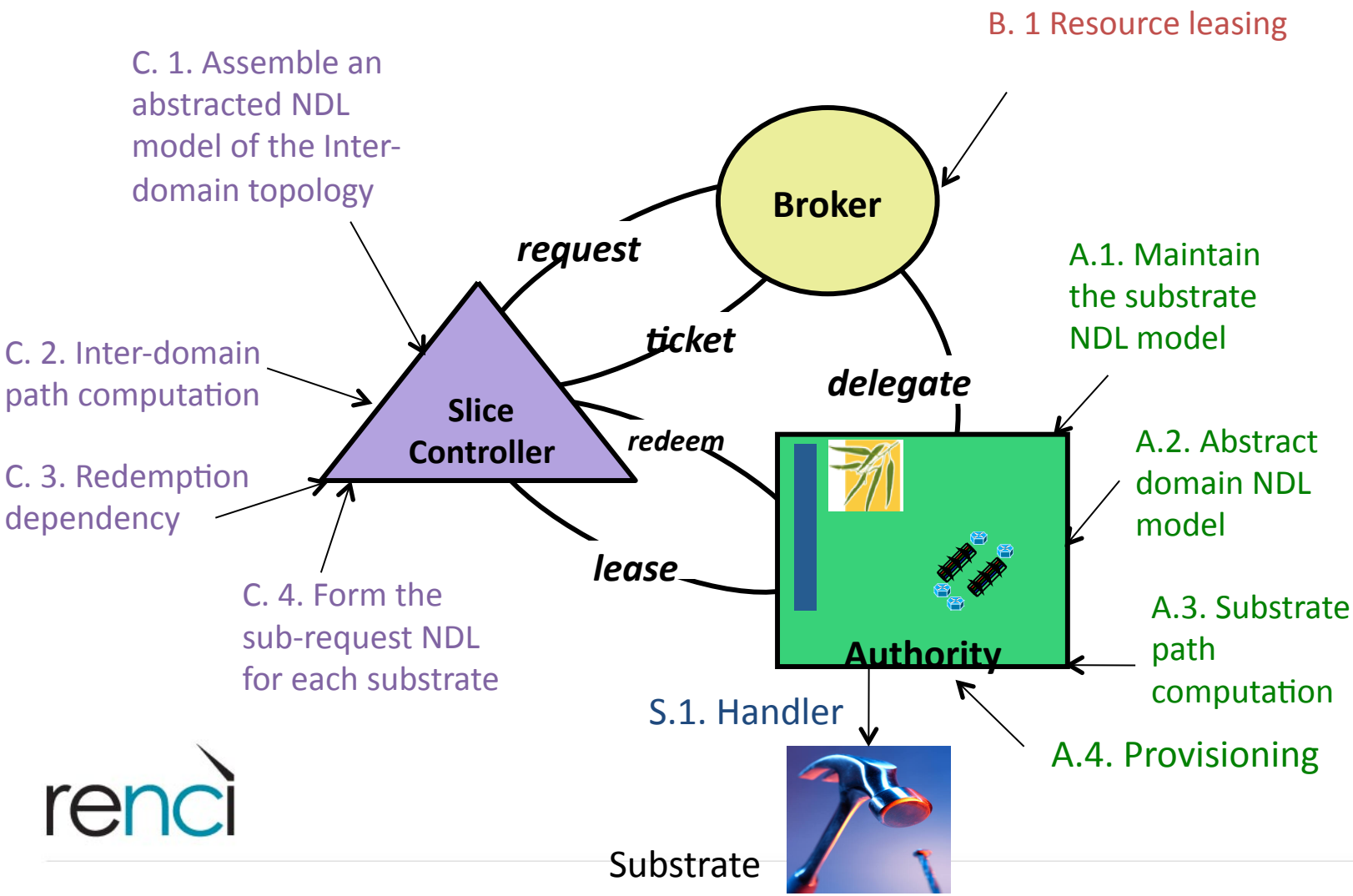
Current state of NDL-OWL in ORCA

- Can be used in AMs
  - BEN AM computes the necessary network element actions based on NDL request input and NDL model describing current state
  - As new connections are provisioned, they are inserted as statements into the model
- .. And experiment controllers
  - Controller computes inter-domain path based on domain descriptions expressed in NDL
  - Each domain description is ‘aggregated’ into a single node with external interfaces to other domains
  - Controller determines the order in which AMs in domains need to redeem tickets in order to accomplish slice orchestration via stitching

