



CTS2 Development Framework Implementation Technical Overview

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Pre-tutorial House Keeping

- This tutorial is not in a computer lab
- If you wish to follow along with the interactive demos you'll need a laptop and the tech stack and set up noted in the requirements document
- This will need to be done before the tutorial starts if you want to follow along
- Instructions are in the requirements document here:
<https://github.com/hsbauer/cts2-example-service/archive/master.zip>



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Who is this Tutorial for?

- Software developers, technical programmers, Information architects, health informaticists, technical analysts
- Should know how to implement the CTS2 technical framework specification at the end of this tutorial



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What do I Need to Know as a Developer

- Introduction to CTS2 recommended
- Some knowledge of UML, CTS2 Specification, XML, JSON, REST required for full implementation
- Java and JavaScript will be helpful for some of the examples
- Command line Maven, Python and Unix/Linux may be helpful as well



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Overview

- CTS2 is an OMG standard for the query, interchange and update of terminological resources.
- This tutorial will provide technical implementers with guidance for the implementation of the standard.



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Terminology Services

Terminologies:

- A list of unique terms and a set of properties helps define our common context for a term.
 - Like a dictionary.
- The way we know how to use terms is more complex:
 - Classifications
 - Synonyms
 - Unstated relationships



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Terminology Services

- Awareness of what is not in a dictionary is a “way of knowing” (This is sometimes called ontology).
- This is often built in to complex terminologies
- A terminology service provides the structure
 - For using this way of knowing about the entities in service
 - For dealing with updates, versioning, history and other administrative functions



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How to Approach the Specification

- The specification is designed for modular implementation. You do not need to implement the entire specification!
- Choose your implementation strategy based on local requirements, not to include a broad spectrum of the specification



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Modular Specification

Implement / use what you need

- Code System Catalog Entry and Code System Version Catalog Entry
- Entity Description and Association
- Value Set Catalog, Value Set Definition and Resolved Value Set
- Map Catalog Entry, Map Version
- Concept Domain, Concept Domain Binding
- Statement



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Modular Functionality

Implement / use what you need

- Read
- Query
- Import
- Export
- Update
- Maintenance
- History
- Temporal



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Every Module Has:

- Formal Information Model in UML
 - Defines the resource, how it is identified and what information it contains
- Formal Computational Model in UML
 - Defines operations that are available for each functional (read, query, import, ...) profile



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Every Module Also Has

- XML Schema representation of the Information Model
- WADL rendering of Computational Model
 - Defines the URLs + operations (GET, PUT, POST, REMOVE) that implement the computations
- WSDL rendering of Computational Model



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Combined they provide a set of rules that:

- Describe (some of) what can be said about various aspects of terminologies
- Provide a straight-forward format for structuring the information
- Provide rules for publishing, querying, exchanging and updating information in a distributed, federated environment



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CTS2 in a nutshell

A set of XML Schemas for:

- Code Systems, Maps, Value Sets and Concept Domain Bindings

A set of URL formation rules for:

- Reading, Querying, Importing and Updating the XML Documents

A set of rules for representing XML in JSON, RDF, Java, Python, ...



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CTS2 Implementation

Planning an Implementation

How do I plan an implementation?

Ask the following questions:

- Do I need to implement a terminology service of my own?
- Do I need unique content?
- Do I need unique services from the content?
- Can I adequately map the content into the CTS2 Model or do I need expert help?



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How do I plan an implementation?

CTS2 Service

A persisted Terminology

- CTS2 doesn't specify how this is done
- It may require wrapping an existing terminology service
 - Providing a mapping and a bridge for legacy technology
- Or creating a direct implementation of CTS2 over a database
 - Starting from scratch against a (set of) persisted terminologies.



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How do I plan an implementation? Are You Consuming Terminology Content?

If so what services do I need from the terminology service:

- Do I want to search for terminology entities?
- Do I need value sets for research forms?
- Do I need to map from one terminology to another?
- Do I need to traverse from a specific term to a more general one. Or establish term classification siblings? Semantic types?



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Ways to Implement

- Service Implementers may want to implement a CTS2 Development Framework (DF) service plugin (This isn't required.)
- CTS2 consumers will want to implement a REST/JSON, REST/XML or SOAP client



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Tutorial Overview

Where to Start

We'll choose CTS2 modules that can serve a fairly wide set of use cases:

CodeSystemCatalogEntry, Entity Description, Value Sets

- And use the same model elements to access code system entities, their associated children, value sets, and versions of code systems.
- Create a service plugin based on this model element
- Note that these are a small part of the API



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CTS2 REST Client API

CTS2 REST Client API

CTS2 is designed on a REST architecture:

- This shapes method calls and naming conventions
 - A directory is a summary of a group of objects, such as code systems or entities. A catalog (list) will provide complete objects
 - Read services generally are looking for a unique identifier for input
 - Query services offer filters on a matching value



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Interactive Demo: CTS2 REST Client API

- The focus will be on read and query module functions
- Entity, code system(s), code system versions and value sets to comprise the examples
- REST calls will be to the NCBO Bioportal CTS2 REST wrapper



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CTS2 REST Client API

How do we know what systems are at a service?

- Start by querying the code systems
- <http://informatics.mayo.edu/cts2/rest/codesystems>
- This returns a directory, or list of summaries of the code systems on that service



```
CodeSystemCatalogEntryDirectory xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/CodeSystem http://informatics.mayo.vn/trunk/cts2/spec/psm/rest/schema/CodeSystem.xsd" complete="PARTIAL" numEntries="50" next="http://informatics.mayo.edu/cts2/odesystems?page=1&maxtoreturn=50">
<core:heading>
  <core:resourceRoot>codesystems</core:resourceRoot>
  <core:resourceURI>http://informatics.mayo.edu/cts2/rest/codesystems</core:resourceURI>
  <core:accessDate>2012-12-26T14:01:47.114-05:00</core:accessDate>
</core:heading>
<entry href="http://informatics.mayo.edu/cts2/rest/codesystem/EMAP" resourceName="EMAP" about="http://purl.bioontology.org/ontology/EMAP" formalName="Mouse gross anatomy and development" codeSystemName="EMAP">
  - <core:resourceSynopsis>
    - <core:value>
      A structured controlled vocabulary of stage-specific anatomical structures of the mouse (Mus).
    </core:value>
  </core:resourceSynopsis>
  - <versions>
    http://informatics.mayo.edu/cts2/rest/codesystem/EMAP/versions
  </versions>
  - <currentVersion>
    <core:version href="http://informatics.mayo.edu/cts2/rest/codesystem/EMAP/version/45267">EMAP_45267_OBO</core:version>
    <core:codeSystem uri="http://purl.bioontology.org/ontology/EMAP" href="http://informatics.mayo.edu/cts2/rest/codesystem/EMAP">EMAP</core:codeSystem>
  </currentVersion>
</entry>
<entry href="http://informatics.mayo.edu/cts2/rest/codesystem/EMO" resourceName="EMO" about="http://purl.bioontology.org/ontology/EMO" formalName="Enzyme Mechanism Ontology" codeSystemName="EMO">
  - <core:resourceSynopsis>
```

CTS2 REST Client API

How can we query individual code systems from this service?

- Working through CodeSystem and CodeSystems REST APIs
 - By name, ontologyId, or description
 - By matching algorithms “contains” or “exact match”



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CTS2 REST API

Searchable fields in the CodeSystemDirectoryEntry

```
- <entry href="http://informatics.mayo.edu/cts2/rest/codesystem/MDR" resourceName="MDR" about="http://purl.bioontology.org/ontology/MDR" formalName="Medical Dictionary for Regulatory Activities Terminology (MedDRA)">
- <core:resourceSynopsis>
  - <core:value>
    Medical Dictionary for Regulatory Activities Terminology (MedDRA)
  </core:value>
</core:resourceSynopsis>
- <versions>
  http://informatics.mayo.edu/cts2/rest/codesystem/MDR/versions
</versions>
- <currentVersion>
  <core:version href="http://informatics.mayo.edu/cts2/rest/codesystem/MDR/version/12.0">MDR_12-0_RRF</core:version>
  <core:codeSystem uri="http://purl.bioontology.org/ontology/MDR" href="http://informatics.mayo.edu/cts2/rest/codesystem/MDR">MDR</core:codeSystem>
</currentVersion>
</entry>
```



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CTS2 REST Client API

Working through codesystems, name is matched against the abbreviated ontology designation.

Example: MedDRA is MDR.

