



Advanced Aspects of FHIR

Hands-on Training Course

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Who am I?



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 - FHIR core team, RIMBAA
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 - www.thefhirplace.com



Program



- Search functionality
- Documents and Messages
- Exercise #1 – Constructing a FHIR Document
- The DSTU2 Class Hierarchy and Operations
- Exercise #2 - Using the validate operation
- Introducing the DSTU2 Conformance Layer
- Using the C#/Java API's
- Interactive session - DSTU2





SEARCH FUNCTIONALITY

Getting “all” patients



- `http://server.org/fhir/Patient`
- Always returns a paged feed
- Use `_count` to indicate number of results per page
- Special case of the “real” search operation:

`http://server.org/fhir/Patient/_search?name=eve`
`http://server.org/fhir/Patient?name=eve`



Search (patient)



Each resource has a set of “standard” search operations, so **not every element can be searched!**

active : token	Whether the patient record is active
address : string	an address in any kind of address/part of the patient
animal-breed : token	the breed for animal patients
animal-species : token	the species for animal patients
birthdate : date	the patient's date of birth
family : string	a portion of the family name of the patient
gender : token	gender of the patient
given : string	a portion of the given name of the patient
identifier : token	A patient identifier
language : token	language code (irrespective of use value)
name : string	a portion of either family or given name of the patient

Our last search used this one



Combining parameters



- Specifying multiple parameters finds resources matching all params → “AND”
- Parameters may list multiple values → “OR”
- `http://server.org/fhir/Patient/_search?birthdate=1972-11-30&language=NL,FR`



Search (patient)



Each search parameter has a 'type'

active : token	Whether the patient record is active
address : string	an address in any kind of address/part of the patient
animal-breed : token	the breed for animal patients
animal-species : token	the species for animal patients
birthdate : date	the patient's date of birth
family : string	a portion of the family name of the patient
gender : token	gender of the patient
given : string	a portion of the given name of the patient
identifier : token	A patient identifier
language : token	language code (in
name : string	a portion of either

Parameter
Type



Ok I get it...or not?



<code>http://server.org/fhir/Patient/</code>	406 hits
<code>http://server.org/fhir/Patient?gender=M</code>	234 hits
<code>http://server.org/fhir/Patient?gender=F</code>	167 hits

Total: 234 + 167 = 401

<code>http://server.org/fhir/Patient/</code>	406 hits
<code>http://server.org/fhir/Patient?gender=M</code>	234 hits
<code>http://server.org/fhir/Patient?gender=F</code>	167 hits
<code>http://server.org/fhir/Patient?gender:missing=true</code>	5 hits

Total: 234 + 167 + 5 = 406



Chained searches



- Patient has a search for “name”.
- Observation has a search for “subject” (the id of the Patient, Group or Device)
- How do I find Observations for a patient, searching using his name?



2 queries in 1



- You (as a client) don't need to do separate operations, just one:

```
http://server.com/fhir/Observation/_search?  
subject.name=jim
```

But note: this still only works on the predefined search parameters. You cannot just use any property of the resource.



More optimizations



- Say we do:
 - <http://fhir.com/fhir/Observation?date=2014-01-20>
 - We get back: a Bundle with 0..* “Observations”
- Now, usually, wouldn't we want the Patient information too? => Need to do “N” queries for the Observation's “subject”
- Quicker:
?_include=Observation.subject
Returns both Observations + Patients





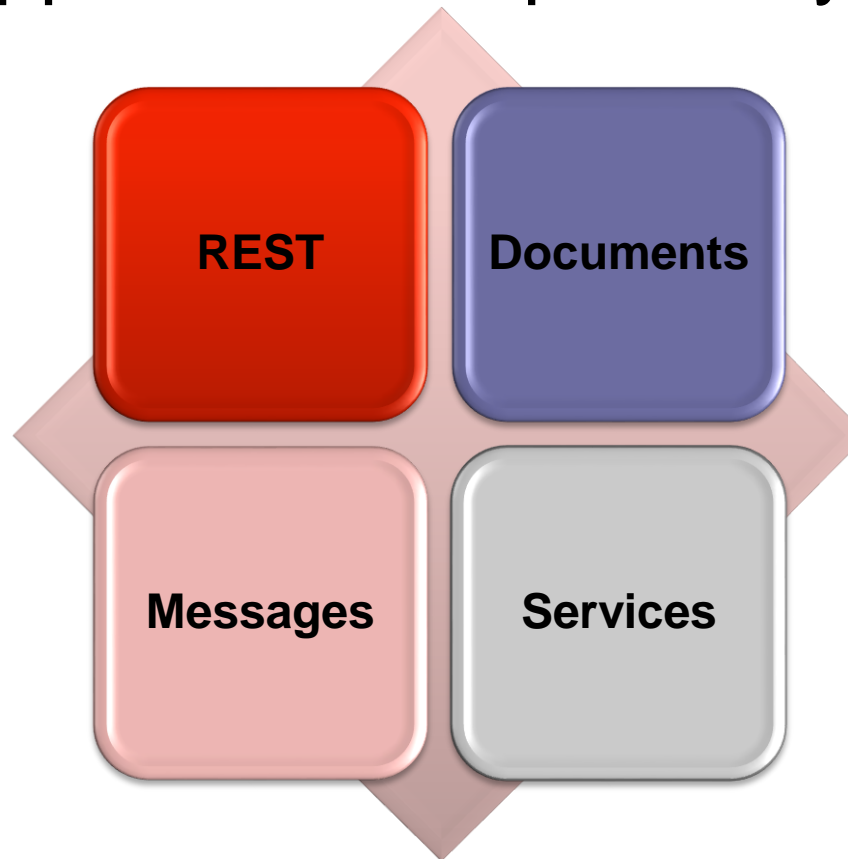
How FHIR supports documents and messages

BEYOND REST

Paradigms



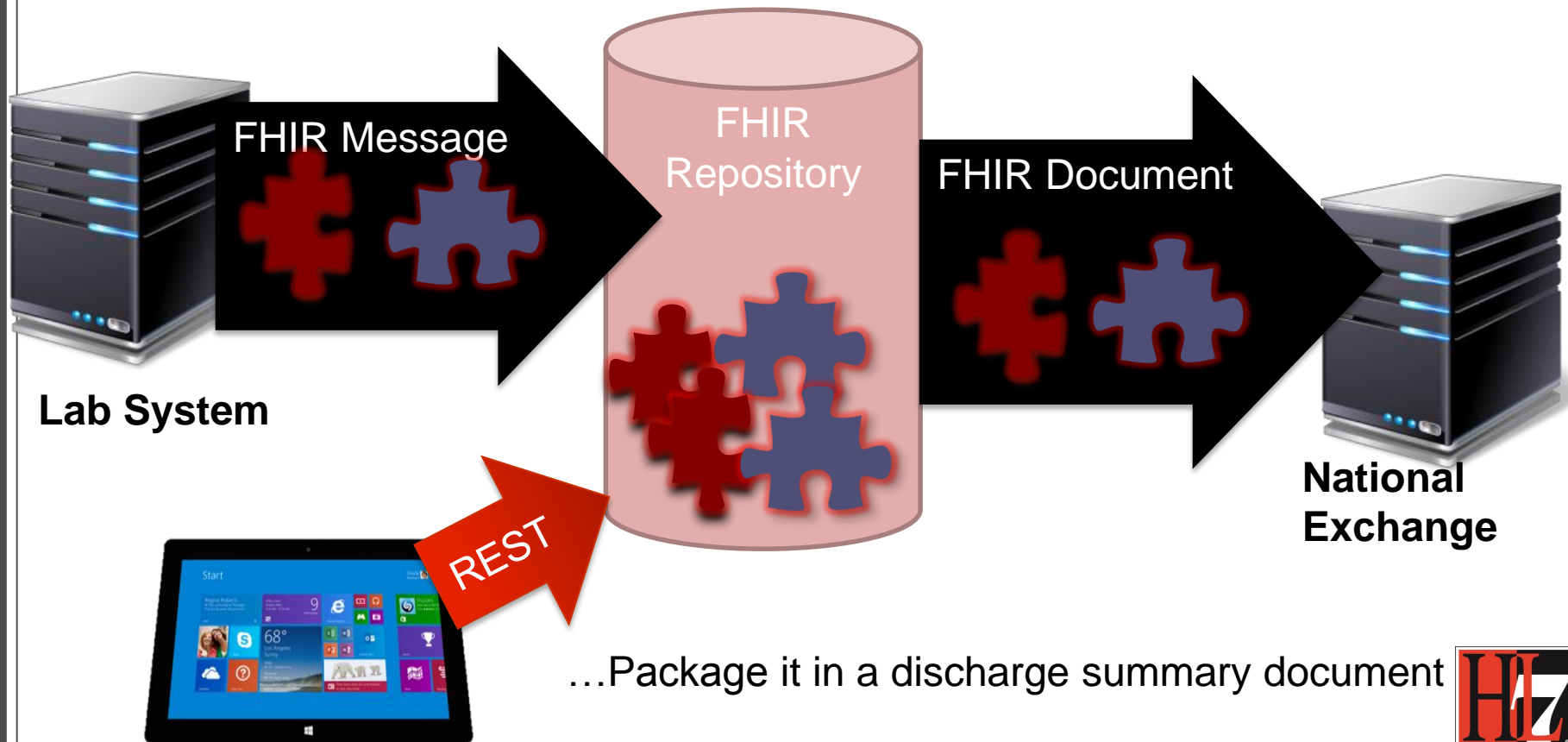
- FHIR supports 4 interoperability paradigms