ORCA: Life cycle of resource models



Inter-domain Model

- Assemble the inter-domain abstract model
  - Another NDL-OWL model
  - Concatenate the abstract models from all the substrates
- Take the end-to-end request
- Form the sub-request NDL-OWL model for each domain on the path
- Determine dependencies for redeeming tickets for resources from domains

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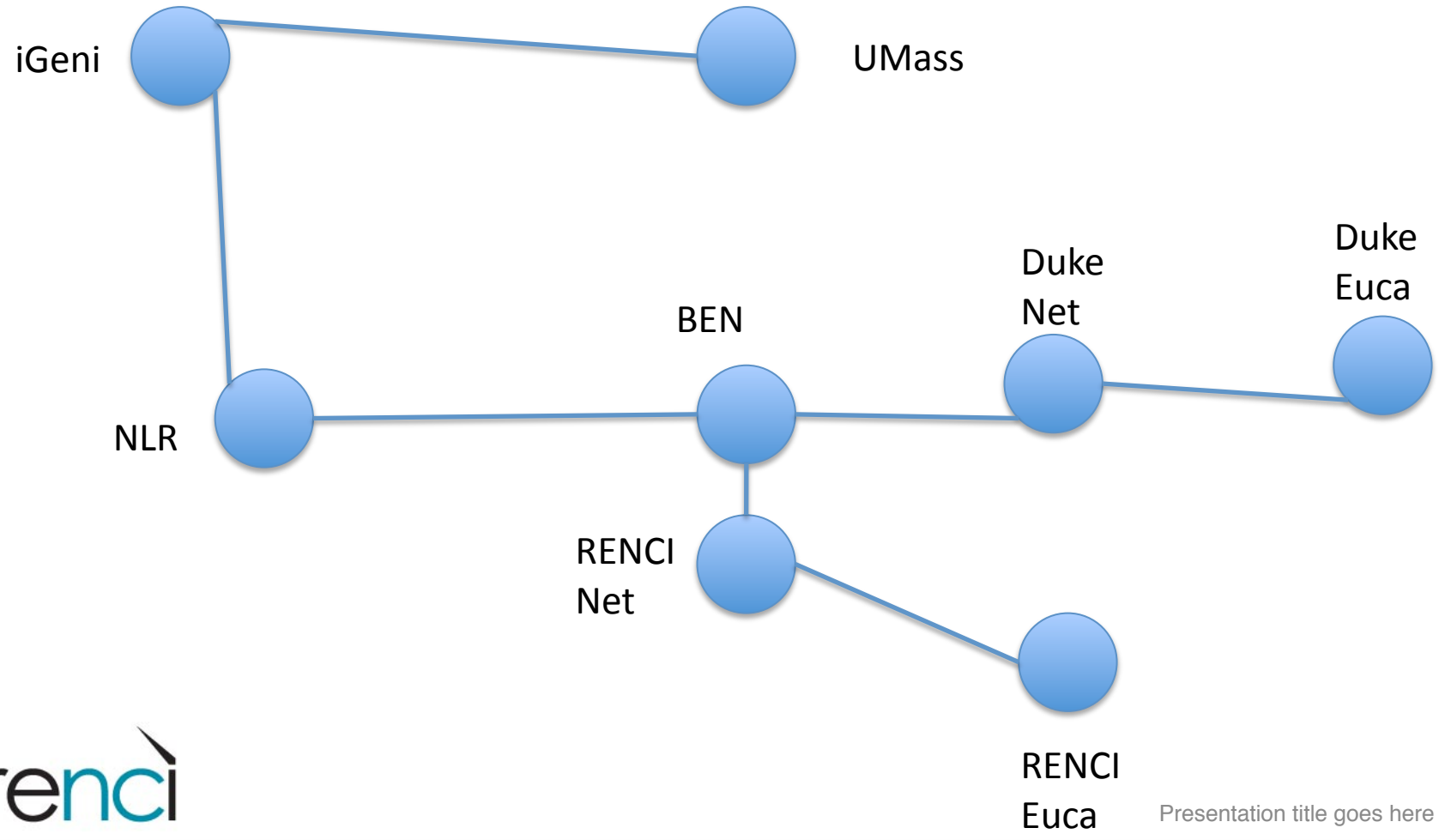
Example: inter-domain model



Intra-domain

- Add the sub-request to the substrate model
- Find the path
- Generate the new connections and add to the substrate model
- Update the resource
- Return the result
  - Label assigned
  - Connection details

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Future of NDL-OWL in ORCA

- Already extended to support computational resources and their attributes
- Measurement resources are next
- With help from Cluster D projects
  - Wireless, sensor networks
- Content/data

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