- [http://informatics.mayo.edu/cts2/rest/
codesystems?
matchvalue=MDR&filtercomponent=resource
Name](http://informatics.mayo.edu/cts2/rest/codesystems?matchvalue=MDR&filtercomponent=resourceName)
- Where matchvalue is the text to match and resourceName is the name field to match



```
- <CodeSystemCatalogEntryDirectory xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/CodeSystem http://informatics.mayo.edu  
/svn/trunk/cts2/spec/psm/rest/schema/CodeSystem.xsd" complete="COMPLETE" numEntries="1">  
- <core:heading>  
  <core:resourceRoot>codesystems</core:resourceRoot>  
  <core:resourceURI>http://informatics.mayo.edu/cts2/rest/codesystems</core:resourceURI>  
- <core:parameter arg="filtercomponent">  
  <core:val>resourceName</core:val>  
  </core:parameter>  
- <core:parameter arg="matchvalue">  
  <core:val>MDR</core:val>  
  </core:parameter>  
  <core:accessDate>2012-12-21T16:39:44.557-05:00</core:accessDate>  
</core:heading>  
- <entry href="http://informatics.mayo.edu/cts2/rest/codesystem/MDR" resourceName="MDR" about="http://purl.bioontology.org  
/ontology/MDR" formalName="MedDRA" codeSystemName="MDR">  
- <core:resourceSynopsis>  
  - <core:value>  
    Medical Dictionary for Regulatory Activities Terminology (MedDRA)  
  </core:value>  
  </core:resourceSynopsis>  
- <versions>  
  http://informatics.mayo.edu/cts2/rest/codesystem/MDR/versions  
  </versions>  
- <currentVersion>  
  <core:version href="http://informatics.mayo.edu/cts2/rest/codesystem/MDR/version/12.0">MDR_12-0_RRF</core:version>  
  <core:codeSystem uri="http://purl.bioontology.org/ontology/MDR" href="http://informatics.mayo.edu/cts2/rest/codesystem  
/MDR">MDR</core:codeSystem>
```

CTS2 REST Client API

Using the codesystems API, the other “filtercomponents” we can match are:

- resourceSynopsis: a description of the resource
- resourceName: the abbreviation of the code system
- about: the URI of the code system
- keyword: contents of the keyword tag
- ontologyId: unique ID of the ontology in the service



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CTS2 REST Client API

Direct read calls to the code system API require a similar knowledge of the abbreviated name of the code system:

- <http://informatics.mayo.edu/cts2/rest/codesystem/VANDF>
- You can get this information by first making a call to the codesystems and returning a directory of codesystems



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```
- <CodeSystemCatalogEntryMsg xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/CodeSystem http://informatics.mayo.edu  
/svn/trunk/cts2/spec/psm/rest/schema/CodeSystem.xsd">  
  - <core:heading>  
    <core:resourceRoot>codesystem/VANDF</core:resourceRoot>  
    - <core:resourceURI>  
      http://informatics.mayo.edu/cts2/rest/codesystem/VANDF  
    </core:resourceURI>  
    <core:accessDate>2012-12-21T16:43:50.197-05:00</core:accessDate>  
  </core:heading>  
  - <codeSystemCatalogEntry entryState="ACTIVE" about="http://purl.bioontology.org/ontology/VANDF" formalName="VANDF"  
    codeSystemName="VANDF">  
    <core:keyword>VANDF</core:keyword>  
    <core:keyword>1527</core:keyword>  
    - <core:resourceSynopsis>  
      <core:value>Veterans Health Administration National Drug File</core:value>  
    </core:resourceSynopsis>  
    - <core:sourceAndRole>  
      <core:source uri="mailto:michael.lincoln@med.va.gov">Michael Lincoln</core:source>  
      <core:role>contact</core:role>  
    </core:sourceAndRole>  
    - <core:property>  
      - <core:predicate uri="http://purl.bioontology.org/predicate/isFlat">  
        <core:namespace>VANDF</core:namespace>  
        <core:name>isFlat</core:name>  
      </core:predicate>  
      - <core:value>  
        - <core:literal>
```

CTS2 REST Client API

A codesystemversions query has a similar query interface for getting all the versions on a given service

- <http://server root/codesystemversions>

A more likely use case might be to get all versions of a given code system:

- <http://informatics.mayo.edu/cts2/rest/codesystem/LNC/versions>



```
- <CodeSystemVersionCatalogEntryDirectory xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/CodeSystemVersion http://informatics.mayo.edu/svn/trunk/cts2/spec/psm/rest/schema/CodeSystemVersion.xsd" complete="COMPLETE" numEntries="4">
  - <core:heading>
    <core:resourceRoot>codesystem/LNC/versions</core:resourceRoot>
    - <core:resourceURI>
      http://informatics.mayo.edu/cts2/rest/codesystem/LNC/versions
    </core:resourceURI>
    <core:accessDate>2012-12-21T16:45:47.514-05:00</core:accessDate>
  </core:heading>
  - <entry href="http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/229" resourceName="LNC"
    about="http://purl.bioontology.org/ontology/LNC" formalName="Logical Observation Identifier Names and Codes"
    documentURI="urn:oid:2.16.840.1.113883.6.1|229" codeSystemVersionName="LNC_229_RRF">
    - <core:resourceSynopsis>
      - <core:value>
        Logical Observation Identifier Names and Codes (LOINC);Version 2.26;January 2, 2009
      </core:value>
    </core:resourceSynopsis>
    <core:officialResourceVersionId>229</core:officialResourceVersionId>
    <versionOf href="http://informatics.mayo.edu/cts2/rest/codesystem/LNC">LNC</versionOf>
    <codeSystemVersionTag/>
  </entry>
  - <entry href="http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/232" resourceName="LNC"
    about="http://purl.bioontology.org/ontology/LNC" formalName="Logical Observation Identifier Names and Codes"
    documentURI="urn:oid:2.16.840.1.113883.6.1|232" codeSystemVersionName="LNC_232_RRF">
    - <core:resourceSynopsis>
      - <core:value>
        Logical Observation Identifier Names and Codes (LOINC);Version 2.26;January 2, 2009
      </core:value>
    </core:resourceSynopsis>
```

CTS2 REST Client API

- Matchvalues options for codesystemversions include resourceName, about and resourceSynopsis
- Perhaps more useful is to get the versions of a given code system as above, then use the href of the version designation to return the desired version
 - <http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/232>
- This also happens to be the syntax for the code system version read function



```
- <CodeSystemVersionCatalogEntryMsg xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/CodeSystemVersion
http://informatics.mayo.edu/svn/trunk/cts2/spec/psm/rest/schema/CodeSystemVersion.xsd">
  - <core:heading>
    <core:resourceRoot>codesystem/LNC/version/232</core:resourceRoot>
    - <core:resourceURI>
      http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/232
    </core:resourceURI>
    <core:accessDate>2012-12-21T16:52:27.553-05:00</core:accessDate>
  </core:heading>
  - <codeSystemVersionCatalogEntry entryState="ACTIVE" about="http://purl.bioontology.org/ontology/LNC" formalName="Logical
Observation Identifier Names and Codes" documentURI="urn:oid:2.16.840.1.113883.6.1|232" state="FINAL"
codeSystemVersionName="LNC_232_RRF">
    <core:keyword>LNC</core:keyword>
    <core:keyword>1350</core:keyword>
    <core:keyword>44774</core:keyword>
  - <core:resourceSynopsis>
    - <core:value>
      Logical Observation Identifier Names and Codes (LOINC);Version 2.26;January 2, 2009
    </core:value>
  </core:resourceSynopsis>
  - <core:sourceAndRole>
    <core:source uri="mailto:loinc@regenstrief.org">Ms. Kathy Mercer, LOINC Developer</core:source>
    <core:role>contact</core:role>
  </core:sourceAndRole>
  - <core:property>
    - <core:predicate uri="http://purl.bioontology.org/predicate/isFoundry">
      <core:namespace>LNC</core:namespace>
```

CTS2 REST Client API

Most users may simply either want to get an entity (a concept) by text match from a vocabulary service.

- [http://informatics.mayo.edu/cts2/rest/entities?
matchvalue=swelling](http://informatics.mayo.edu/cts2/rest/entities?matchvalue=swelling)

Or they may want to get an entity from a particular version of a particular code system:

[http://informatics.mayo.edu/cts2/rest/codesystem/
LNC/version/232/entities?
matchvalue=Cefoperazone](http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/232/entities?matchvalue=Cefoperazone)



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```
- <EntityDirectory xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/Entity http://informatics.mayo.edu/svn/trunk/cts2/spec  
/psm/rest/schema/Entity.xsd" complete="COMPLETE" numEntries="19">  
  - <core:heading>  
    <core:resourceRoot>codesystem/LNC/version/232/entities</core:resourceRoot>  
    - <core:resourceURI>  
      http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/232/entities  
    </core:resourceURI>  
    - <core:parameter arg="matchvalue">  
      <core:val>Cefoperazone</core:val>  
    </core:parameter>  
    <core:accessDate>2012-12-21T16:54:49.073-05:00</core:accessDate>  
  </core:heading>  
  - <entry about="http://purl.bioontology.org/ontology/LNC/LP14524-0" href="http://informatics.mayo.edu/cts2/rest/codesystem  
/LNC/version/236/entity/LP14524-0">  
    - <core:name>  
      <core:namespace>LNC</core:namespace>  
      <core:name>LP14524-0</core:name>  
    </core:name>  
    - <core:knownEntityDescription>  
      - <core:describingCodeSystemVersion>  
        <core:version href="http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/236">LNC_236_UMLS-  
        RELA</core:version>  
        <core:codeSystem uri="http://purl.bioontology.org/ontology/LNC" href="http://informatics.mayo.edu/cts2/rest/codesystem  
/LNC">LNC</core:codeSystem>  
      </core:describingCodeSystemVersion>  
      <core:designation>Cefoperazone</core:designation>  
    </core:knownEntityDescription>
```

CTS2 REST Client API

Having chosen a desired entity from that list we can resolve the full entity with an entity read:

- <http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/232/entity/100-8>



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```
- <EntityDescriptionMsg xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/Entity http://informatics.mayo.edu/svn/trunk/cts2/spec/psm/rest/schema/Entity.xsd">
  - <core:heading>
    <core:resourceRoot>codesystem/LNC/version/232/entity/100-8</core:resourceRoot>
  - <core:resourceURI>
    http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/232/entity/100-8
  </core:resourceURI>
  <core:accessDate>2012-12-21T16:56:37.710-05:00</core:accessDate>
</core:heading>
- <EntityDescription>
  - <namedEntity about="http://purl.bioontology.org/ontology/LNC/100-8" entryState="ACTIVE">
    - <entityID>
      <core:namespace>LNC</core:namespace>
      <core:name>100-8</core:name>
    </entityID>
    - <describingCodeSystemVersion>
      <core:version href="http://informatics.mayo.edu/cts2/rest/codesystem/LNC/version/232">LNC_232_RRF</core:version>
      <core:codeSystem uri="http://purl.bioontology.org/ontology/LNC" href="http://informatics.mayo.edu/cts2/rest/codesystem/LNC">LNC</core:codeSystem>
    </describingCodeSystemVersion>
    - <designation designationRole="PREFERRED">
      - <core:value>
        Cefoperazone:Susceptibility:Point in time:Isolate:Quantitative or Ordinal:Minimum Inhibitory Concentration
      </core:value>
    </designation>
    - <designation designationRole="ALTERNATIVE">
      <core:value>Cefoperazone:Susc:Pt:Isolate:OrdQn:MIC</core:value>
    </designation>
  </namedEntity>
</EntityDescription>
```

CTS2 REST Client API

This lays the foundation for a couple of likely scenarios. Starting from the code system:

- Display available coding schemes to user
 - User chooses coding schemes
- Display versions to user
 - User chooses code system version
- Display text match for concept search
 - User initiates text search and makes choice from matches



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CTS2 REST Client API

Alternatively:

- Display text match field to user
 - User enters text match
- Display list of entity matches
 - User chooses match
- Display selected user friendly entity attributes and properties to user



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CTS2 REST Client API

Developer Strategies:

- Parse initial XML for resourceName and construct REST queries
- Parse the href from each set of queries and use the resulting XML to resolve further. (Remember each result has href(s) pointing to new resource options.)



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CTS2 REST Client API

Value Sets

Using valueset and valuesets and resolvedvalueset API's:

- What value sets are on the service:
- <http://informatics.mayo.edu/cts2/rest/valuesets>

```
- <entry href="http://informatics.mayo.edu/cts2/rest/valueset/provenance" resourceName="provenance" about="http://purl.b...<br/>- <core:resourceSynopsis><br/>- <core:value><br/>    This file is imported by vivo-core-public-1.5.owl. It contains terms related to people for the purpose of accumulating<br/>    </core:value><br/>  </core:resourceSynopsis><br/></entry>
```

- href value can be resolved to an individual value set



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CTS2 REST Client API

Value Sets: Pagination

Parsing values for “complete” and “next” tag will allow developers to page through results:

```
- <ResolvedValueSetDirectory xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/ValueSetDefinition http://informatics.mayo.edu/cts2/rest/resolvedvaluesets?complete=PARTIAL&maxtoreturn=50">
  - <core:heading>
    <core:resourceRoot>resolvedvaluesets</core:resourceRoot>
    - <core:resourceURI>
      http://informatics.mayo.edu/cts2/rest/resolvedvaluesets
    </core:resourceURI>
    <core:accessDate>2012-11-30T09:31:15.092-05:00</core:accessDate>
  </core:heading>
```

If complete value is “PARTIAL” then you can parse and resolve next value.



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CTS2 REST Client API

Value Sets

Getting a value set (using the href value):

<http://informatics.mayo.edu/cts2/rest/valueset/provenance>

```
- <ValueSetCatalogEntryMsg xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/ValueSet http://informatics.mayo.edu/svn/trunk /cts2/spec/psm/rest/schema/ValueSet.xsd">
  - <core:heading>
    <core:resourceRoot>valueset/provenance</core:resourceRoot>
    - <core:resourceURI>
      http://informatics.mayo.edu/cts2/rest/valueset/provenance
    </core:resourceURI>
    <core:accessDate>2012-12-21T16:59:14.292-05:00</core:accessDate>
  </core:heading>
  - <valueSetCatalogEntry entryState="ACTIVE" about="http://purl.bioontology.org/view/provenance" formalName="Provenance" valueSetName="provenance">
```



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CTS2 REST Client API

Value Sets

Resolving a value set (adding the resolution parameter):

<http://informatics.mayo.edu/cts2/rest/valueset/provenance/resolution>



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```
- <IterableResolvedValueSet xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/ValueSetDefinition http://informatics.mayo.edu  
/svn/trunk/cts2/spec/psm/rest/schema/ValueSetDefinition.xsd" complete="COMPLETE" numEntries="3">  
- <core:heading>  
- <core:resourceRoot>  
    valueset/provenance/definition/provenance_1-5_OWL/resolution  
</core:resourceRoot>  
- <core:resourceURI>  
    http://informatics.mayo.edu/cts2/rest/valueset/provenance/definition/provenance_1-5_OWL/resolution  
</core:resourceURI>  
    <core:accessDate>2012-12-21T17:04:05.481-05:00</core:accessDate>  
</core:heading>  
- <resolutionInfo>  
- <resolutionOf>  
    <core:valueSetDefinition>provenance_1-5_OWL</core:valueSetDefinition>  
    <core:valueSet uri="http://purl.bioontology.org/view/provenance" href="http://informatics.mayo.edu/cts2/rest/valueset  
/provenance">provenance</core:valueSet>  
</resolutionOf>  
- <resolvedUsingCodeSystem>  
    <core:version href="http://informatics.mayo.edu/cts2/rest/codesystem/vivo/version/1.5">vivo_1-5_OWL</core:version>  
    <core:codeSystem uri="http://purl.bioontology.org/ontology/vivo" href="http://informatics.mayo.edu/cts2/rest/codesystem  
/vivo">vivo</core:codeSystem>  
    </resolvedUsingCodeSystem>  
</resolutionInfo>  
- <entry uri="http://vivoweb.org/ontology/core#Authorship" href="http://informatics.mayo.edu/cts2/rest/codesystem/provenance/version  
/1.5/entity/vivo:Authorship">  
    <core:namespace>vivo</core:namespace>  
    <core:name>Authorship</core:name>
```

CTS2 REST Client API

Value Sets

Getting the resolved value set objects:

[http://informatics.mayo.edu/cts2/rest/
resolvedvaluesets](http://informatics.mayo.edu/cts2/rest/resolvedvaluesets)

Resolution using the href value from these results gives direct access to the resolved value set.



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```
- <ResolvedValueSetDirectory xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/ValueSetDefinition http://informatics.mayo.edu  
/svn/trunk/cts2/spec/psm/rest/schema/ValueSetDefinition.xsd" complete="PARTIAL" numEntries="50" next="http://informatics.mayo.edu  
/cts2/rest/resolvedvaluesets?page=1&maxtoreturn=50">  
- <core:heading>  
  <core:resourceRoot>resolvedvaluesets</core:resourceRoot>  
- <core:resourceURI>  
  http://informatics.mayo.edu/cts2/rest/resolvedvaluesets  
</core:resourceURI>  
  <core:accessDate>2012-12-21T17:21:24.014-05:00</core:accessDate>  
</core:heading>  
- <entry resolvedValueSetURI="http://purl.bioontology.org/view/BRO-Chinese/resolution/41005" href="http://informatics.mayo.edu  
/cts2/rest/valueset/BRO-Chinese/definition/BRO-Chinese_2-5_OWL/resolution/41005">  
- <resolvedHeader>  
- <resolutionOf>  
  <core:valueSetDefinition>BRO-Chinese_2-5_OWL</core:valueSetDefinition>  
  <core:valueSet uri="http://purl.bioontology.org/view/BRO-Chinese" href="http://informatics.mayo.edu/cts2/rest/valueset  
/BRO-Chinese">BRO-Chinese</core:valueSet>  
</resolutionOf>  
- <resolvedUsingCodeSystem>  
  <core:version href="http://informatics.mayo.edu/cts2/rest/codesystem/BRO/version/2.7.1">BRO_2-7-1_OWL-  
  FULL</core:version>  
  <core:codeSystem uri="http://purl.bioontology.org/ontology/BRO" href="http://informatics.mayo.edu/cts2/rest/codesystem  
/BRO">BRO</core:codeSystem>  
</resolvedUsingCodeSystem>  
</resolvedHeader>  
</entry>  
- <entry resolvedValueSetURI="http://purl.bioontology.org/view/OGMD_OWL/resolution/43092" href="http://informatics.mayo.edu
```

CTS2 REST Client API

Summary

- Developers should now be able to text match search on CTS2 module attributes
- Retrieve coding schemes, entities, and value sets
- Page through large result sets
- Follow href values to other module definitions as they are available



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CTS2 Implementation

Command Line and XSLT Transforms

CTS2 REST Client

Command Line

Windows, Linux and Unix can pull in CTS2 XML via command line REST calls.

On Linux and Unix the curl command can be used to pull xml into a file where an application can process it and serve it up to a user.



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CTS2 REST Client

Command Line

- For example:
- curl
<http://informatics.mayo.edu/cts2/rest/valuesets>
> valuesets.xml
- Pipes a CTS2 value set into an xml document where it could be served up on an eXist XML database or processed into a more user friendly file using a XSLT style sheet



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CTS2 REST Client

Command Line and XSLT

Exercise:

Use curl or a browser to get some CTS2 object in XML from a service

Use an XSLT transform to transform the values into an HTML representation.



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CTS2 REST Client

Command Line and XSLT

Using Firefox open the following in tabs:

- <http://informatics.mayo.edu/cts2/rest/valuesets>
- <http://markbucayan.appspot.com/xslt/index.html>
- And the two XSLT files in the example folder
- Use the ValueSetCatalogEntryDirectory.xsl to transform the first XML page. Use the link to click through to an IterableResolvedValueSet and try the second XSL, IterableResVS



CTS2 REST Clients

Python and Scala

REST Clients Tutorial

Platform Independence

- REST means platform independent clients
- REST can be consumed by any client that can make http or https connections and parse XML or JSON
- Python and Scala can both achieve this
- In the example folders there is sample code for Python and Scala REST consuming clients

Note: Not an interactive demo



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REST Clients

Platform Independence: Python

Python, a C++ based scripting language, can create a simple REST client in a few lines of code

- This example depends on a library not included in the regular Python distribution:

from restful_lib import Connection



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REST Clients

Platform Independence: Python

- Create the connection:

```
conn = Connection("http://informatics.mayo.edu/cts2/rest")
```

```
reply = conn.request_get("/valuesets?format=json",  
headers={'Accept':'application/json;q=1.0'})
```



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REST Clients

Platform Independence: Python

Test the response and print it:

if reply['headers']['status'] == '200':

print reply['body']

print eval(reply['body'])



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REST Clients

Platform Independence: Python

Here is a short, self-contained script that does a search on value sets matching the word “Sequence”:

```
conn = Connection("http://informatics.mayo.edu/cts2/  
rest")
```

```
print conn.request_get("/valuesets?  
matchvalue='Sequence'")['body']
```



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REST Clients

Platform Independence: Python

Using a couple of integrated Python libraries you can also do authentication using https.

