HL7 FHIR

For developers

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HL7 International Co-chair

Agenda

- Talk (me)
- Show (me → you)
- Do (you)

- Discuss (we)

FHIR BASICS RECAP

The Acronym

Fast

Relative – No technology can make integration as fast as we'd like

Healthcare

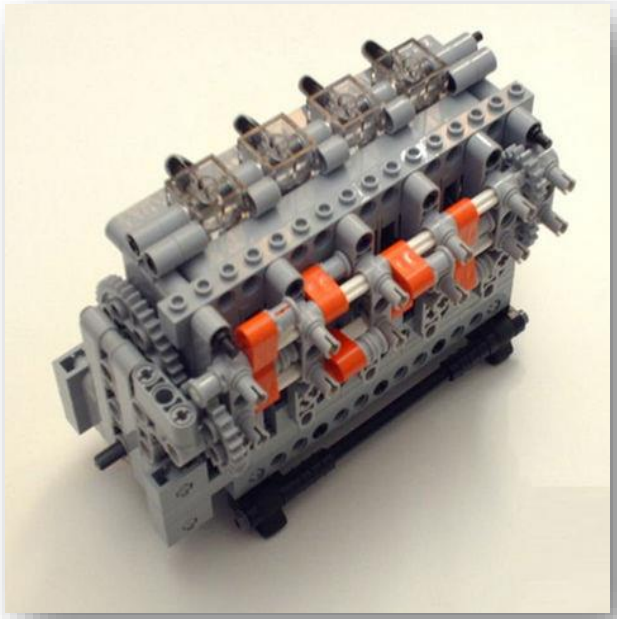
Interoperability

That's why we're here

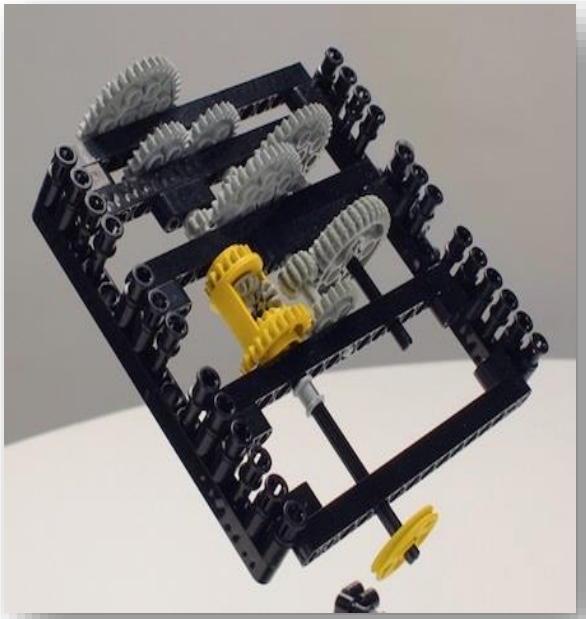
Resources

Building blocks – more on these to follow

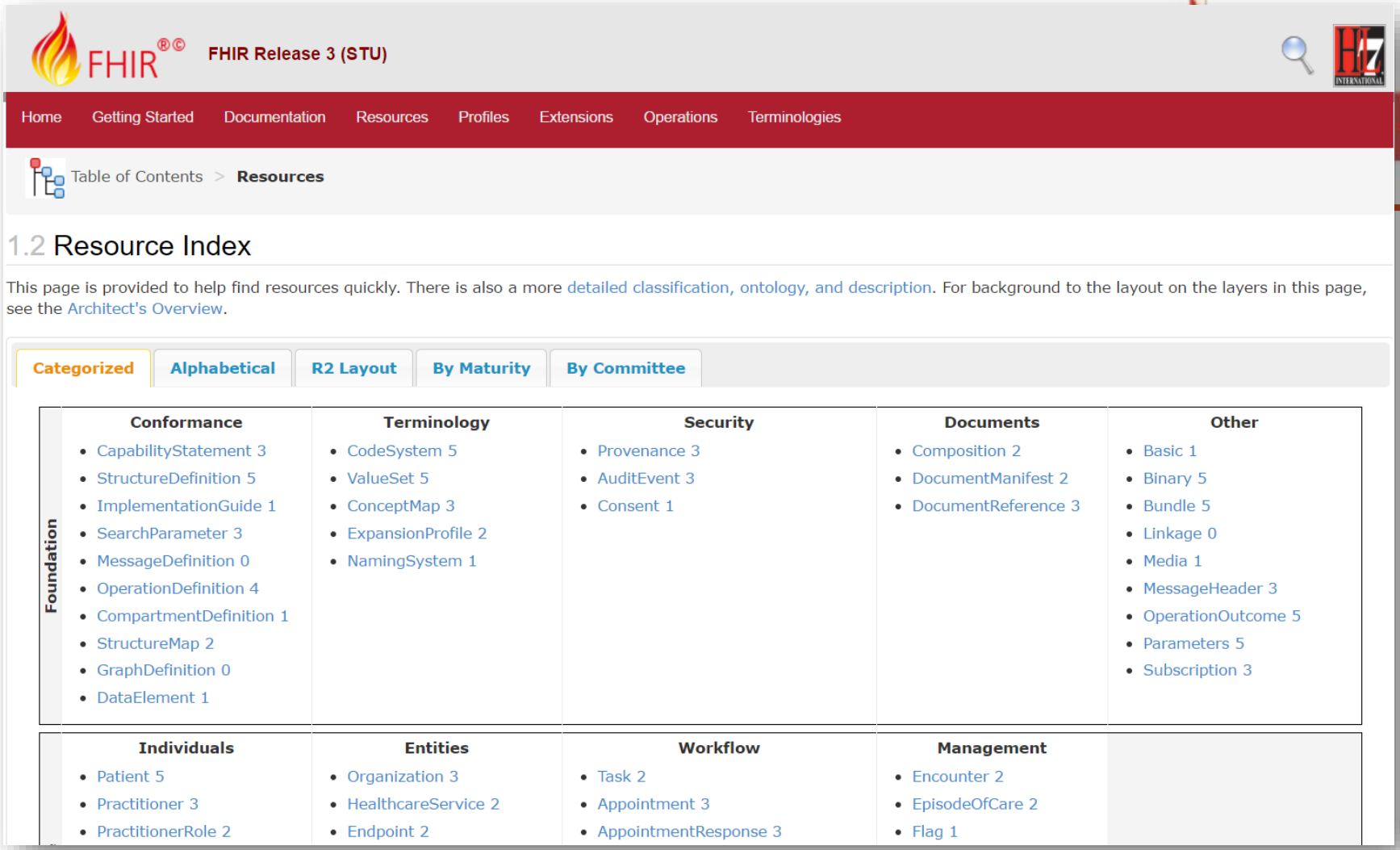
Resources



Patient

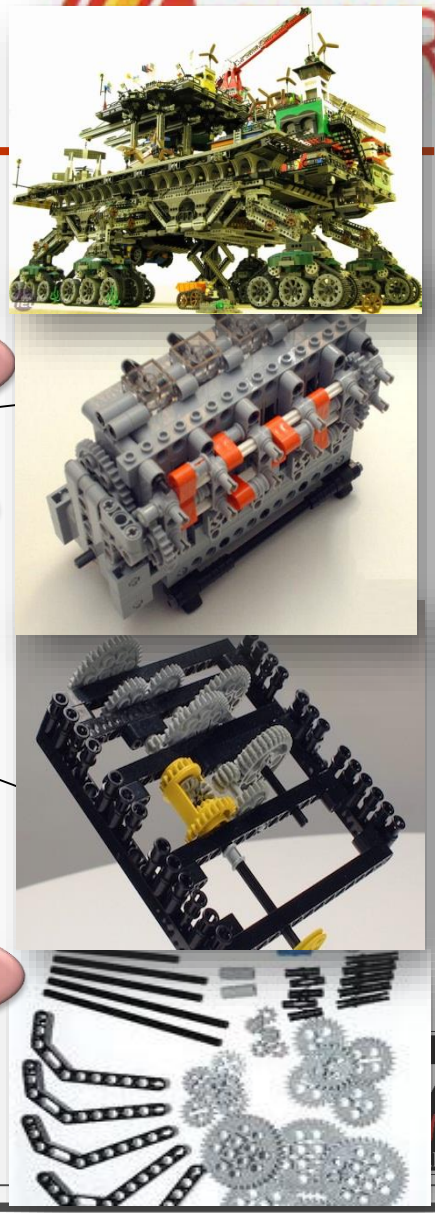


Prescription



http://www.hl7.org/fhir/resourcelist.html

Cover all usecases - (n)ever



Specific

IHE PDQ

C-CCD

FHIR

HL7v3 CMETS

openEHR Templates

openEHR Archetypes

HL7v2

HL7 CDA

HL7v3 RIM