Regardless of **paradigm**
the content **is the same**



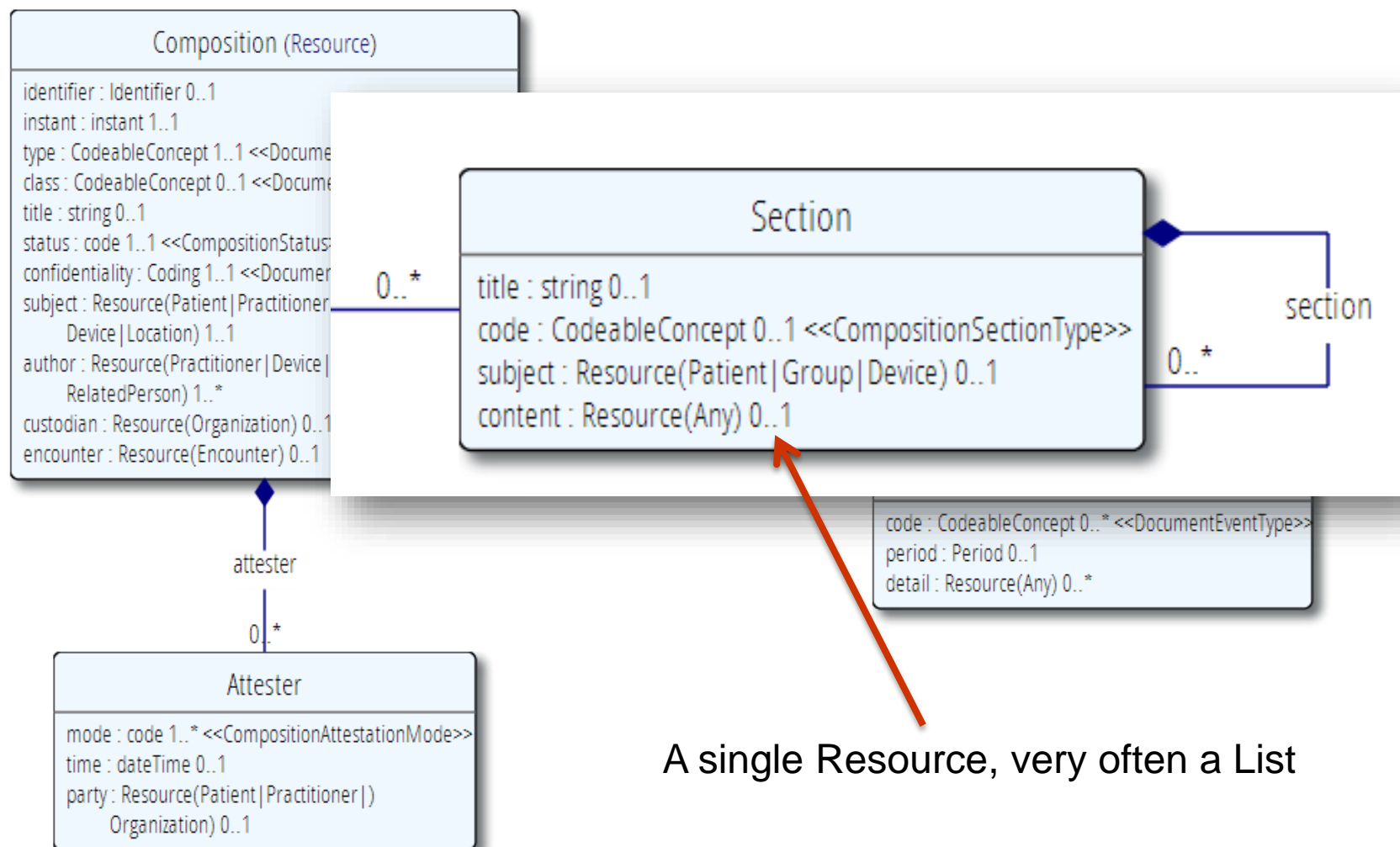
Receive a lab result in a message...



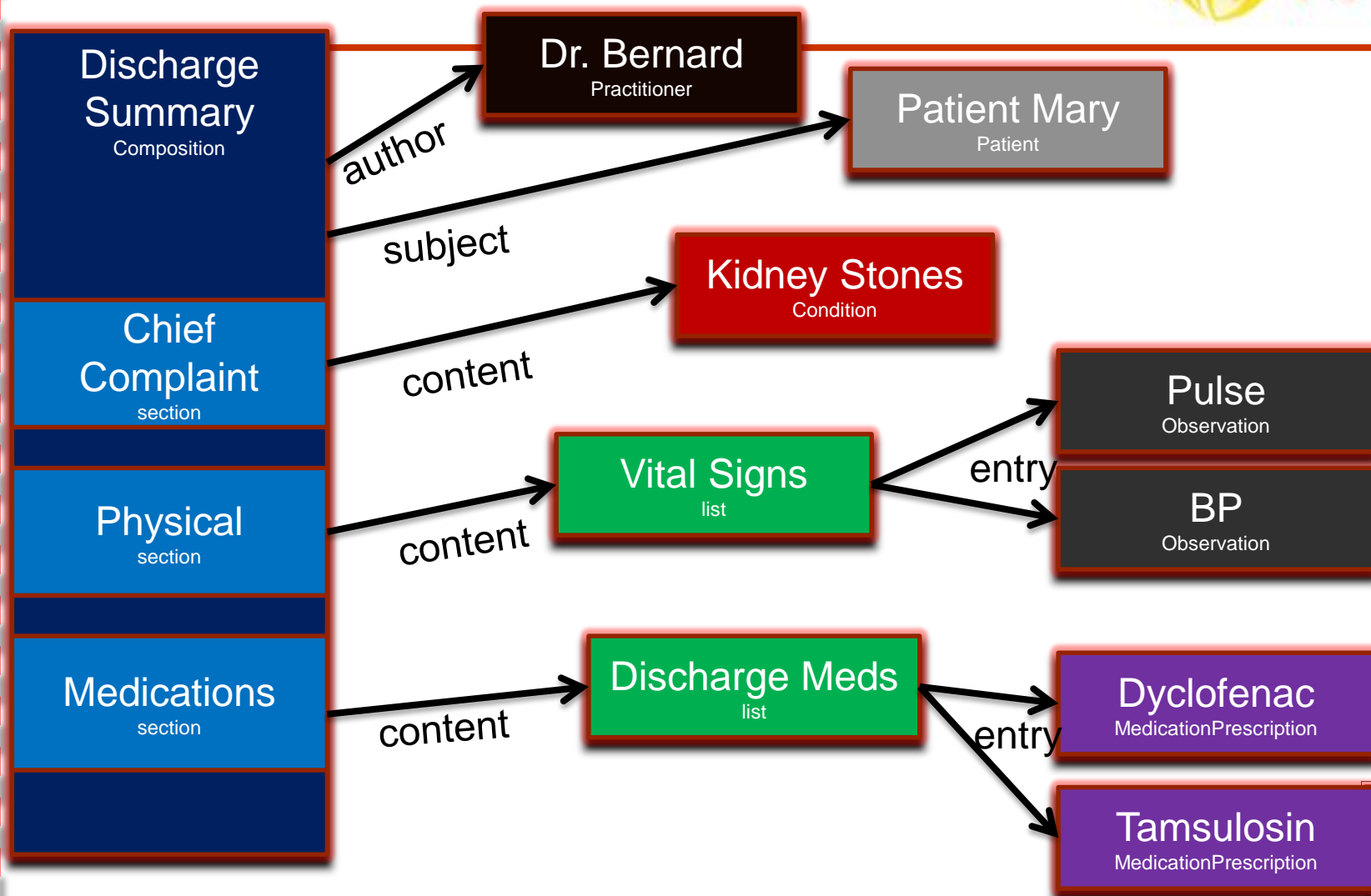
...Package it in a discharge summary document



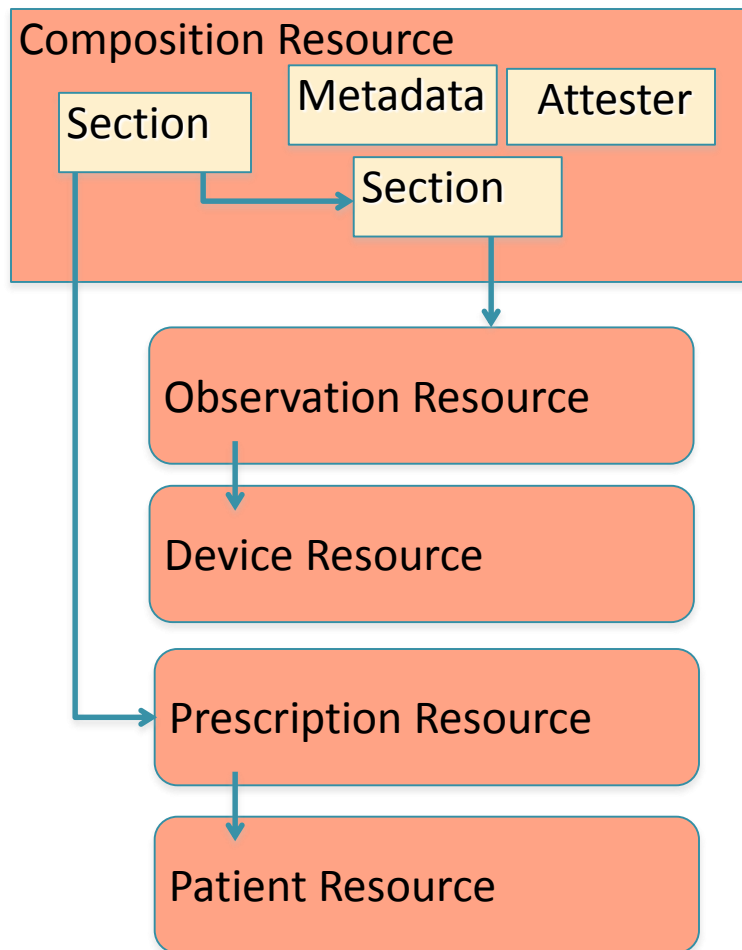
The Document resource



FHIR Document



Documents – are bundles



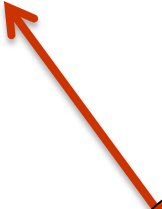
```
<feed>
  <entry>
    <Composition />
  </entry>
  <entry>
    <Observation />
  </entry>
  <entry>
    <Device />
  </entry>
  <entry>
    <Prescription />
  </entry>
  <entry>
    <Patient />
  </entry>
</feed>
```



Tag as "Document"