```
import urllib2, base64

request = urllib2.Request("https://informatics.mayo.edu/cts2/services/mat/valueset/2.16.840.1.113883.3.526.02.99/resolution")
base64string = base64.encodestring('%s:%s' % ("name", "password")).replace('\n', '')
request.add_header("Authorization", "Basic %s" % base64string)
result = urllib2.urlopen(request)
data = result.read()
print data
```

(Requires valid username and password)



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REST Clients

Platform Independence: Scala

- Scala is a functional programming language that compiles to Java bytecode
- As such it can reuse some of the same Java libraries used in the Java example



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REST Clients

Platform Independence: Scala

Import Java http and Scala input/output libraries:

```
import java.net.{HttpURLConnection, URL}
```

```
import io.Source
```

Create an executable Scala object:

```
object CTS2RestClient extends App{
```

```
}
```



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REST Clients

Platform Independence: Scala

Add some code to connect to the service:

val connection =

new URL("http://informatics.mayo.edu/cts2/rest/valuesets").openConnection().asInstanceOf[HttpURLConnection]



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REST Clients

Platform Independence: Scala

Get the input Stream:

```
val inputStream = connection.getInputStream
```

```
val src = Source.fromInputStream(inputStream)
```

Print it out:

```
src.getLines().foreach(println)
```



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CTS2 Client Implementation Building Blocks and Examples

CTS2 UI Basics

CTS2 JavaScript Examples

JSFiddle - Overview

- We will use JSFiddle to work with the web related files
 - JSFiddle allows us to see all the files (CSS, JavaScript, and HTML) in one page and edit them
 - Changes are seen immediately
- <http://jsfiddle.net/>



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CTS2 JavaScript Examples

The Basics

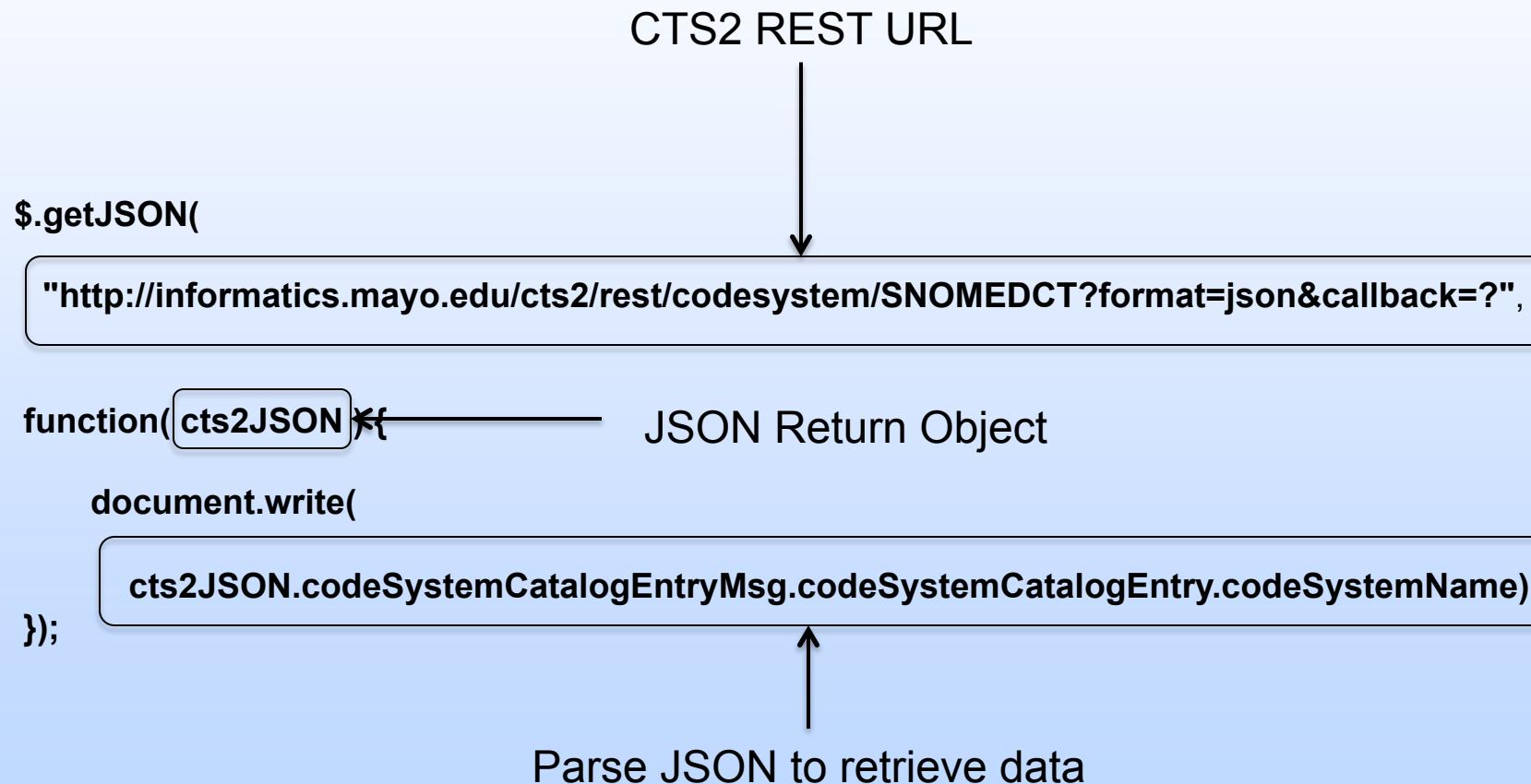
- JavaScript and JSON
- Quickly and easily:
 - Query and display a code system
 - Browser
 - JavaScript
- Simple requirements:
 - URL
 - REST call that returns JSON object
 - Parse/display the JSON



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CTS2 JavaScript Examples

The Basics



CTS2 JavaScript Examples

The Basics – Code Systems

- Quickly and easily:
 - Access a listing of codes systems
 - Access code systems from different CTS2 services
 - Access code system properties



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CTS2 JavaScript Examples

The Basics – Value Sets

- Quickly and easily:
 - Access a listing of value sets
 - Access value set properties
 - Access value set entities (resolved)



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CTS2 JavaScript Examples

How to build from the Basics

- Building blocks
 - We can use the simple calls as the foundation to create more complex UI widgets and applications
- Several JavaScript UI Libraries available:
 - jQuery
 - GWT
 - SmartGWT
 - Others

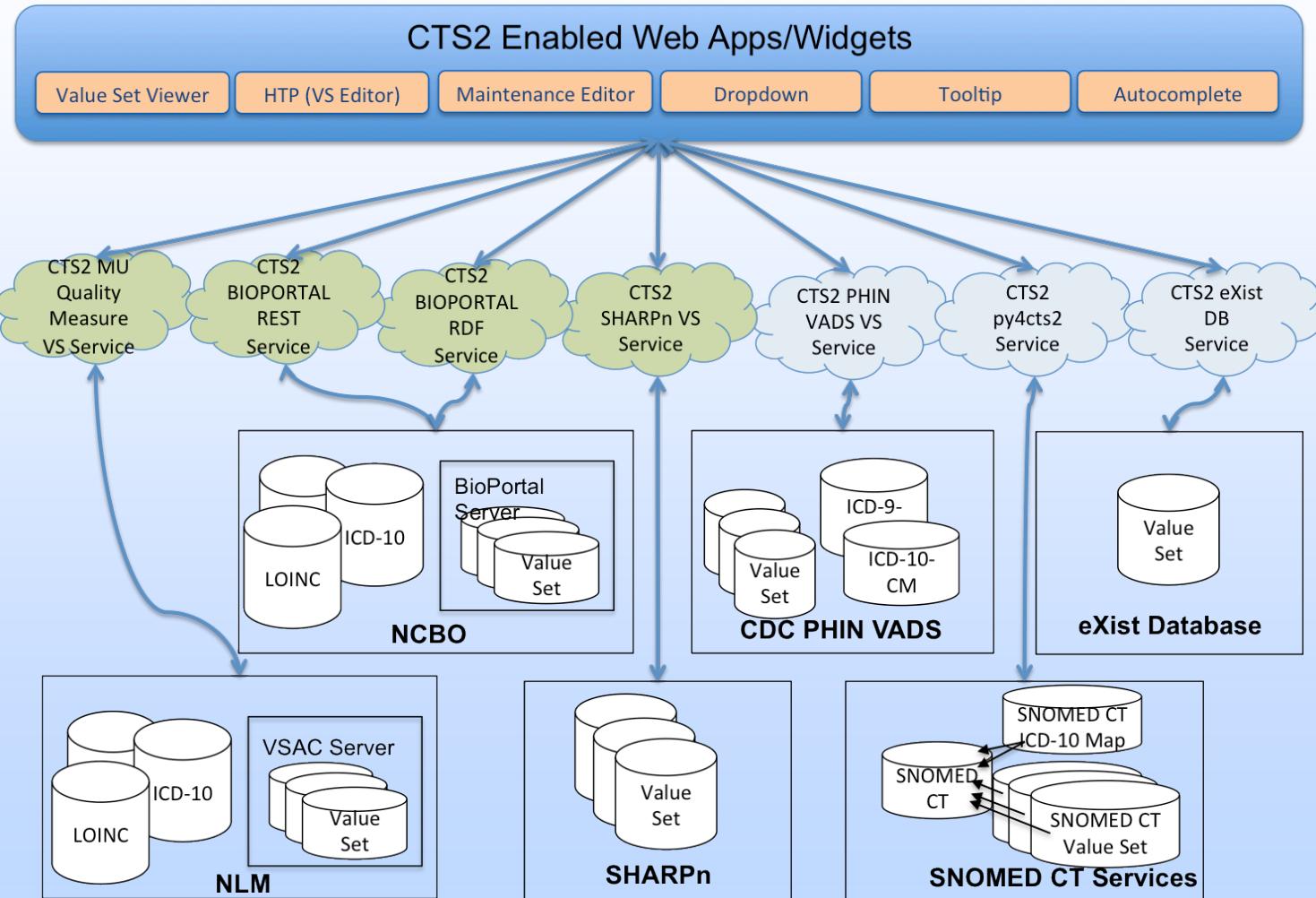


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CTS2 UI Widgets and Application Examples

CTS2 Implementations

Overview



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Displaying CTS2 Content

- We have developed several customizable widgets that can be added to a web page to present CTS2 content
- Open source and available in GitHub:
 - <https://github.com/cts2/>



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CTS2 Enabled UI Widgets

Overview

- Tooltips
 - jQuery tooltip widget used to display value sets and code systems when you mouse over text
- Autocomplete
 - jQuery autocomplete widget used to suggest value sets as you type
- Dropdown
 - jQuery example to fill a select (dropdown) with specific resolved value sets



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CTS2 Enabled UI Widgets

Demonstration

- <http://informatics.mayo.edu/cts2widgets/widgets.html>
- Features and customization points of each widget:
 - Ability to set the value set ID/code system ID to retrieve different values
 - Cascading Style Sheets (CSS) to change the look and feel
 - CTS2 parameterized values to customize the query



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UI Widget: Tooltip

CTS2 Enabled UI Widgets

Lab Exercise - Tooltip

- Retrieve a list of available value sets:
 - <http://informatics.mayo.edu/cts2/rest/valuesets>
- Select any value set – **resourceName**
 - Example: **skos**



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CTS2 Enabled UI Widgets

Lab Exercise - Tooltip

- Look at the result of value set call:
 - [http://informatics.mayo.edu/cts2/rest/valueset/skos\\$format=json](http://informatics.mayo.edu/cts2/rest/valueset/skos$format=json)
- We will use the data returned here to populate our CTS2 tooltip widget



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CTS2 Enabled UI Widgets

Lab Exercise – Tooltip: Add new Tooltip

- <http://jsfiddle.net/coryendle/n9bWF/>
- Create a new tooltip for your value set ID
 - Add the HTML to display the tooltip with your value set ID