openEHR RM

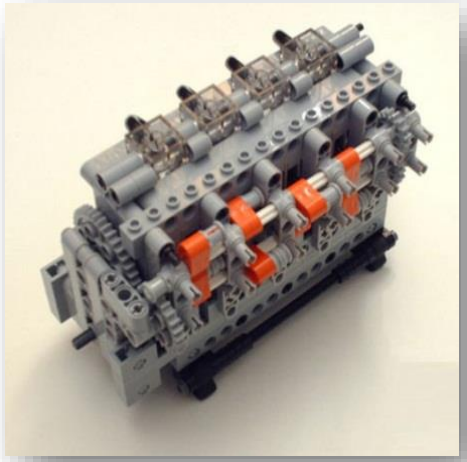
Generic

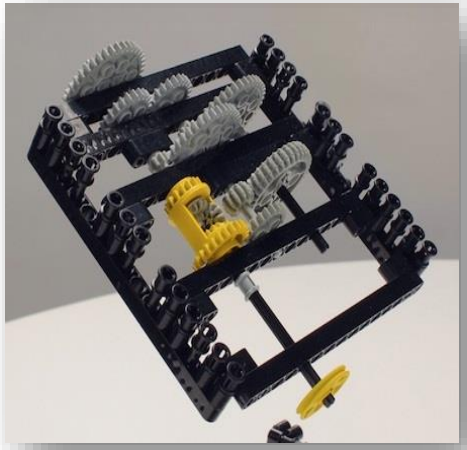
The 80/20 rule

- Design for the 80%, not 100%
  - Only include data elements in the artifacts if 80% of all implementers of that artifact will use the data element
- Allow easy extension for the remaining 20% of elements
  - which often make up 80% of current specs
  - Vocabulary approach to extension definition

V3/OpenEHR are designed to cover the 100%.

Extensibility





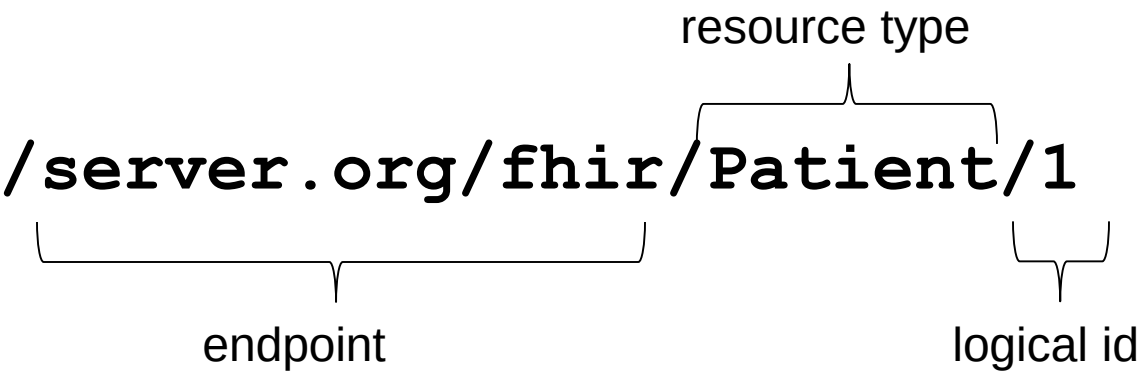
Structure of a Resource
(XML example)

```
<Patient xmlns="http://hl7.org/fhir">
  <id value="patient1"/>
  <meta>
    <versionId value="v2"/>
  </meta>
  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml">
      <p>Henry Levin the 7th</p>
    </div>
  </text>
  <extension url="http://hl7.org/fhir/StructureDefinition/patient-birthTime">
    <valueDateTime value="1932-09-24T14:35:45-05:00"/>
  </extension>
  <identifier>
    <use value="usual"/>
    <system value="http://acme.org/identifiers/mrn"/>
    <value value="12345"/>
  </identifier>
  <name>
    <family value="Levin"/>
    <given value="Henry"/>
  </name>
  <gender value="male"/>
  <birthDate value="1932-09-24"/>
  <managingOrganization>
    <reference value="Organization/123xyz"/>
    <display value="Good Health Clinic"/>
  </managingOrganization>
  <active value="true"/>
</Patient>
```

- Metadata
- Human Readable Summary
- Extension with reference to its definition
- Standard Data Content:
  - MRN
  - Name
  - Gender
  - Date of Birth
  - Provider