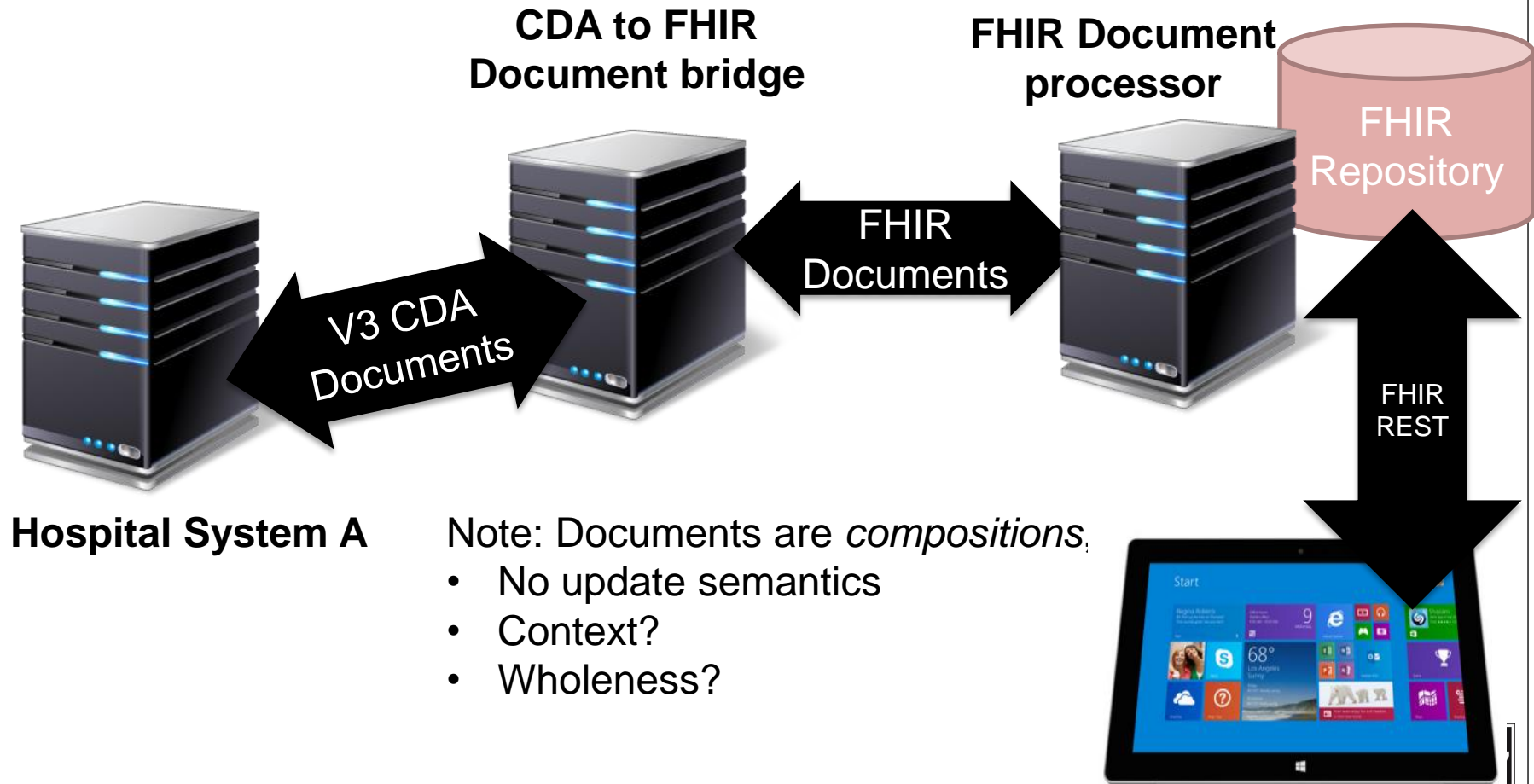
```
<feed xmlns="http://www.w3.org/2005/Atom">
  <title>This is my first Bundle</title>
  <id>urn:uuid:9f395ee0-19d2-4760-baf6-097fda52d914</id>
  <updated>2014-03-10T12:42:08.6834841Z</updated>
  <category term="http://hl7.org/fhir/tag/document"
    scheme="http://hl7.org/fhir/tag" />
  <entry></entry>
```



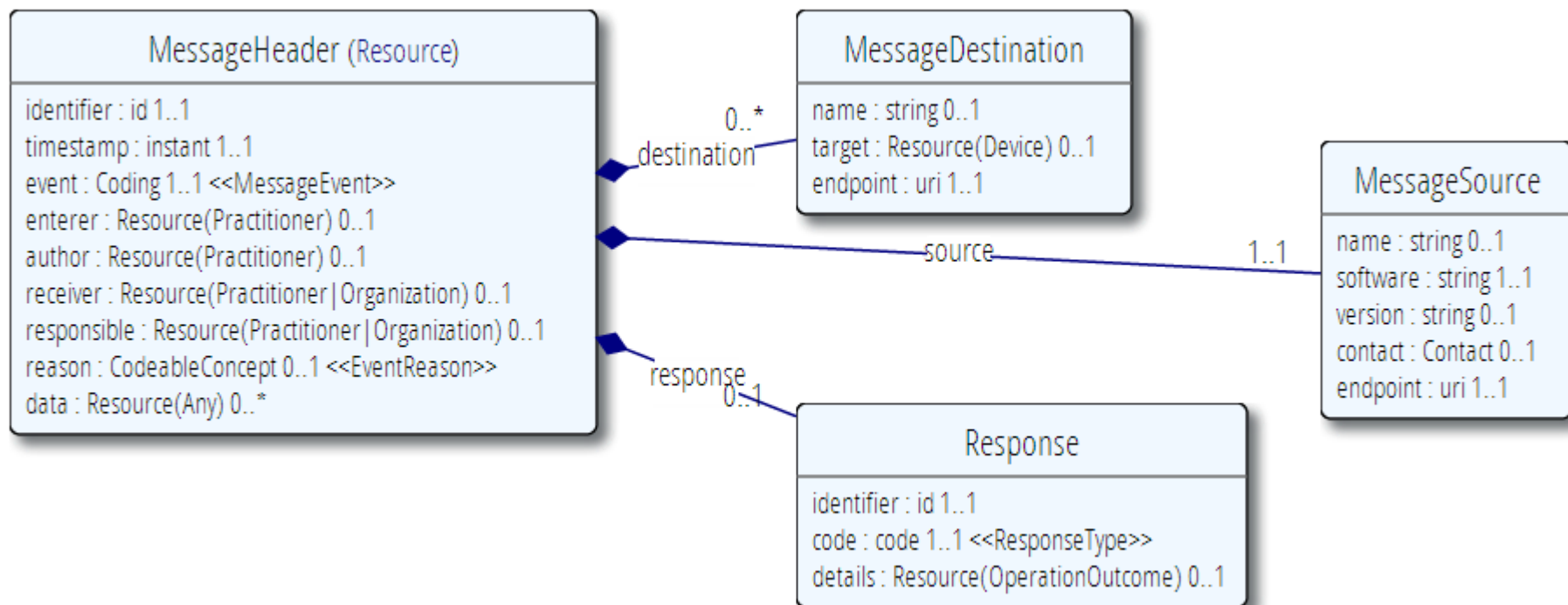
This Bundle
is a
Document



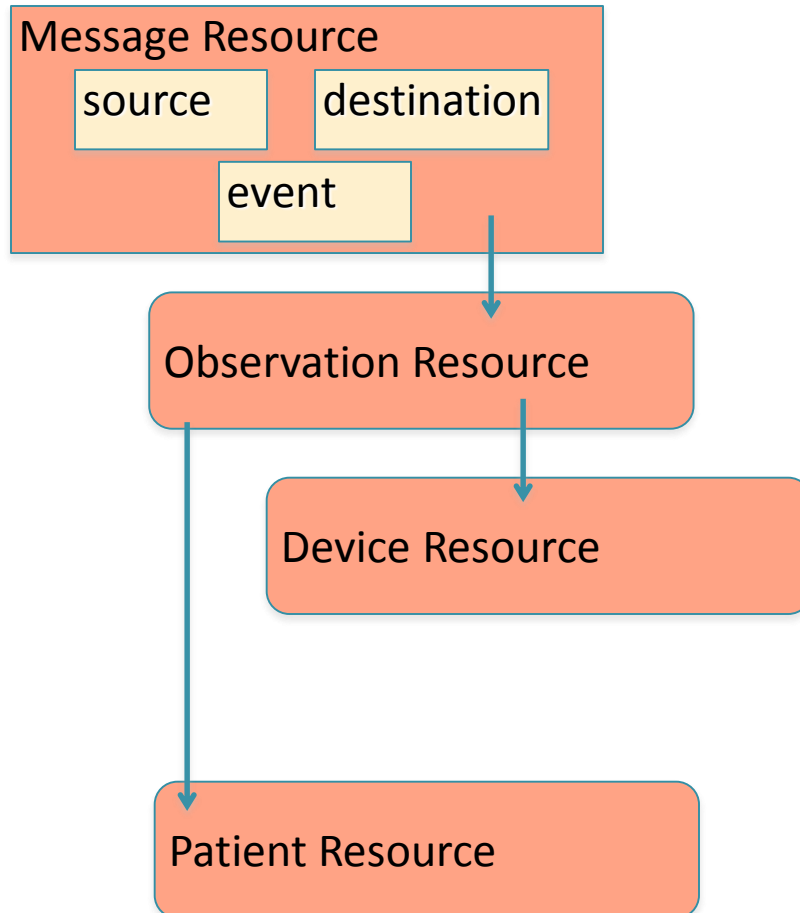
V3 and FHIR



MessageHeader Resource



Messages – are bundles



```
<feed>
  <entry>
    <MessageHeader />
  </entry>
  <entry>
    <Observation />
  </entry>
  <entry>
    <Patient />
  </entry>
  <entry>
    <Device />
  </entry>
</feed>
```



Tag as "Message"



```
<feed xmlns="http://www.w3.org/2005/Atom">
  <title>This is my first Bundle</title>
  <id>urn:uuid:9f395ee0-19d2-4760-baf6-097fda52d914</id>
  <updated>2014-03-10T12:42:08.6834841Z</updated>
  <category term="http://hl7.org/fhir/tag/message"
    scheme="http://hl7.org/fhir/tag" />
  <entry></entry>
```