```
<p><a href="#" class="hint_vs" data-id="skos">SKOS</a> Value Set Demo.</p>
```

- Select the “Run” button to test your changes.



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CTS2 Enabled UI Widgets

Lab Exercise – Tooltip: Add a row to the tooltip

- Update the tooltip to display another row of data. We will add the entryState status:
- Find the following function:
 - *function getValueSetTableInfo(valueSetJson)*
 - Add another variable:

```
var entryState =  
valueSetJson.valueSetCatalogEntryMsg.valueSetC  
atalogEntry.entryState;
```



CTS2 Enabled UI Widgets

Lab Exercise – Tooltip: Add a row to the tooltip

- Add another HTML row:

```
"<tr><td class=\"noWrap\">Entry State:</td><td>" + entryState + "</td></tr>" +
```

- Select the “Run” button to test your changes



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CTS2 Enabled UI Widgets

Lab Exercise – Tooltip: Add a row to the tooltip

- Now when you mouse over a value set ID, you will see an additional row called “Entry State” in the tooltip



Value Set

Name: skos

Formal Name: SKOS (concepts)

Description: This file is imported by vivo-core-1.5.owl. It contains terms relating to concepts from the <http://www.w3.org/2004/02/skos/core#> namespace of the SKOS (Simple Knowledge Organization System) ontology that are included in the vivo ontology.

Entry State: ACTIVE



UI Widget: Dropdown

CTS2 Enabled UI Widgets

Lab Exercise – Dropdown: Country of Birth

- We will create a dropdown to select a person's country of birth
- Retrieve a list of available value sets from CDC PHINVADS CTS2 service:
 - <http://informatics.mayo.edu/cts2/services/phinvads/valuesets?maxtoreturn=100>
- Select the value set where:
 - valueSetName="PHVS_BirthCountry_CDC"



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CTS2 Enabled UI Widgets

Lab Exercise – Dropdown: Country of Birth

- Look at the result of resolved value set call:
 - http://informatics.mayo.edu/cts2/services/phinvads/valueset/PHVS_BirthCountry_CDC/resolution?format=json
- We will use the data returned here to populate our CTS2 dropdown widget



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CTS2 Enabled UI Widgets

Lab Exercise – Dropdown: Country of Birth

- JSFiddle code:
 - <http://jsfiddle.net/coryendle/bhTaD/>
- In the HTML code, we will add another dropdown to select the country of birth
- After the code for the “Severity” dropdown, add the following line of code:
*

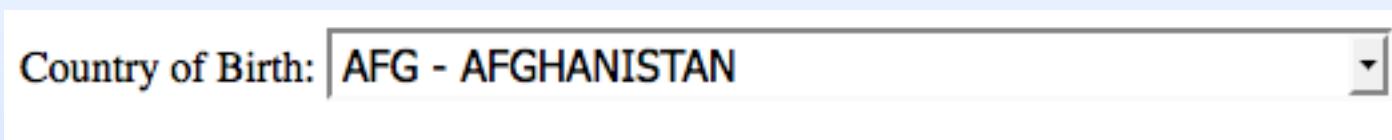
 Country of Birth: <select class="cts2-valueset(name : PHVS_BirthCountry_CDC;max: 500)"></select>*



CTS2 Enabled UI Widgets

Lab Exercise – Dropdown: Country of Birth

- Select the “Run” button to test your changes
- You will now see the Country of Birth dropdown:



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CTS2 Web App Implementations

Putting it all together

UIs created for CTS2 Implementations

CTS2 Value Set Viewer

- Generic Value Set Browser/export
 - Uses the building blocks
- Initially created for Meaningful Use (MU) Quality Measure Value Set Service to serve NLM value sets
 - Can view any CTS2 compliant value set service (NCBO, PHINVADS, CDC, VSAC)
- <https://informatics.mayo.edu/vsmc/?showAll=true>



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UIs created for CTS2 Implementations

CTS2 Value Set Viewer

<https://informatics.mayo.edu/cts2/services/mat/valuesets?&maxtoreturn=100>



Meaningful Use Quality Measure Value Set Service

Log Out

Value Sets | Help ▾

Service : CTS2 Service

Search : Enter Search Text

NQF Number : Any NQF Number

Measure ID : Any Measure ID

Format : CSV (Excel)

Search Results

Download	Formal Name	Value Set Identifier
<input type="checkbox"/>	Atrial Ablation	2.16.840.1.113883.3.117.1.7.1.242
<input type="checkbox"/>	Atrial Ablation	2.16.840.1.113883.3.117.1.7.1.243
<input type="checkbox"/>	Atrial Fibrillation/Flutter	2.16.840.1.113883.3.117.1.7.1.202
<input type="checkbox"/>	Atrial Fibrillation/Flutter	2.16.840.1.113883.3.117.1.7.1.244
<input type="checkbox"/>	Atrial Fibrillation/Flutter	2.16.840.1.113883.3.117.1.7.1.245

Value Set Properties

Resource Name: 2.16.840.1.113883.3.117.1.7.1.242

Formal Name: Atrial Ablation

Description:

State: ACTIVE

Developer: National Committee for Quality Assurance

Name Value

eMeasure Identifier 71

eMeasure Status Complete

Data provided by the US National Library of Medicine

<https://informatics.mayo.edu/cts2/services/mat/valueset/2.16.840.1.113883.3.464.0001.152/resolution>

<https://informatics.mayo.edu/cts2/services/mat/valueset/2.16.840.1.113883.3.464.0001.152>



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UIs created for CTS2 Implementations

CTS2 Value Set Viewer



Meaningful Use Quality Measure Value Set Service

cendle | Log Out

Value Sets | Help ▾

Service : CTS2 Service

Search : Enter Search Text

Entity Details

Percutaneous transluminal ablation of wall of atrium

Lexical

URI: <http://snomed.info/id/428290007>
Code: 428290007
Code System: SNOMED_CT_core
Preferred Name: Percutaneous transluminal ablation of wall of atrium

Properties

Associations

Parent: [Percutaneous transluminal ablation](#)
Parent: [Destructive procedure on heart](#)

Ancestors

Using py4cts2 implementation to retrieve entities and their associations

Close

Description

aze procedure for atrial fibrillation (procedure)
rcutaneous transluminal ablation of atrioventricular nod
rcutaneous transluminal ablation of wall of atrium (proc
lation of atrioventricular node (procedure)
open ablation of atrioventricular node (procedure)

Data provided by the US National Library of Medicine

Part of the CTS2 Ecosystem



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Web Applications

CTS2 Maintenance Editor

- Application for managing CodeSystems, Entities, and Change Sets
- Demonstration of CTS2 maintenance functionality
- Currently in development
- <http://informatics.mayo.edu/exist/cts2/rest/editor/console>



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CTS2 Client Implementation Building Blocks and Examples

Summary

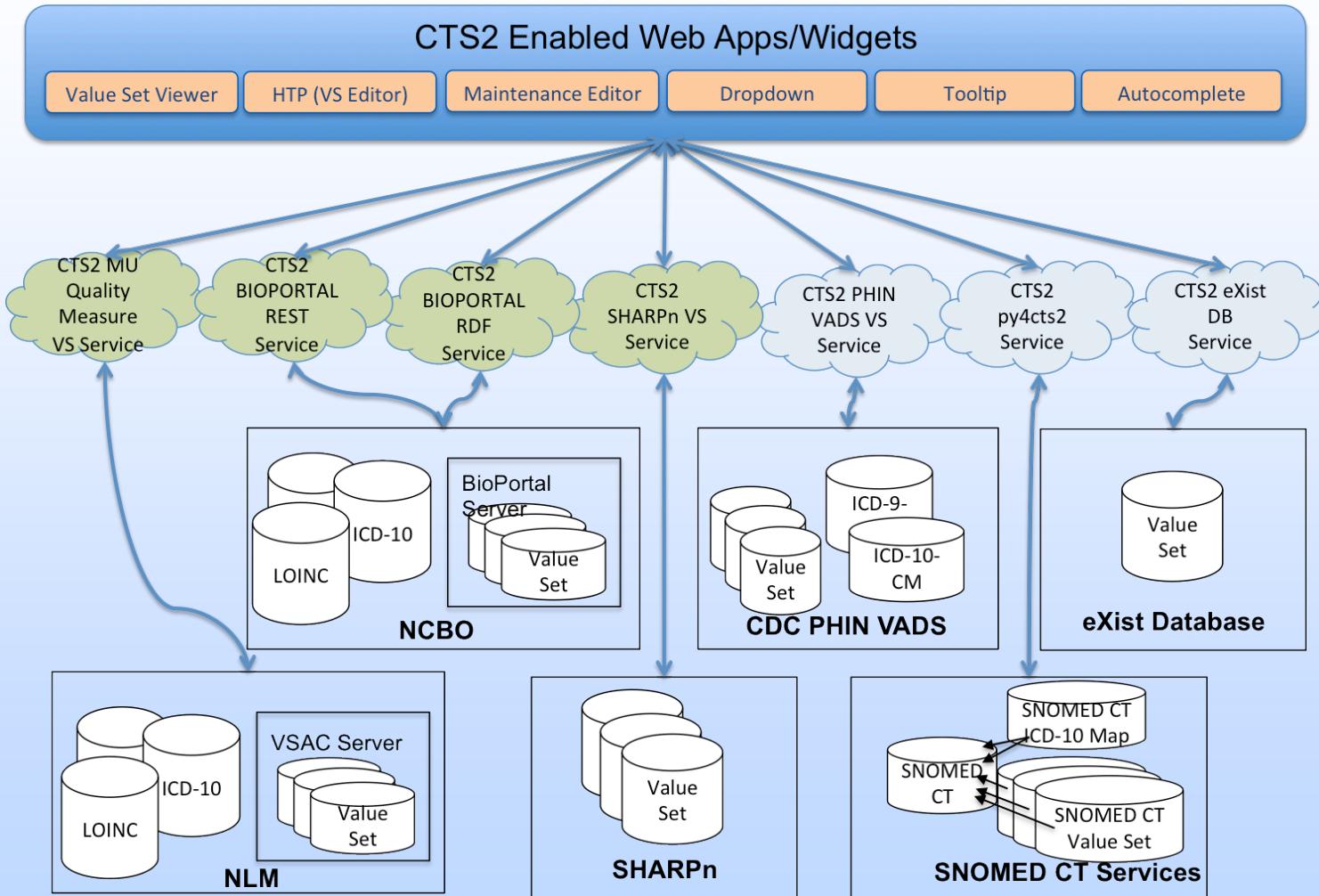
UI and Widget Review

- Quickly and easily retrieve CTS2 content
 - Building blocks
- Customizable UI widgets available to quickly utilize CTS2 content
- Examples of Web Applications that utilized CTS2 service
 - Created with the building blocks
- Open Source



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CTS2 Implementations



Questions

CTS2 Java REST Client

CTS2 REST Client

Java

- Create a new Maven project in Eclipse using cts2.rest as the group and artifact id
- Check the box that allows you to make a simple Maven project (No Archetypes)
- Create a class in src/main/java with a main method

(Code is found in the cts2-example-service zip
ValueSetClient.java)



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CTS2 REST Client

Java

Create a method called `getValueSets` with a return value of `void`.

public void getValueSets()

You'll need some kind of REST URL to resolve:

*String uri = "
http://informatics.mayo.edu/cts2/rest/valuesets";*

And convert to a Java URL

URL url;

try { url = new URL(uri);



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CTS2 REST Client

Java

Create a connection:

```
HttpURLConnection connection =  
(HttpURLConnection) url.openConnection();
```

Test it:

```
if (connection.getResponseCode() != 200) { throw new  
RuntimeException("Failed : The HTTP error code is :  
" + connection.getResponseCode()); }
```



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CTS2 REST Client

Java

Stream it into a buffered reader:

```
BufferedReader br = new BufferedReader(new  
InputStreamReader( (connection.getInputStream())));
```

Here the output can be printed:

```
String output;
```

```
System.out.println("Output from Server .... \n"); while  
( (output = br.readLine()) != null)  
{ System.out.println(output); }
```



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CTS2 REST Client

Java

The normal use case for XML consumption is to marshal to java objects.

Create a new method: *getValueSet()*

We'll make a REST call that returns JSON and consume it using some CTS2 specific code.

```
String uri = "  
http://informatics.mayo.edu/cts2/rest/valuesets?  
matchvalue=Sequence&format=json";
```

And add a request parameter to the connection:
connection.setRequestProperty("Accept", "text/json");



CTS2 REST Client

Java

- We'll handle the buffered output differently:

```
JsonConverter converter = new JsonConverter();
```

```
ValueSetCatalogEntryDirectory valuesetcat =  
converter.fromJson(builder.toString(),  
ValueSetCatalogEntryDirectory.class);
```

- Uses CTS2 Development Framework classes to handle parsing and marshaling duties



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CTS2 REST Client

Java

This will cause some compiling errors, so we'll add some values to the maven project. First add a repository:

```
<repositories>
  <repository>
    <id>edu.informatics.maven.release</id>
    <name>Informatics Maven Release Repository</name>
    <url>http://informatics.mayo.edu/maven/content/repositories/releases</url>
  </repository>
</repositories>
```

(From the CodeandPomSnippets file)



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CTS2 REST Client

Java

Then add a single dependency:

```
<dependency>
    <groupId>edu.mayo.cts2.framework</groupId>
    <artifactId>core</artifactId>
    <version>0.8.0</version>
</dependency>
```

The CTS2 Development Framework solves a number of the parsing and marshaling problems so long as you marshal the XML or JSON into a CTS2 object.



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CTS2 REST Client

Java

Add code to print some output:

```
List<ValueSetCatalogEntrySummary> sum =  
valuesetcat.getEntryAsReference();  
  
for(ValueSetCatalogEntrySummary s : sum){  
  
    System.out.println(s.getFormalName());  
  
    System.out.println(s.getCurrentDefinition());  
  
    System.out.println(s.getResourceName());  
  
    System.out.println(s.getValueSetName());  
  
    System.out.println(s.getHref());  
}
```



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CTS2 REST Client

Java

And disconnect:

connection.disconnect();



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CTS2 REST Client

Java

Create a main method and run one of the methods:

```
public static void main(String[] args){  
    new ValueSetClient().getValueSet();  
}
```



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CTS2 REST Client

Java

Simple REST clients can be duplicated in any number of implementation environments.

See details of more Java, Python, Scala and Unix based curl command implementations here:

[http://informatics.mayo.edu/CTS2_V3/index.php/
Value Set REST API and Implementation Examples](http://informatics.mayo.edu/CTS2_V3/index.php/Value_Set_REST_API_and_Implementation_Examples)



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CTS2 Plugin Tutorial Overview

CTS2 Development Framework

Providing a Toolset

- REST HTTP URL bindings
 - CTS2 model as Java Beans
 - Various Builder pattern query building objects
- CTS2 REST client
 - Manages JSON and XML parsing and Marshaling of either into CTS2 model objects
- Plugin admin structure
 - A quick start on your own service



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CTS2 Implementation Service Plugin Tutorial

CTS2 Plugins

How are Development Framework Plugins Used?

A plugin can be used to add a service to the CTS2 Development Framework base.

- Given a source terminology with it's own data model and corresponding database schema
- Map it into a set of CTS2 Model Objects and attach it to the framework where it can be served up in CTS2 REST



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CTS2 plugins

How are Plugins Used?

How can a plugin be enabled within the CTS2 Development Framework?

- Every plugin must implement the ServiceProvider Interface*
- The jarred plugin will be uploaded to the stand alone CTS2 Development Framework server.

*edu.mayo.cts2.framework.service.provider.ServiceProvider



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CTS2 Development Framework Service

Plugin Example

Requirements

- Maven
- Eclipse with the Maven plugin
- Example Code
- Stand alone CTS2 Framework Server
- MySQL loaded with small Gene Ontology database



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CTS2 Development Framework Service

Plugin Example

Goals for this part of tutorial

- Connect to a database
- Integrate 3rd party software into the build
- Map source data to a CTS2 model element
- Get the standalone development framework service up and running
- Integrate the plugin into the service



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Interactive Demo

Service Plugin

If you want to follow along, you should at this point have:

- Maven installed
- MySQL server started with the Gene Ontology loaded into a database named “godata”
- The example project pulled into Eclipse
- The code snippet folder available
- Initial clean and install of the maven build

Instructions here: <https://github.com/hsbauer/cts2-example-service/archive/master.zip>



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Interactive Demo

Service Plugin

After running the clean install command your output should look something like this:

```
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
2012-11-26 11:38:20.619:INFO:/webapp-rest:Destroying Spring FrameworkServlet 'appServlet'
INFO : org.springframework.web.context.support.XmlWebApplicationContext - Closing WebApplicationContext for namespace
[INFO] Total time: 24.123s
[INFO] Finished at: Mon Nov 26 11:38:20 CST 2012
[INFO] Final Memory: 48M/99M
[INFO] -----
2012-11-26 11:38:21.082:INFO::Shutdown hook executing
INFO : org.springframework.beans.factory.support.DefaultListableBeanFactory - Destroying singletons in org.springframework.beans.factory.support.DefaultListableBeanFactory@1a2...
2012-11-26 11:38:21.114:INFO:/webapp-rest:Closing Spring root WebApplicationContext
INFO : org.springframework.web.context.support.XmlWebApplicationContext - Closing Root WebApplicationContext: startup
INFO : org.springframework.beans.factory.support.DefaultListableBeanFactory - Destroying singletons in org.springframework.beans.factory.support.DefaultListableBeanFactory@1a2...
2012-11-26 11:38:21.218:INFO::Shutdown hook complete
```



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Interactive Demo

Service Plugin

Connecting to a unique source.

- Copy the JDBCConnector.java file to the `edu.mayo.cts2.framework.plugin.service.example` folder of the example-service

cts2-example-service-master 3	Today 7:05 AM
CodeAndPomSnippets.doc	Today 7:05 AM
CTS2PluginRequirements.docx	Today 7:05 AM
example-service.zip	Today 7:05 AM
go_daily-termdb-data	Today 7:05 AM
JDBCCOnnection.java	Today 7:05 AM
README.md	Today 7:05 AM



Interactive Demo

Service Plugin

Adjust the hard coded connection properties to your local MySQL installation.

```
public Connection createConnection() {
    Connection con = null;
    if (connection != null) {
        System.out.println("Connection Failed");
    } else {
        try {
            con = DriverManager.getConnection(
                "jdbc:mysql://localhost:3306/godata", "root",
                "lexgrid");
            System.out.println("Connected");
        } catch (SQLException e) {
            System.out.println(e.toString());
        }
    }
    return con;
}
```



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Interactive Demo

Service Plugin

Running the main method we see we need a JDBC driver class.

```
java.lang.ClassNotFoundException: com.mysql.jdbc.Driver
java.sql.SQLException: No suitable driver found for jdbc:mysql://localhost:3306/godata
Exception in thread "main" java.lang.NullPointerException
    at edu.mayo.cts2.framework.plugin.service.example.JDBCCOnnection.getResult(JDBCCOnnection.java:67)
    at edu.mayo.cts2.framework.plugin.service.example.JDBCCOnnection.main(JDBCCOnnection.java:70)
```

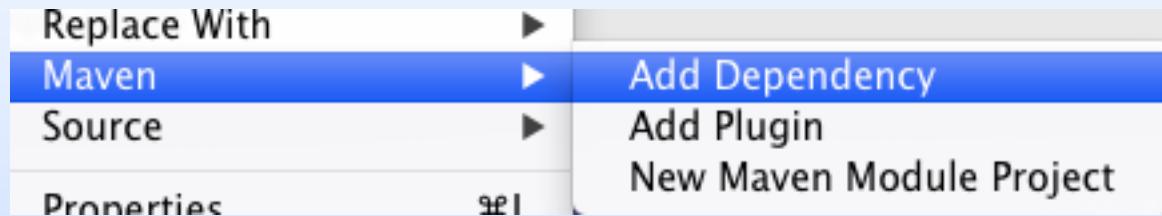


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Interactive Demo

Service Plugin

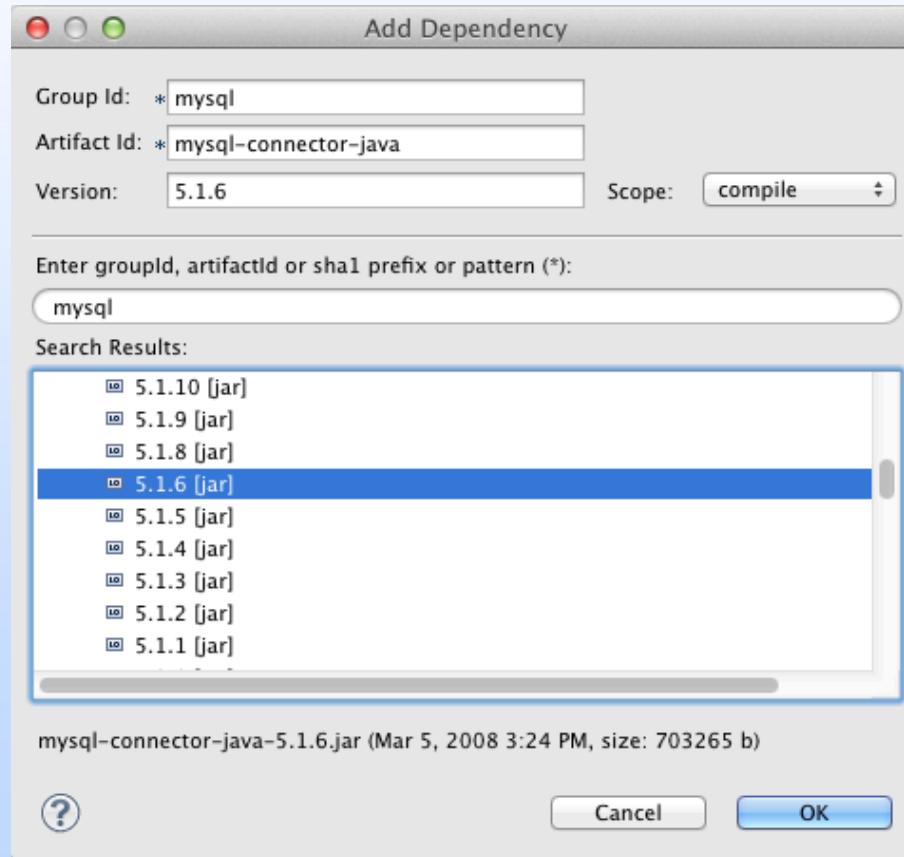
Using Eclipse as our example we'll add a dependency to the pom.xml file:



Interactive Demo

Service Plugin

Add the MySQL connector version 5.1.6 to the pom file:



Interactive Demo

Service Plugin

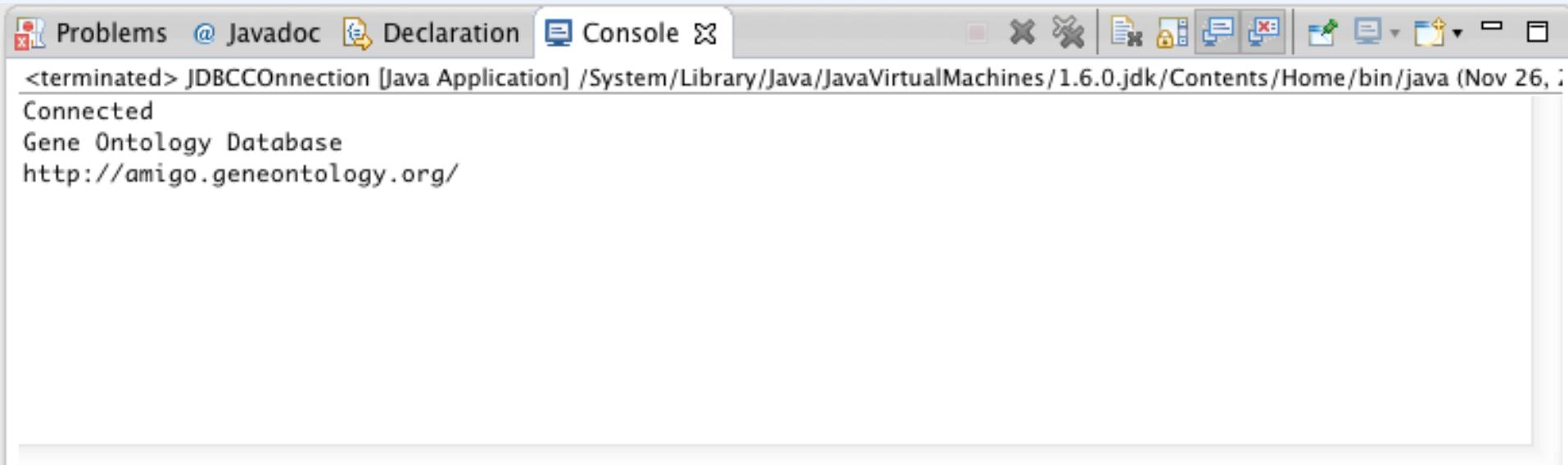
Alternatively you can cut and paste from the CodeAndPomSnippets file:

```
<!--This adds the third party jar to the plugin -->
<dependency>
    <groupId>mysql</groupId>
    <artifactId>mysql-connector-java</artifactId>
    <version>5.1.6</version>
</dependency>
```



Interactive Demo Service Plugin

Running the main method against the “godata” database should give you output like this:



The screenshot shows a Java application running in an IDE. The title bar indicates it's a JDBC Connection [Java Application]. The console tab is active, displaying the following text:

```
<terminated> JDBCConnection [Java Application] /System/Library/Java/JavaVirtualMachines/1.6.0.jdk/Contents/Home/bin/java (Nov 26, 2011)
Connected
Gene Ontology Database
http://amigo.geneontology.org/
```



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Interactive Demo

Service Plugin

This gives us local runtime access to the connector – Let's add it to the build using the OSGI bundling plugin (maven-bundle-plugin) and leave the other dependencies unresolved. We do this by adding it to the pom file:

```
<Import-Package>
    edu.mayo.cts2.framework.service.provider,
    *;resolution:=optional
</Import-Package>
<Embed-Dependency>
    mysql-connector-java
</Embed-Dependency>
```



Interactive Demo

Service Plugin

- The current mapping of the CTS2 CodeSystemCatalogEntry object is hardcoded
- Change that to a dynamic method:
 - Copy and paste over the entire read method with the snippet from the CodeAndPomSnippet's file
 - This runs a query against the database depending upon the abbreviated name of a code system
- Run the Maven **clean** and **install** methods



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Interactive Demo

Service Plugin

Start the standalone server:

```
r0223758:software m029206$ java -XX:PermSize=128m -XX:MaxPermSize=512m -jar  
cts2framework-standalone.jar
```

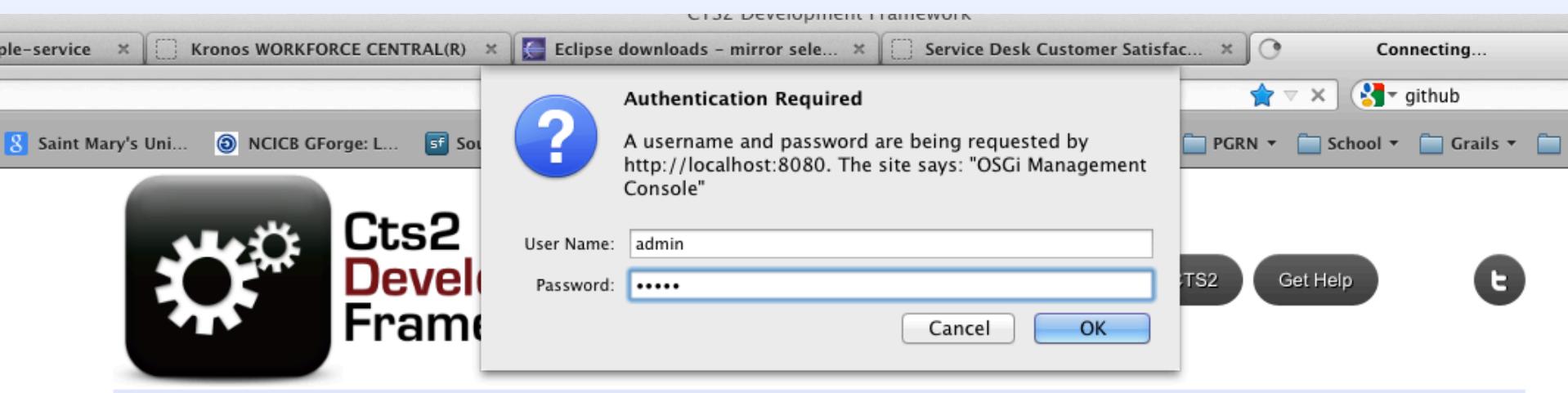


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Interactive Demo Service Plugin

Click on the Admin Console button on the resulting web page:



Login using admin/admin.



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Interactive Demo: Service Plugin Import Plugin to Framework

Click on install/update

CTS2 Development Framework Web Console

Bundles



Bundle information: 29 bundles in total, 28 bundles active, 1 active fragments, 0 bundles resolved, 0 bundles installed.

Id	Name	Version	Category	Status	Actions
0	System Bundle (ora.apache.felix.framework)	3.0.2		Active	Install/Update...



Interactive Demo: Service Plugin

Import Plugin to Framework

Upload the jar

Upload / Install Bundles X

Start Bundle

Start Level

x example-service-0.7.0.jar

Interactive Demo: Service Plugin

Import Plugin to Framework

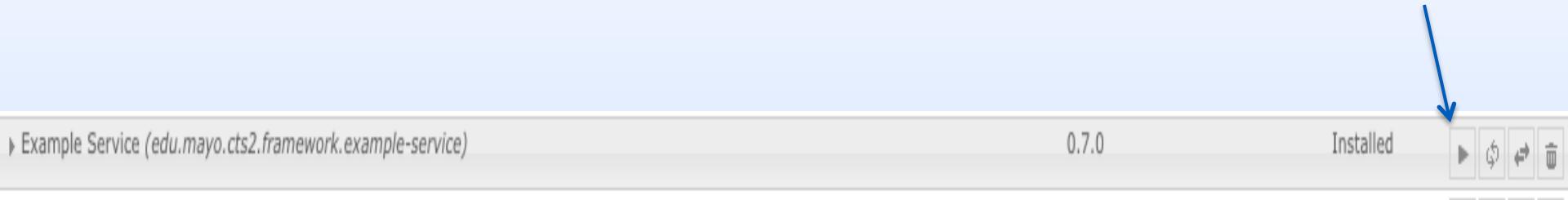
example-service	Today 12:05 PM
▶ bin	Today 10:11 AM
pom.xml	Today 11:58 AM
▶ src	Nov 15, 2012 11:17 AM
▶ target	Today 12:01 PM
▶ classes	Today 12:01 PM
example-service-0.7.0-tests.jar	Today 12:01 PM
example-service-0.7.0.jar	Today 12:01 PM
▶ generated-sources	Today 12:01 PM
▶ maven-archiver	Today 12:01 PM
▶ surefire	Today 12:01 PM
▶ test-classes	Today 12:01 PM
▶ test-plugins	Today 12:01 PM
▶ testconfigdir	Today 12:01 PM
▶ war	Today 12:01 PM
▶ work	Today 12:01 PM
...	...



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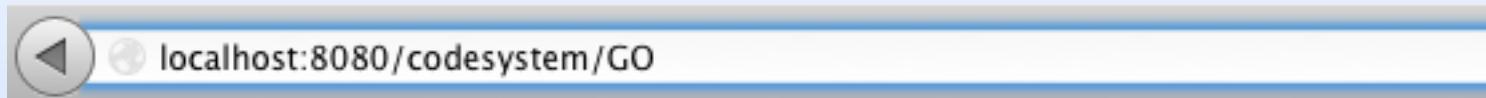
Interactive Demo: Service Plugin Import Plugin to Framework

If necessary start the plugin:



Interactive Demo: Service Plugin Import Plugin to Framework

Create a REST call in a browser address bar:



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Interactive Demo Service Plugin

Expected Results

```
- <CodeSystemCatalogEntryMsg xsi:schemaLocation="http://schema.omg.org/spec/CTS2/1.0/CodeSystem http://informatics.ma
- <core:heading>
  <core:resourceRoot>codesystem/GO</core:resourceRoot>
  <core:resourceURI>http://localhost:8080/codesystem/GO</core:resourceURI>
  <core:accessDate>2012-11-26T12:23:37.669-06:00</core:accessDate>
</core:heading>
- <codeSystemCatalogEntry entryState="ACTIVE" about="Gene Ontology Database GO" codeSystemName="GO">
  - <core:resourceSynopsis>
    <core:value>http://amigo.geneontology.org/ GO</core:value>
  </core:resourceSynopsis>
</codeSystemCatalogEntry>
</CodeSystemCatalogEntryMsg>
```



Interactive Demo

Service Plugin

What have we learned:

- What class needs to be extended to create a plugin class
- How to create a mapping from a source to a CTS2 compatible element
- How to import third party software into the OSGI bundling system using maven
- How to run the CTS2 Development Framework Standalone server and upload a plugin to it



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References

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 - http://www.bioontology.org/wiki/index.php/CTS2_BioPortal_wrapper_summary
- Sample REST calls for Module Specifications against an RDF triple store:
 - http://www.bioontology.org/wiki/index.php/CTS2_RDF_Plugin
- REST interfaces for CTS2:
 - <http://informatics.mayo.edu/cts2/index.php/REST>
- Service Plugin resources:
 - <https://github.com/hsbauer/cts2-example-service/archive/master.zip>
 - <http://informatics.mayo.edu/cts2/framework/downloads/cts2framework-standalone.jar>
 - <http://www.mysql.com/downloads/mysql/5.1.html>
 - <http://maven.apache.org/download.html> (Maven 2.2.1)
 - <http://www.eclipse.org/downloads/>



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 - <http://informatics.mayo.edu/cts2/rest/valuesets>
- BioPortal RDF Wrapper
 - <http://informatics.mayo.edu/cts2/services/bioportal-rdf/valuesets>
- BioPortal SPARQL endpoint:
 - <http://sparql.bioontology.org/>
- MU Quality Measure Value Set Service
 - <https://informatics.mayo.edu/cts2/services/mat/valuesets>
- GUIs that display CTS2 Content:
 - <https://informatics.mayo.edu/vsmc>
 - <http://www.phenotypeportal.org/>
- UI Widgets Example:
 - <http://informatics.mayo.edu/cts2widgets/widgets.html>



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References

- UI Widgets in GitHub:
 - <https://github.com/cts2/>
 - <https://github.com/cts2/cts2autocomplete>
 - <https://github.com/cts2/cts2tooltip>
 - <https://github.com/cts2/cts2dropdown>
- jQuery UI Widget Reference:
 - <http://jqueryui.com/>
- JSFiddle UI Widgets Lab Exercises:
 - Tooltip: <http://jsfiddle.net/coryendle/n9bWF/>
 - Autocomplete: <http://jsfiddle.net/coryendle/dKjXs/>
 - Dropdown: <http://jsfiddle.net/coryendle/bhTaD/>



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Questions & Discussion