A Resource's identity

- In fact: a URL
  - **`http://server.org/fhir/Patient/1`**



"Business" identifiers

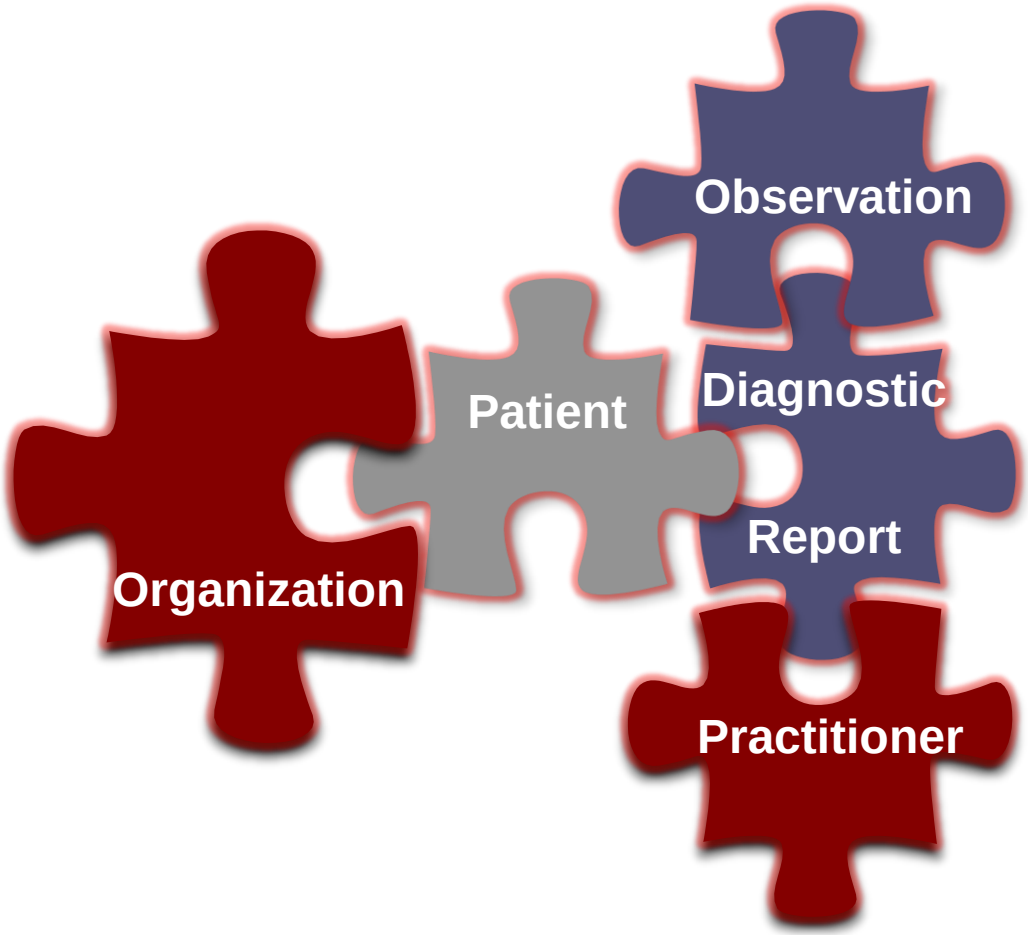
DiagnosticReport (DomainResource)

identifier : Identifier [0..*]
basedOn : Reference [0..*] CarePlan|ImmunizationRecommendation|MedicationRequest|NutritionOrder|ProcedureRequest|ReferralRequest
status : code [1..1] DiagnosticReportStatus!
category : CodeableConcept [0..1] Diagnostic Service Section ??
code : CodeableConcept [1..1] LOINC Diagnostic Report ?
subject : Reference [0..1] Patient|Group|Device|Location
context : Reference [0..1] Encounter|EpisodeOfCare
effective[x] : Type [0..1] dateTime|Period
issued : instant [0..1]
specimen : Reference [0..*] Specimen
result : Reference [0..*] Observation
imagingStudy : Reference [0..*] ImagingStudy|ImagingManifest
conclusion : string [0..1]
codedDiagnosis : CodeableConcept [0..*] SNOMED CT Clinical Findings??
presentedForm : Attachment [0..*]

Patient (DomainResource)

identifier : Identifier [0..*]
active : boolean [0..1]
name : HumanName [0..*]
telecom : ContactPoint [0..*]
gender : code [0..1] AdministrativeGender!
birthDate : date [0..1]
deceased[x] : Type [0..1] boolean|dateTime
address : Address [0..*]
maritalStatus : CodeableConcept [0..1] Marital Status +
multipleBirth[x] : Type [0..1] boolean|integer
photo : Attachment [0..*]
generalPractitioner : Reference [0..*] Organization|Practitioner
managingOrganization : Reference [0..1] Organization

It’s all about combining resources . . .



FHIR

DiagnosticReport			DomainResource
identifier	Σ	0..*	Identifier
subject	Σ	0..1	Reference(Patient | Group | Device | Location)
context	Σ	0..1	Reference(Encounter | EpisodeOfCare)
issued	Σ	0..1	instant
performer	Σ	0..*	BackboneElement
role	Σ	0..1	CodeableConcept
actor	Σ	1..1	Reference(Practitioner | Organization)
specimen		0..*	Reference(Specimen)
result		0..*	Reference(Observation)