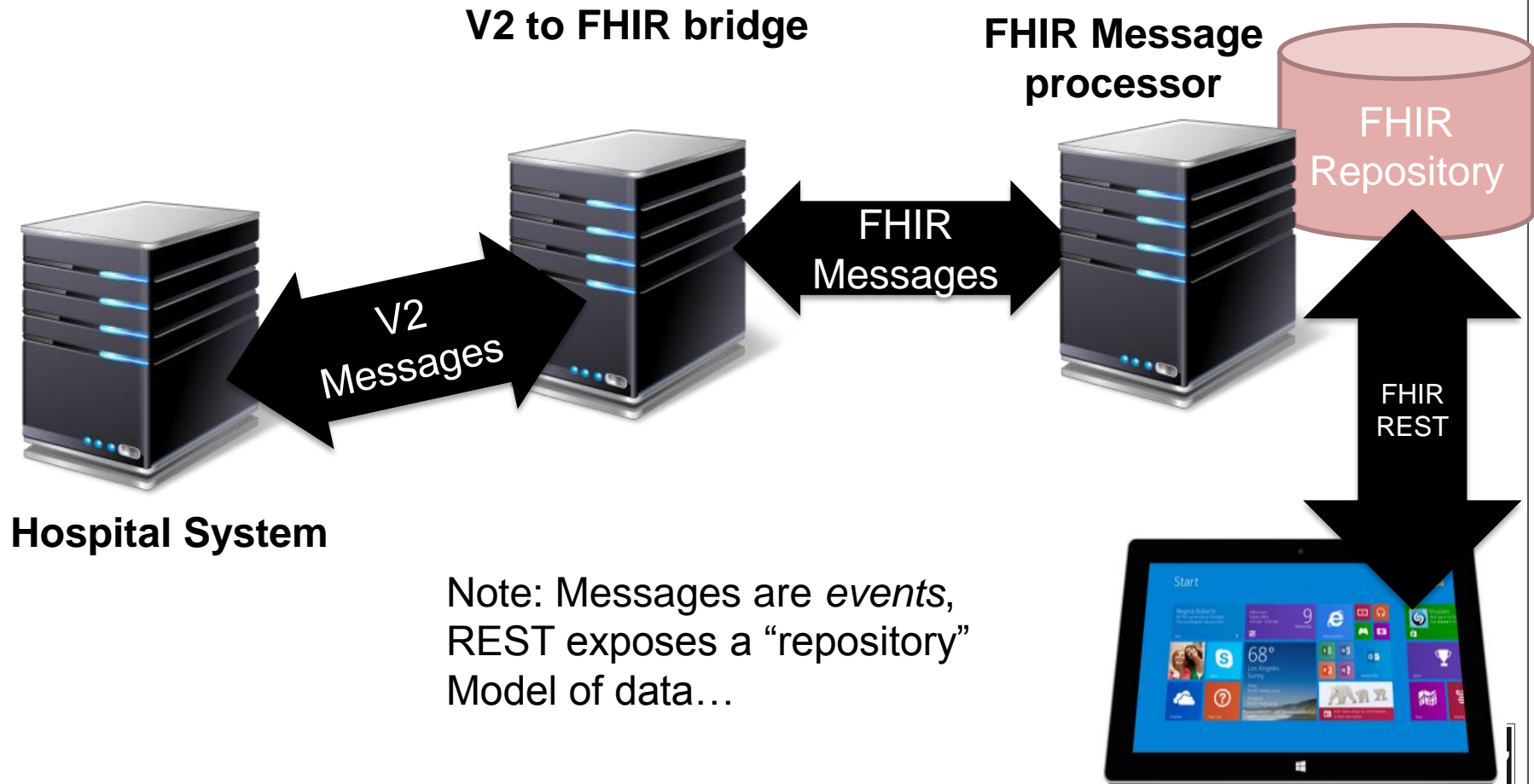
Sending messages



- Again, REST not necessary, but...
- There is an explicit REST endpoint:
 - <http://server.org/fhir/Mailbox>
- No storage implied. Might be a router, converted to v2, etc. etc.
- The server can process them based on the event code and return the response as another message (again a bundle).



V2 and FHIR



Exercise #1



Composing a FHIR Document

(45 minutes)



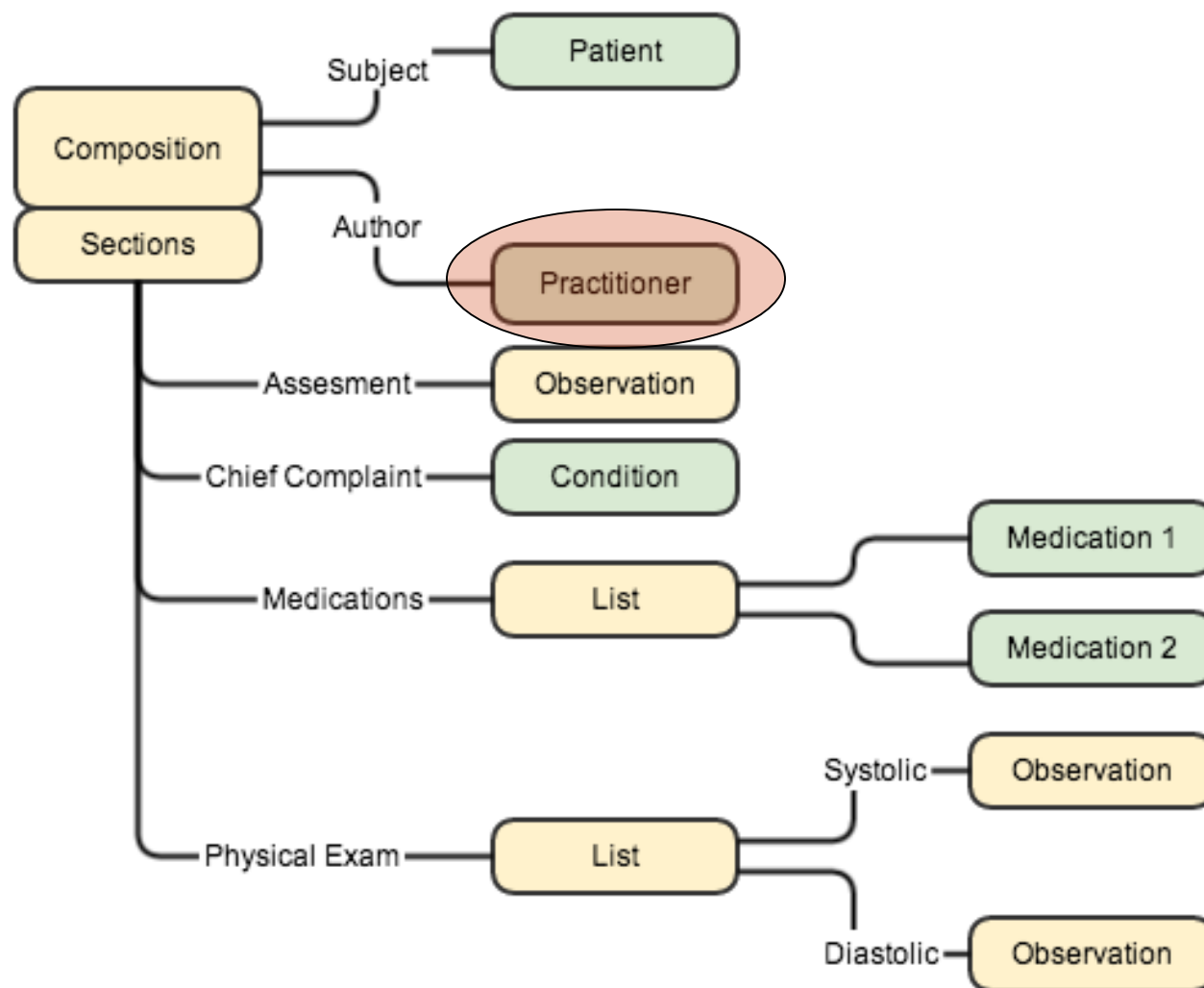
Exercise #1



-
- **Open PatsyPregnantDocument.xml**
 - **Sketch the structure of the document from the “root” Composition to the sections and the resources referenced in the sections.**
 - **Which element references an external resource?**
 - **Add a Medications section (not necessary to fully fill out a Medication Resource though)**
 - *What if our EHR only has human-readable text available describing the medications?*



The sample document





Looking forward to DSTU2

CLASS HIERARCHY

No hierarchy in DSTU1



- There were just “resources”
- The metadata (also the id) was not part of the resource data and class definitions
- Resources had no “base class” with common properties (extensions, text)
- FAQ: Where are those properties?

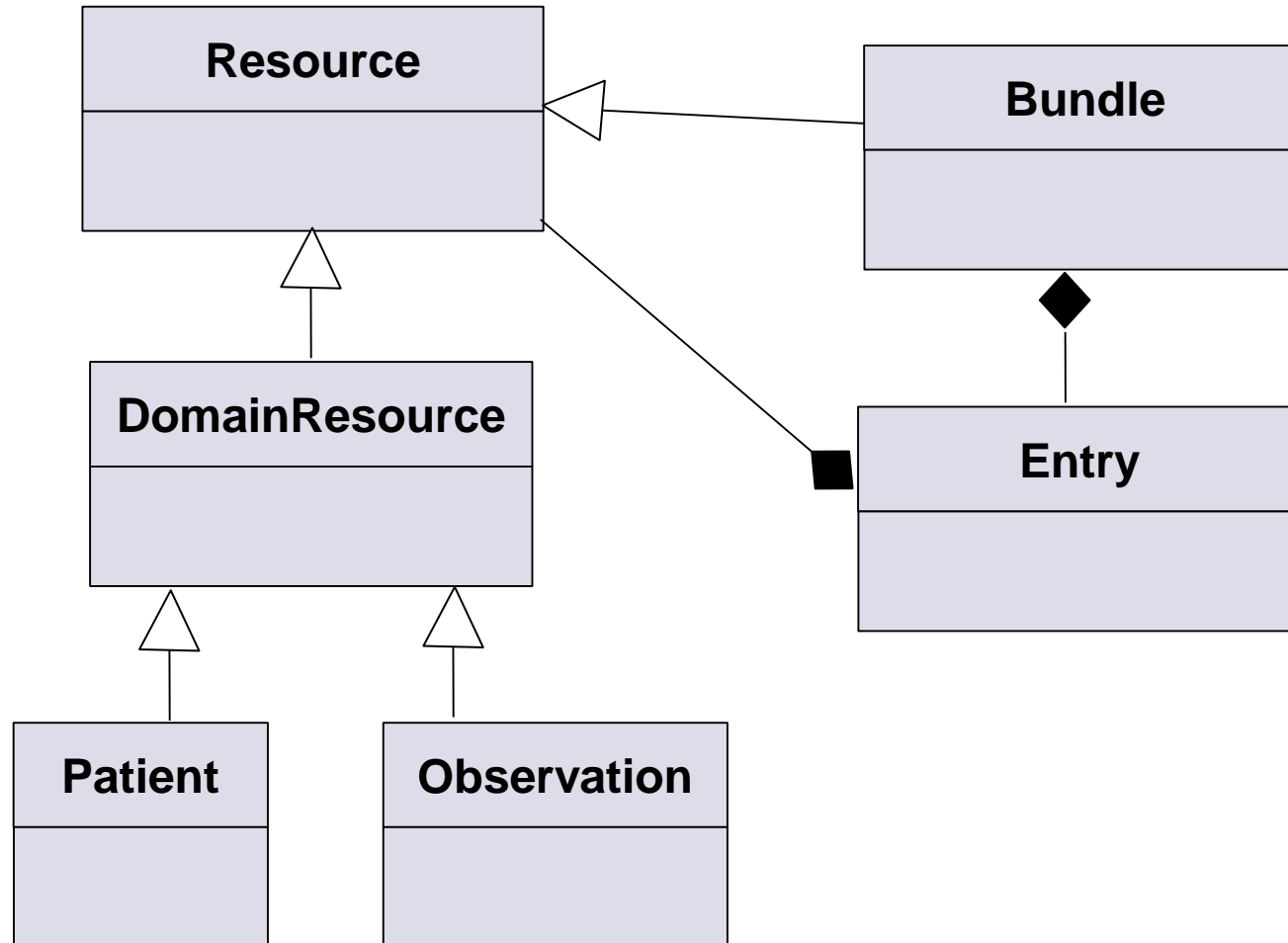


More trouble

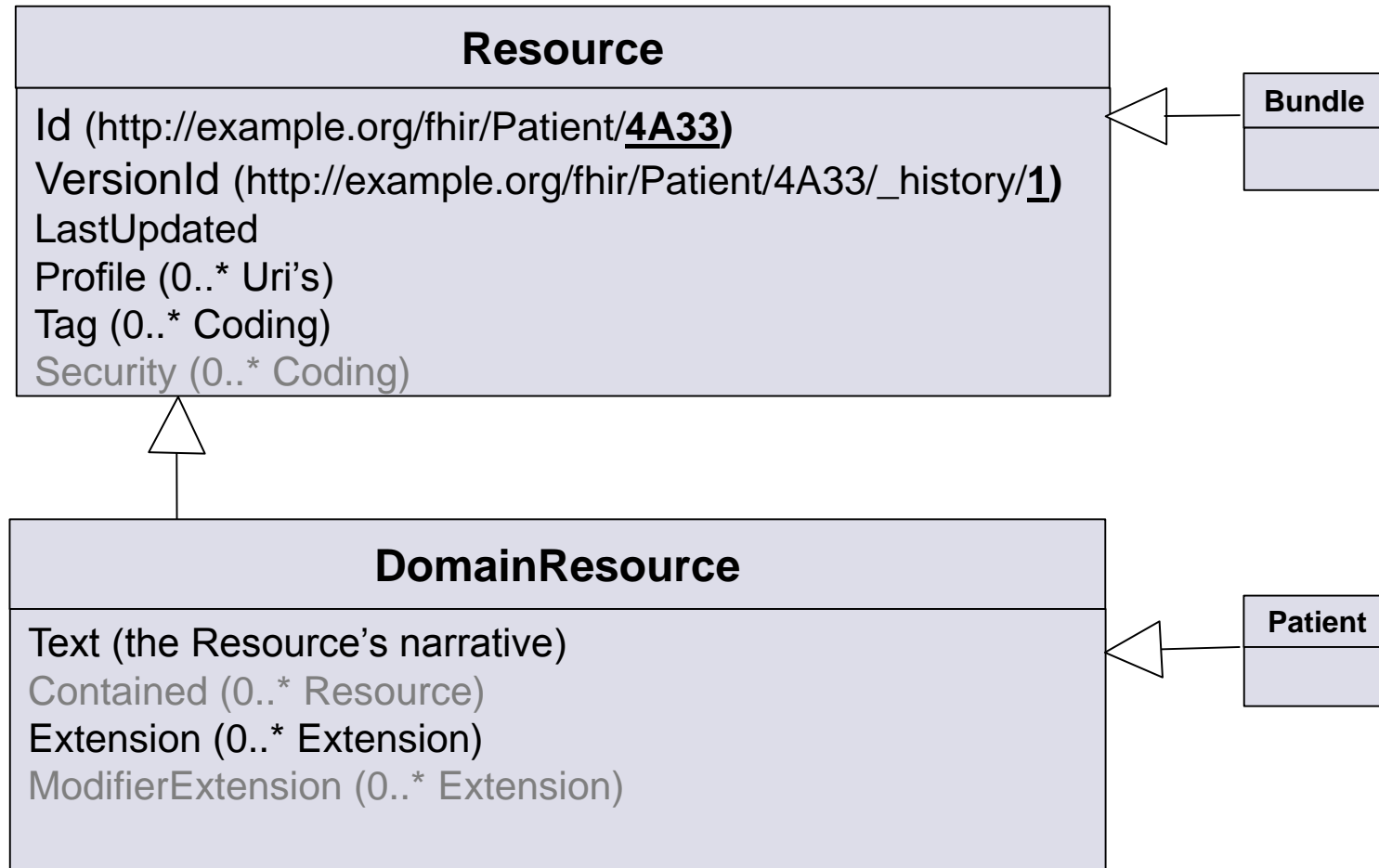


- In DSTU1 we had Resources and we combined Resources into Bundles
- But Bundles were Atom...
- Two parsers, two code paths, no commonality

Overview



Basic elements



The Base Resource



Resource «Resource»

id : id 0..1

meta : Meta 0..1

implicitRules : uri 0..1

language : code 0..1 « Language »

Base Resource in the specification

Defining FHIR resources



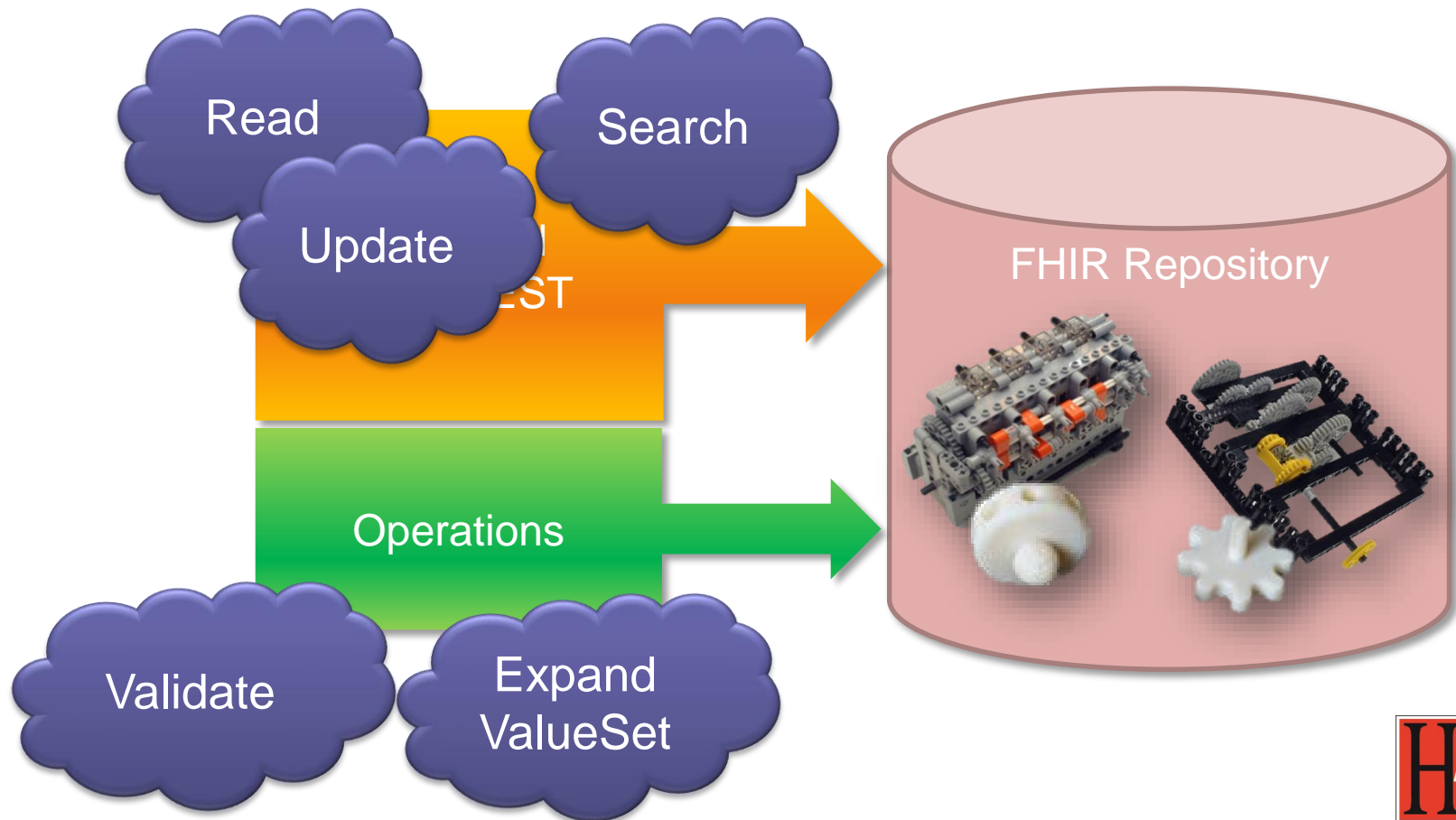
```
<Patient xmlns="http://hl7.org/fhir">
  <id value="example"/>
  <meta>
    <versionId value="1" />
    <lastUpdated value="2013-03-17T16:18:45.001" />
    <profile value="http://example.org/fhir/StructureDefinition/patient-nl" />
    <profile value="http://example.org/fhir/StructureDefinition/out-patient-nl" />
    <security>
      <system value="http://hl7.org/fhir/v3/ActCode"/>
      <code value="CEL"/>
      <display value="Celebrity"/>
    </security>
    <tag>
      <system value="http://example.org/fhir/vs/ProductionState"/>
      <code value="TEST" />
      <display value="Testdata - do not use" />
    </tag>
  </meta>
  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml"><!-- snip --></div>
  </text>
  <extension url="http://hl7.org/fhir/StructureDefinition/patient-birthTime">
    <valueTime value="14:35:45"/>
  </extension>
  <!-- MRN assigned by ACME healthcare on 6-May 2001 -->
  <identifier>
    <use value="usual"/>
    <label value="MRN"/>
    <system value="urn:oid:1.2.36.146.595.217.0.1"/>
  </identifier>
</Patient>
```