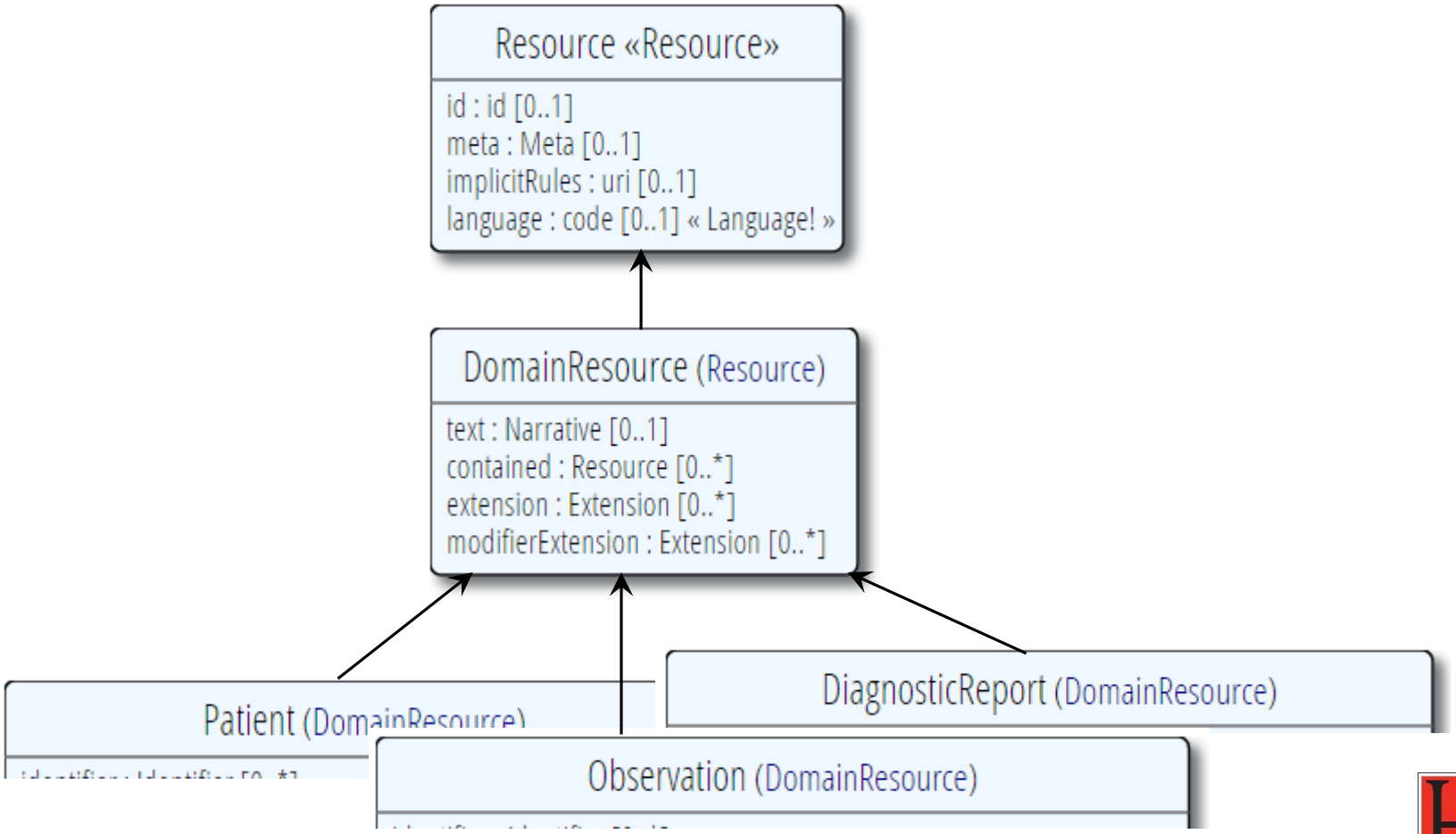
Resource Reference

example snippet taken from a DiagnosticReport:

```
<subject>
  <reference value="Patient/f001"/>
  <display value="P. van den Heuvel"/>
</subject>
```

```
"subject": {
  "reference": "Patient/f001",
  "display": "P. van den Heuvel"
},
```

Technical hierarchy



Communicating resources
(with REST)

create

The create interaction creates a new resource in a server assigned location. The create interaction is performed by an HTTP POST operation as shown:

```
POST [base]/[type] {?_format=[mime-type]}
```

read

The read interaction accesses the current contents of a resource. The interaction is performed by an HTTP GET operation as shown:

```
GET [base]/[type]/[id] {?_format=[mime-type]}
```

update

The update interaction creates a new current version for an existing resource or creates a new resource if no resource already exists for the given id. The update interaction is performed by an HTTP PUT operation as shown:

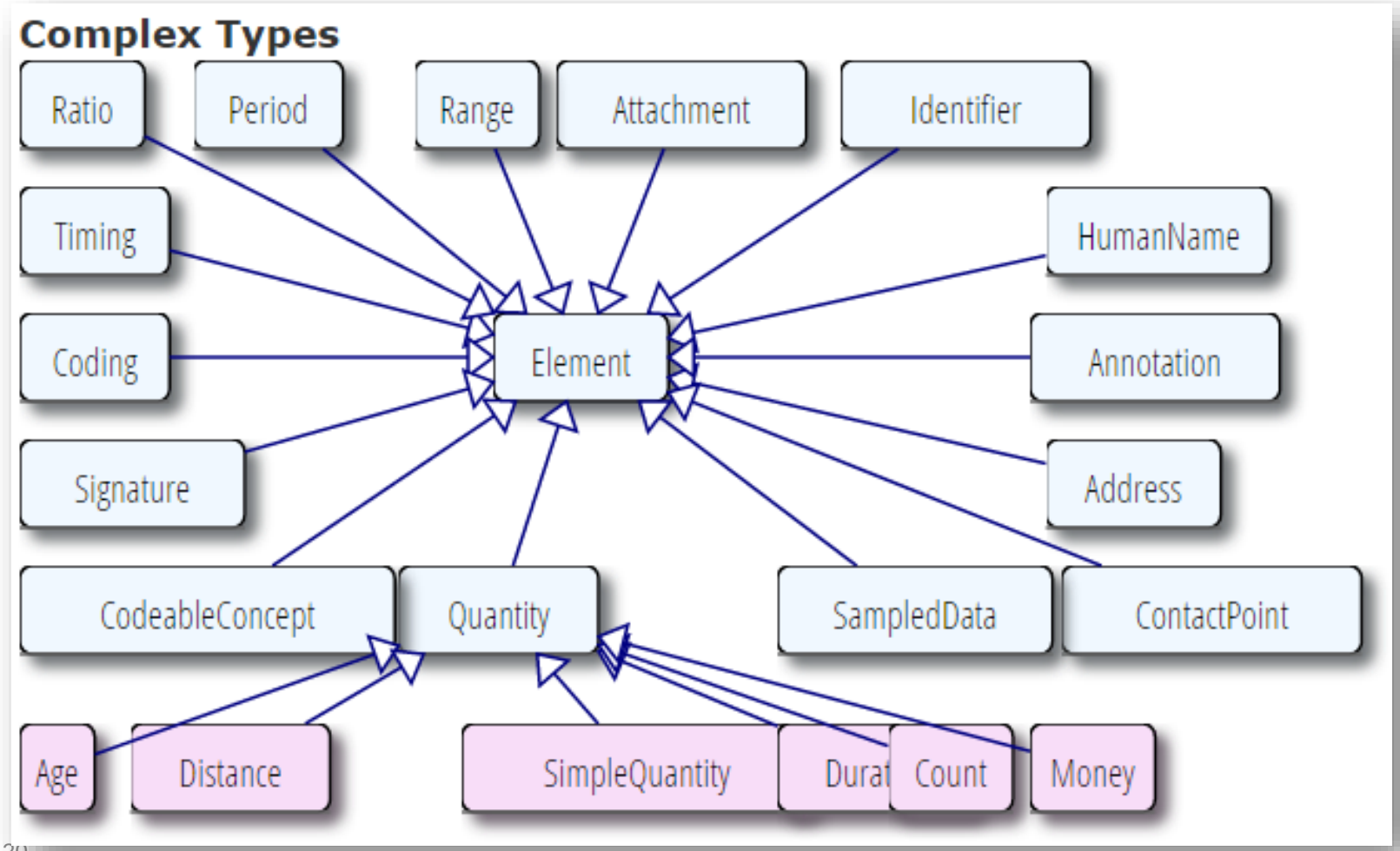
```
PUT [base]/[type]/[id] {?_format=[mime-type]}
```

delete

The delete interaction removes an existing resource. The interaction is performed by an HTTP DELETE operation as shown:

```
DELETE [base]/[type]/[id]
```

Datatypes, complex



Complex Datatypes

Quantity

value : decimal [0..1]
comparator : code [0..1] « QuantityComparator! »
unit : string [0..1]
system : uri [0..1]
code : code [0..1]