Looking forward to DSTU2

INTRODUCING THE OPERATIONS FRAMEWORK

Operations framework



Operations framework



- Seamlessly extends the RESTful API
- Uses an RPC-like paradigm
- Operations
 - have a name
 - have input and output parameters
 - have a context - system, resource type, or resource instance

See specification for defined FHIR operations

Operation request

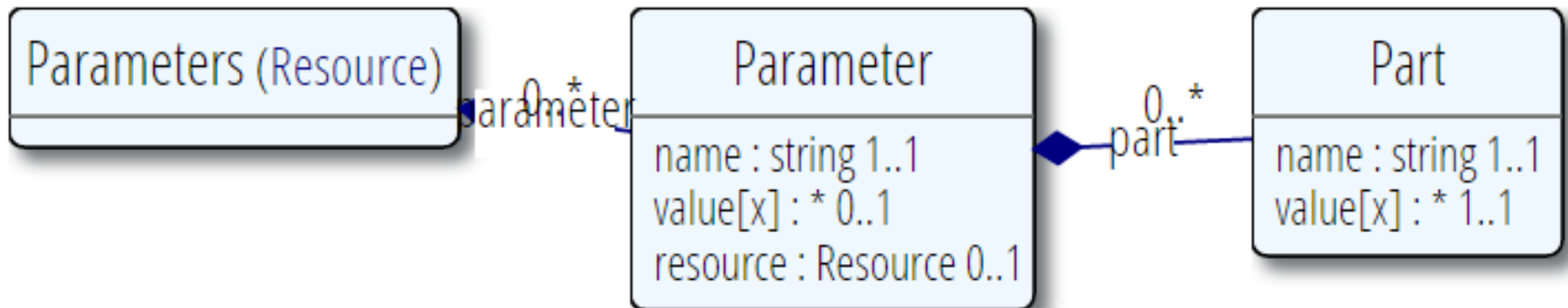


- HTTP POST

- End-point depends on context:

- system: [base]/\$[name]
- resource type [base]/[type]/\$[name]
- resource instance: [base]/[type]/[id]/\$[name]
- Example:
POST [base]/ValueSet/\$expand

Parameters Resource



Example

POST [base]/ValueSet/\$expand HTTP/1.1

Content-Type: application/fhir+xml

```
<!--
  This is an example of a operation request for a value set
  expansion where the value set is submitted on the fly
-->
<Parameters xmlns="http://hl7.org/fhir">
  <parameter>
    <name value="filter"/>
    <valueString name="abdo"/>
  </parameter>
  <parameter>
    <name value="valueset"/>
    <resource>
      <ValueSet>
        <text>
          <status value="generated"/>
          <div xmlns="http://www.w3.org/1999/xhtml"><!-- Snipped for brevity --></div>
        </text>
        <identifier value="http://hl7.org/fhir/vs/body-site"/>
        <name value="SNOMED CT Body Structures"/>
        <!-- snipped -->
      </ValueSet>
    </resource>
  </parameter>
</Parameters>
```

Exercise #2



Using the validate operation

(45 minutes)



Exercise #2



- **Validate the Patient** “uslab-example1” **against the profile** <http://fhir-dev.healthintersections.com.au/open/Profile/patient-uslab-uslabpatient>
 - Locate the “validate” operation on the base resource in the spec and look at the parameters
 - Construct a Parameters object containing the “uslab-example1” Patient and the profile <http://fhir-dev.healthintersections.com.au/open/Profile/patient-uslab-uslabpatient>
 - Invoke the \$validate operation on the correct endpoint. Why are there two possible endpoints?



Operation Outcome



- When something goes wrong....return the OperationOutcome Resource!

```
<OperationOutcome>
  <text>
    <status value="additional"/>
    <div xmlns="http://www.w3.org/1999/xhtml">
      <p>W is not a recognized code for Gender.</p>
    </div>
  </text>
  <issue>
    <severity value="error"/>
    <type>
      <system value="http://test.org/issueCodeSystem"/>
      <code value="V15"/>
      <display value="InvalidCode"/>
    </type>
    <location value="/Person[1]/gender[1]"/>
  </issue>
</OperationOutcome>
```





Looking forward to DSTU2

INTRODUCING THE CONFORMANCE LAYER

How to adapt the specs to meet our needs



“Profile”

**Structure
Definition**

ConceptMap

**SearchParam
Definition**

NamingSystem

**Operation
Definition**



ValueSet

Conformance



The need for Conformance

- Many different contexts in healthcare, but a single “core spec” with operations and Resources
- Need to be able to describe restrictions based on use and context
- Allow for these usage statements to:
 - Authored in a structured manner
 - Published in a repository
 - Used as the basis for validation, code, report and UI generation

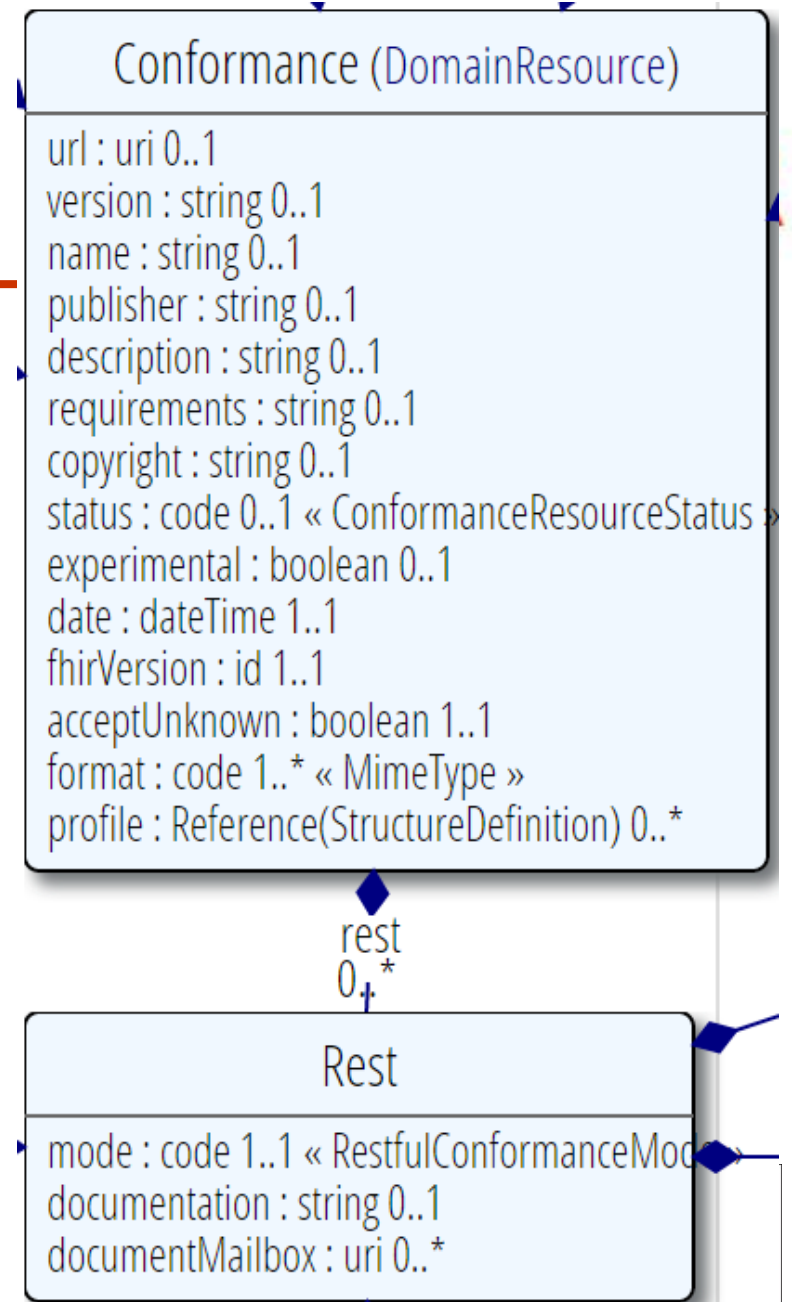


Extend/restrict the API

Conformance

describes how a client or server uses or should use the FHIR API

- Which wire formats supported?
- Which resources?
- Which operations (read, create, update, search)
- Which FHIR version?
- What search operations?
- Is this a test server?
- Who can I contact?
- What's the name of the software?