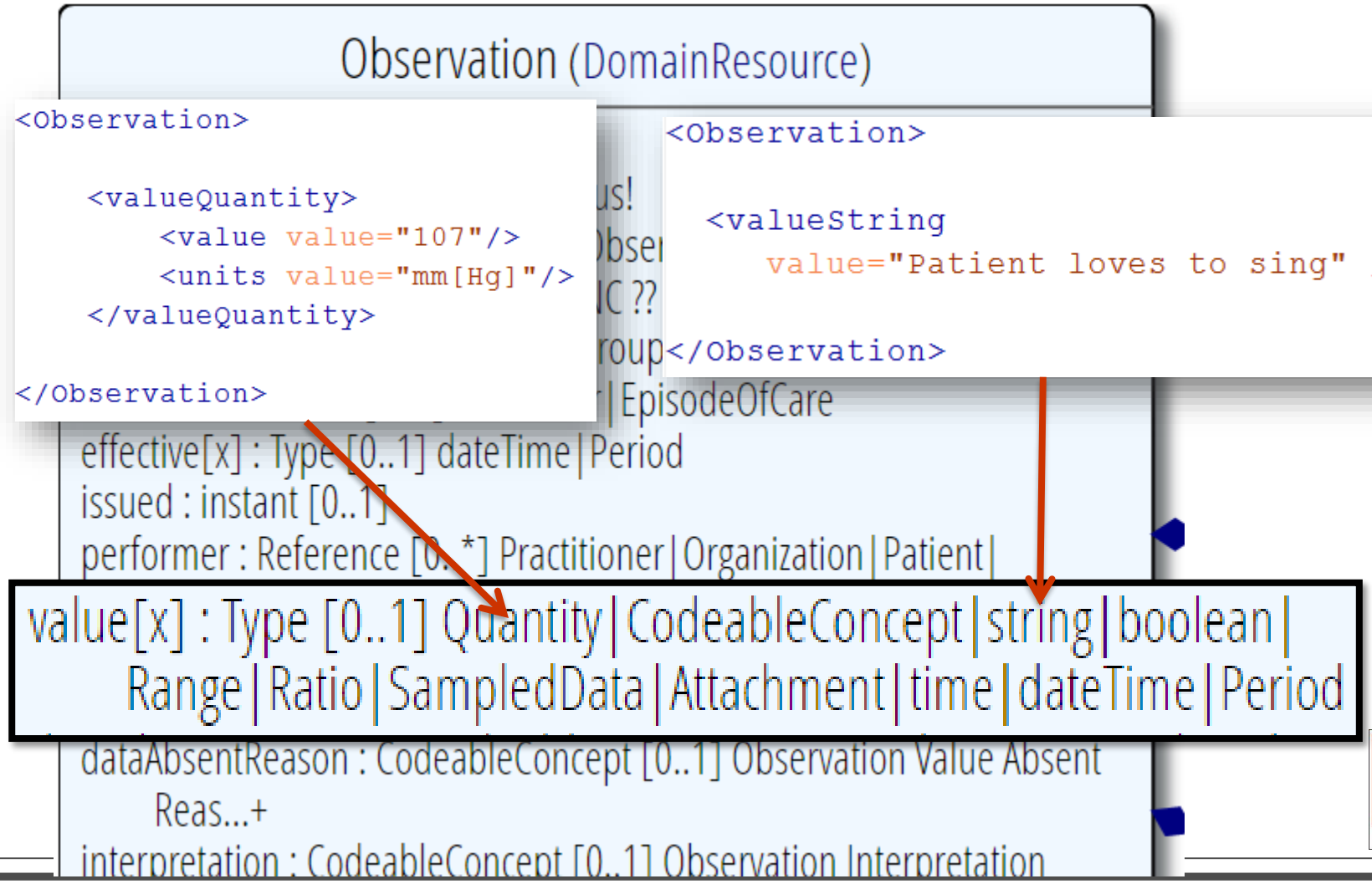
HumanName

use : code [0..1] NameUse!
text : string [0..1]
family : string [0..1]
given : string [0..*]
prefix : string [0..*]
suffix : string [0..*]
period : Period [0..1]

```
<time>
   <value value="25" />
   <unit value="sec" />
   <system value="http://unitsofmeasure.org" />
   <code value="s" />
 </time>
```

```
<name>
  <family value="Everyman" />
  <given value="Adam" />
  <given value="A." />
</name>
```

"Choice" properties



QUESTIONS?

How FHIR communicates sets of resources

BUNDLES

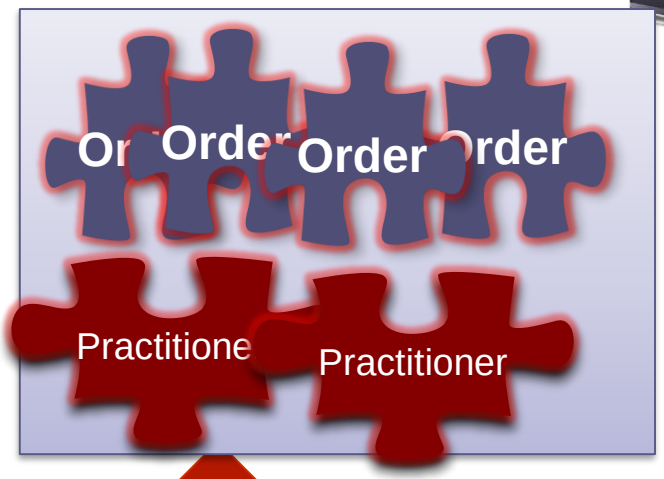
Communicating sets

- We need to communicate sets of Resources
  - Search result
  - History
  - Multiple-resource inserts (“batches”)
  - Transactions

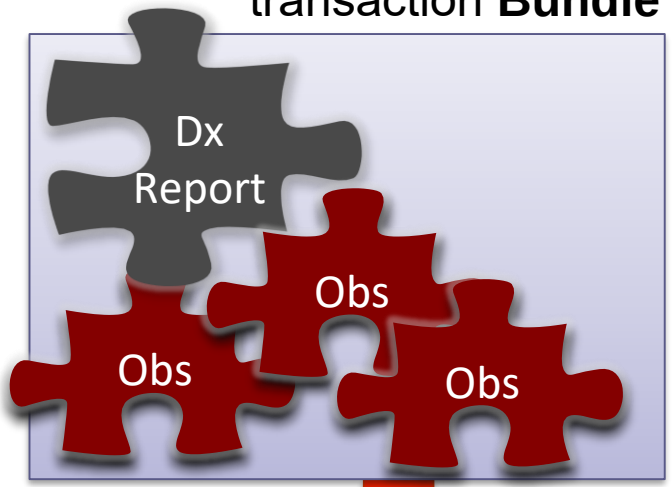
Bundling resources

Lab System

"searchset **Bundle**"



"transaction **Bundle**"



Query
Orders

Post
Lab result

FHIR server

Bundle..is a resource!