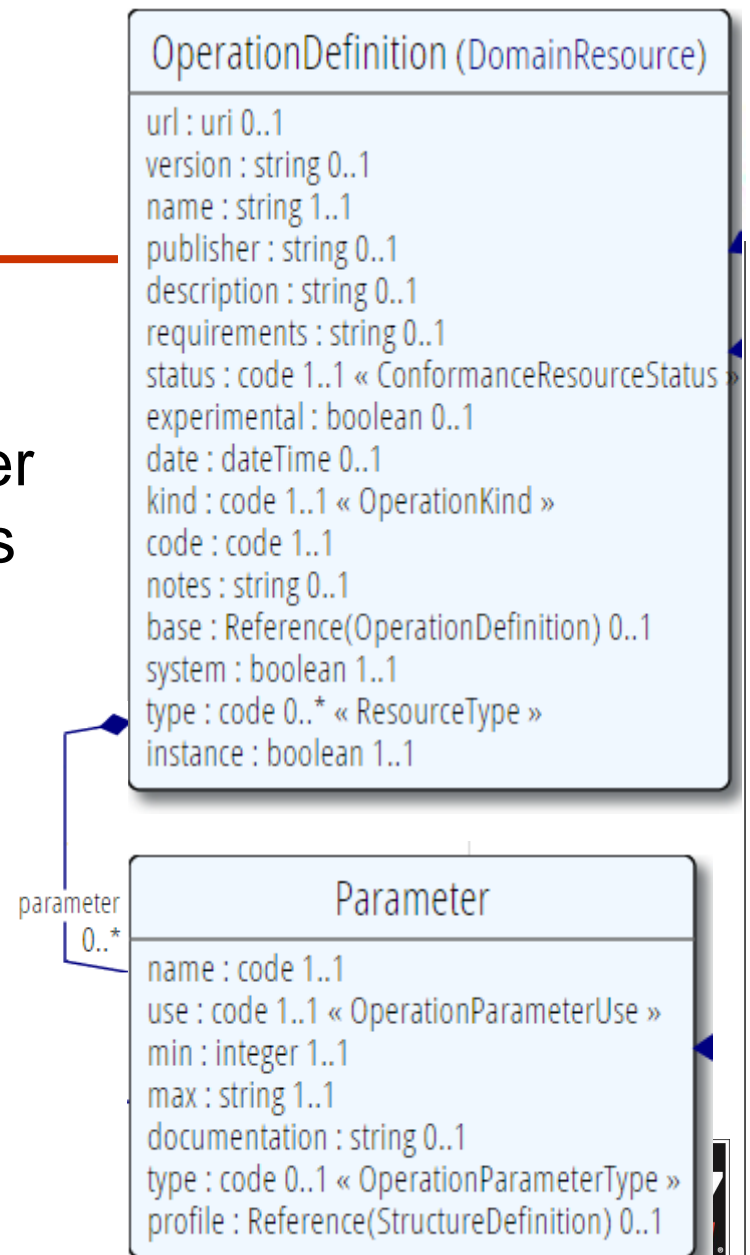


Extend/restrict the API

OperationDefinition

describes additional operations over and above the RESTful interactions defined in the specification

- What is the name?
- Input/output parameters
- What does it do?
- Works on which resources?



StructureDefinition (DomainResource)

```

url : uri 1..1
identifier : Identifier 0..*
version : string 0..1
name : string 1..1
useContext : CodeableConcept 0..* « ConformanceUseContext+ »
display : string 0..1
publisher : string 0..1
description : string 0..1
requirements : string 0..1
copyright : string 0..1
code : Coding 0..*
status : code 1..1 « ConformanceResourceStatus »
experimental : boolean 0..1
date : dateTime 0..1
fhirVersion : id 0..1
type : code 1..1 « StructureDefinitionType »
abstract : boolean 1..1
contextType : code 0..1 « ExtensionContext »
context : string 0..*
base : uri 0..1
  
```

Differential

element : ElementDefinition 1..*

differential 0..1

StructureDefinition

- Core definition (see [validation.zip](#))
- Constraints
- Extensions

snapshot

0..1

Snapshot

element : ElementDefinition 1..*

Extend/restrict Resources

■ StructureDefinition

describes additional restrictions on or possible extensions to a resource or datatype

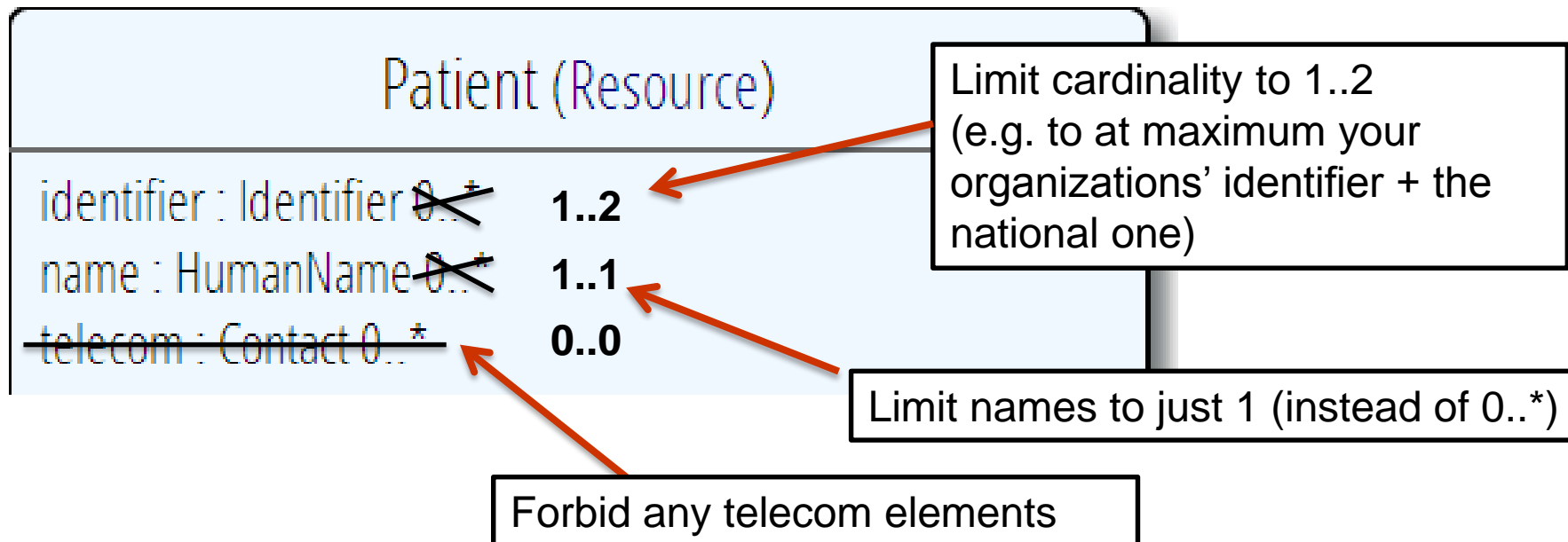
“Must use only the Dutch national patient identifier”

“In our Patient registration system, we use these maritalStatus codes beyond those provided by HL7...”

“We need to add a field to specify the Tax Office of an organization”



Constraining cardinality



Note: something that's mandatory in the core definition cannot be made optional in a profile



Limit value domains



```
deceased[x] : boolean | dateTime 0..1  
address : Address 0..*  
maritalStatus : CodeableConcept 0..1 <<MaritalStatus>>  
multipleBirth[x] : boolean | integer 0..1  
photo : Attachment 0..*  
communication : CodeableConcept 0..* <<Language>>  
provider : Resource(Organization) 0..1 OrganizationNL  
link : Resource(Patient) 0..*  
active : boolean 0..1 ="true"
```

If deceased is given, it must be a dateTime, not a boolean

Use our national codes for MaritalStatus

Use another profiled Resource

Fix value: Only allow "active" Patients



Extending a resource



```
<Patient>
  <name>
    <use value="official"/>
    <given value="Östlund">
      <extension url="http://hl7.org/fhir/Profile/
        iso-21090#name-qualifier">
        <valueCode value="MID"/>
      </extension>
    </given>
  </name>
</Patient>
```

Key = location of formal definition

Value = value according to definition

ValueSets



1.21.2.1.24 Value Set for codes in <http://hl7.org/fhir/administrative-gender>

This is a value set defined by the FHIR project. Related v3 content: [v3 Code System AdministrativeGender](#).

Summary

Code System URL: <http://hl7.org/fhir/administrative-gender>

Value Set URL: <http://hl7.org/fhir/vs/administrative-gender>

Definition: The gender of a person used for administrative purposes

Formal value Set definition : [XML](#) or [JSON](#).

This value set contains 4 concepts

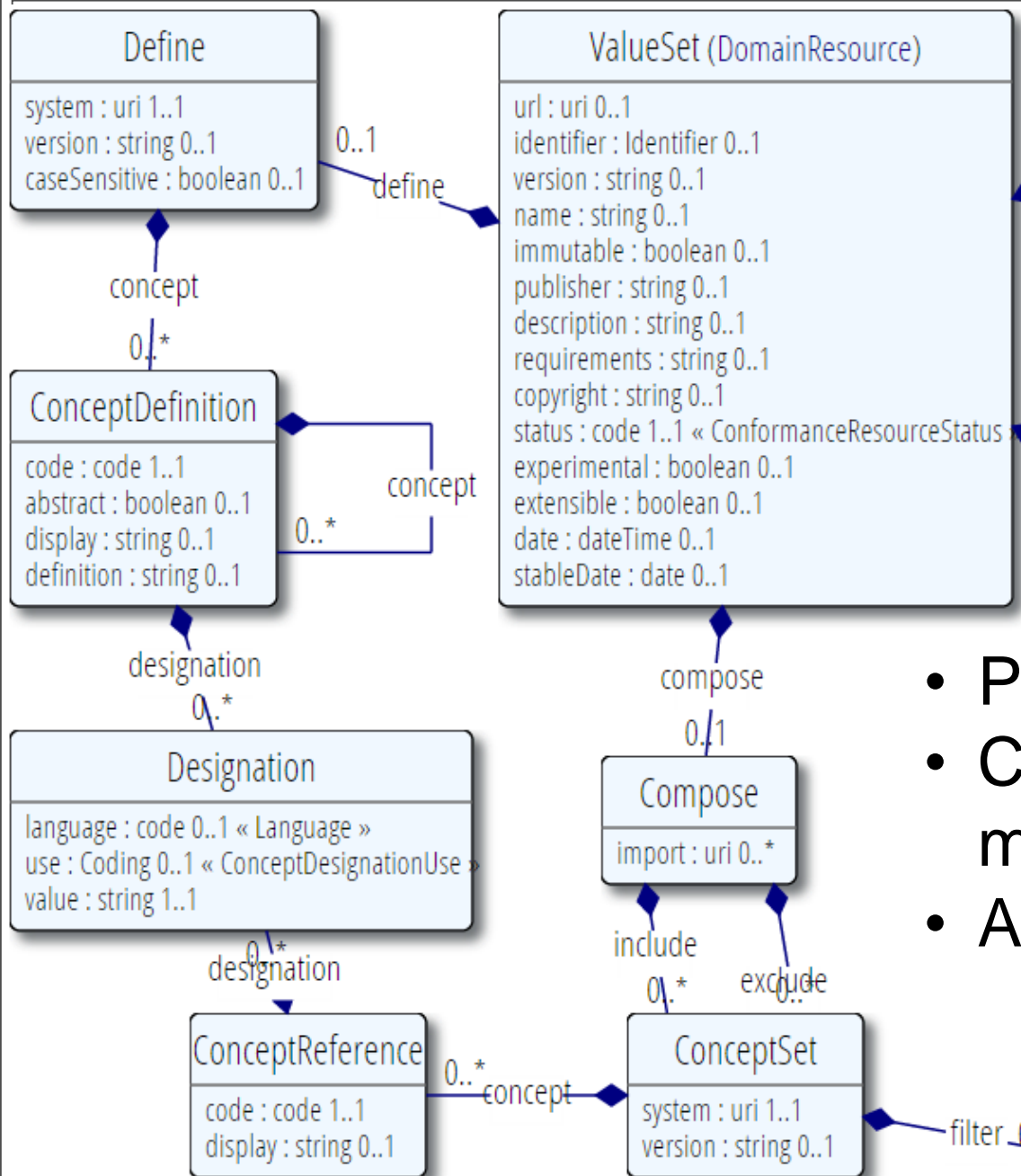
1.21.2.1.24.1 AdministrativeGender

The gender of a person used for administrative purposes

This value set defines its own terms in the system <http://hl7.org/fhir/administrative-gender>

Code	Display	Definition	v3 Map (AdministrativeGender)	v2 Map (0001)
male	Male	Male	=M	=M
female	Female	Female	=F	=F
other	Other	Other	>UN	>A >O
unknown	Unknown	Unknown	=UNK	=U





- Publication meta-data
- Concepts from 1 or more existing systems
- Additional concepts

Implementation Guide Publication



**Structure
Definition**

ValueSet

ConceptMap

NamingSystem

OperationDefinition

Publication tool

Website

Examples

Profiled resources

Validation
Schema's

DictXml

Resource profiles





Welcome

This FHIR Implementation Guide is written for software developers taking part in the Helse Vest project. It contains all information necessary to write software using FHIR to interoperate with the Helse Vest system. It covers the scope and architecture down to the data definitions and support libraries that can be used.

Contents

- [Chapter 2 - FHIR in Norway](#) Describes the current status of FHIR in the more broader of-concept within Norway.
- [Chapter 3 - Scope](#) Learn about the goal of the Laboratory proof-of-concept, its use-cases and the scope of the project.
- [Chapter 4 - Architecture](#) What technical environment is the project running in, how is it structured and what are the dependencies.
- [Chapter 5 - Working With FHIR and Rest](#) Find Step-by-step examples for creating, retrieving and updating a DiagnosticReport in .NET
- [Chapter 6 - Profile Data Definition](#) Describes the data used in the project in full detail, including the profiles.
- [Chapter 7 - Getting Started](#) Contains links to get you up and running developing software using the support libraries for specific platforms.



Observation Structure

This Observation represents a single lab result for a patient. It is derived from the normal Observation result, constraints:

- The Name must be plain text. **(required)**
- A String Value of the observation.
- An interpretation of the observation. Chosen from the value set that is defined especially for this domain.
- The actual test time. **(required)**
- The status of the result code. Chosen from the value set that is defined especially for this domain. **(required)**
- The patient (subject) on which the observation was made.
- The organization in which the observation was made. **(required)**

Name	Card.	Type	Description & Constraints
Observation	0..1	Resource	Laboratory result Inv-2: Can only have normal range if value is a quantity
★ extension	0..*	Extension	Additional Content defined by implementations
★ modifierExtension	0..*	Extension	Extensions that cannot be ignored
text	0..1	Narrative	Text summary of the resource, for human interpretation
contained	0..*	Resource	Contained, inline Resources
name	1..1	CodeableConcept	Type of observation (code / type) Binding: ObservationType
★ extension	0..*	Extension	Additional Content defined by implementations
★ modifierExtension	0..*	Extension	Extensions that cannot be ignored
coding	0..0	Coding	
text	1..1	string	Plain text representation of the concept
value[x]	0..1	string	Actual result
interpretation	0..1	CodeableConcept	High, low, normal, etc. Binding: valueset.hl7labresultinterpretation
comments	0..0	string	
applies[x]	1..1	dateTime	Actual testtime.



Using the Reference Implementations

HL7.FHIR SUPPORT API

Reference implementations



- Contents
 - Model – classes generated from the spec
 - Parsers – Parsers generated from the spec
 - Serializers – Serializers generated from the spec
 - FhirClient
 - Validation
- Java – Maven
- .NET – NuGet “FHIR”, or GitHub “fhir-net-api”





Main Page
Categories

groups
Work Groups
User Groups

meetings

general

Tools



Create account

Log in

Page Discussion

Read

View source

View history

Search



Publicly Available FHIR Servers for testing

Back to [FHIR](#) home page

Introduction

This page lists FHIR servers that are publically available for testing. In order to avoid spam etc, the servers are generally password protected. A contact is provided to get a password.

List

Note that these servers are testing servers. They may be sporadically unavailable, and as the FHIR specification is a moving target, they may not always implement the latest version, or do so correctly.

- <http://fhir.healthintersections.com.au/> - Grahame's test server.
 - Supports all resource types, all operations, xml + json
 - implementation details: open source - see [\[\[1\]\]](#)
 - also available using SSL at <https://fhir.healthintersections.com.au/> (not operational right now)
 - see [Health Intersections FHIR Server login documentation](#) for OAuth
- <http://spark.furore.com/> - Ewout's test server (previously fhir.furore.com). The actual service endpoint is at <http://spark.furore.com/fhir/>.
 - Supports all resource types, all operations, xml + json
 - implementation details: C# reference implementation, WebApi 2.0 library, Mongo DB for storage and search.



Example



Let's look at the validation exercise and see what the reference implementation can do for you

Example: validation with the API



```
[TestMethod]
public void InvokeResourceValidation()
{
    var client = new FhirClient(testEndpoint);

    var pat = client.Read<Patient>(ResourceIdentity.Build("Patient", "uslab-example1"));
    var vresult = client.ValidateResource(pat, null,
        new FhirUri("http://fhir-dev.healthintersections.com.au/open" +
            "/Profile/patient-uslab-uslabpatient"));

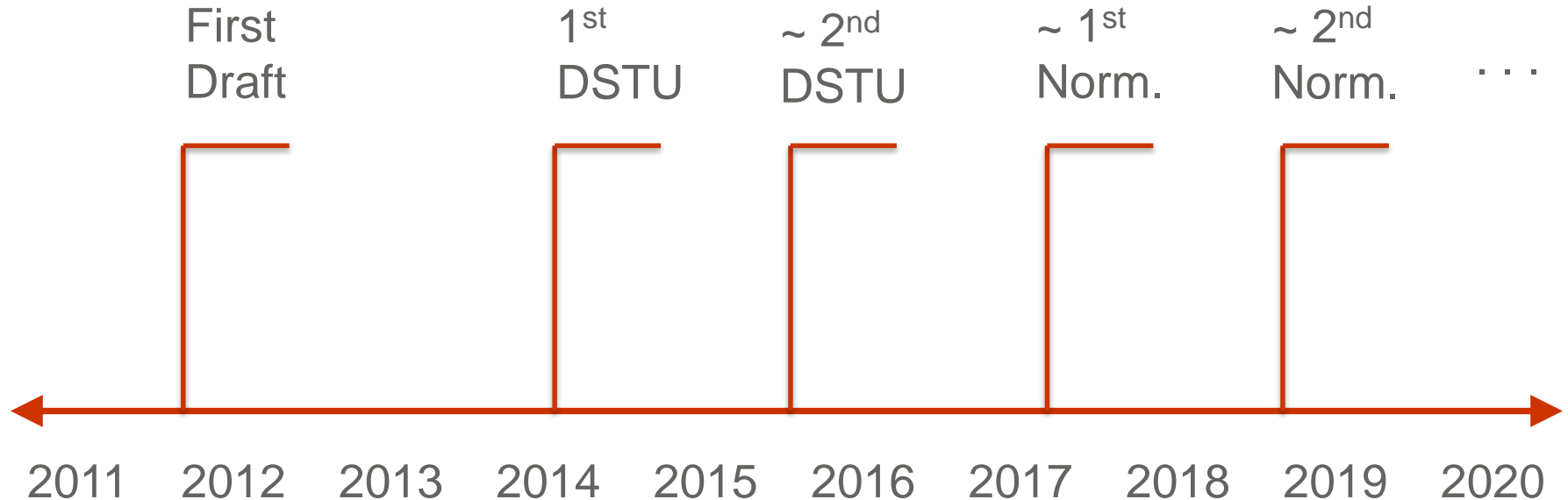
    Assert.IsTrue(vresult.Success());
}
```





INTERACTIVE SESSION

FHIR Timeline (planned)



**What would you like to know
about DSTU2?**



WHAT'S NEXT?

Next Steps for **you**



- Read the spec: <http://hl7.org/fhir>
- Try implementing it
- Come to a Connectathon!
- **fhir@lists.hl7.org**
- **#FHIR**
- **Implementor's Skype Channel**
- **StackOverflow: hl7 fhir tag**



International Working Group Meeting

Mark Your Calendar and Join Us!

Paris, France
May 10 – 15



International HL7 FHIR Developer Days

November 18-20, 2015 in Amsterdam

- Education
 - Tutorials
- Connectathon
 - Meet fellow developers
 - Put FHIR to the test
- Networking
 - FHIR experts and authors on hand



<http://fhir.furore.com/devdays>



The End – Questions?