2.36 Resource Bundle - Content

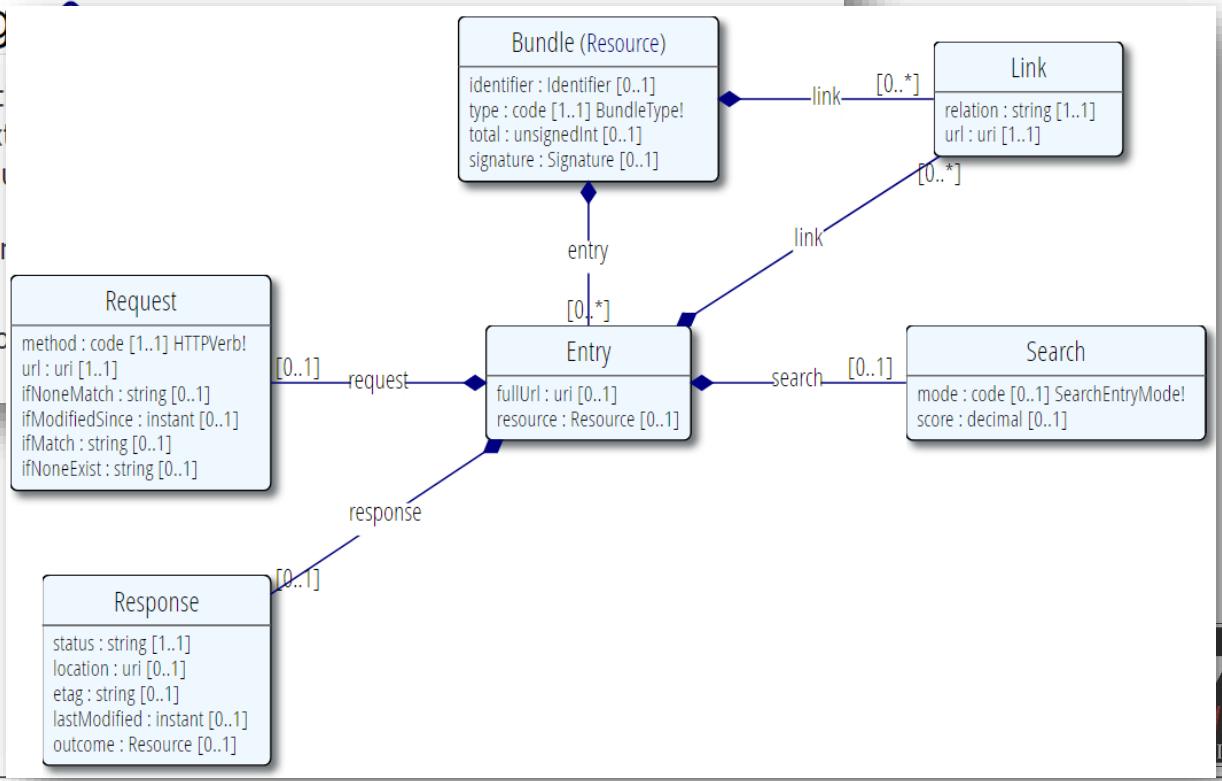
FHIR Infrastructure Work Group	Maturity Level: 5	Trial Use	Compartments: Not linked to any defined compartments

A container for a collection of resources.

2.36.1 Scope and Usag

One common operation performed wit
single instance with containing contex
together. These resource bundles are

- Returning a set of resources that
RESTful Search)
- Returning a set of versions of resc
History)



An example Bundle

```
<Bundle xmlns="http://hl7.org/fhir">
    <id value="urn:uuid:1d2de686-03d8-4451-afc0-193104c3464e" />
    <meta>
        <lastUpdated value="2015-04-26T20:25:15.6271425Z" />
    </meta>
    <type value="searchset" />
    <total value="1" />
    <link>
        <relation value="self" />
        <url value="http://fhir-dstu2-nprogram.azurewebsites.net/Patient/.
    </link>
    <entry>
        <resource>
            <Patient xmlns="http://hl7.org/fhir">
                ...
    </entry>
    <entry>
        <resource>
            <Organization xmlns="http://hl7.org/fhir">
                ...
    </entry>
</Bundle>
```

Link types

Code	Description
current	The URL that defines this item
first	First set of records in a query set
last	Last set of records in a query set
next	Next set of records in a query set
previous	Previous set of records from this one
self	Conveys an identifier for the link's context.

SEARCH FUNCTIONALITY

Basic search

- Syntax

```
GET [base]/[resourcetype]?name=value&...
```

- Getting all patients

```
GET http://acme.org/fhir/Patient
```

- Example:

```
GET http://acme.org/fhir/Patient?name=eve
```

Search parameters

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

Name	Type	Description	Paths
active	token	Whether the patient record is active	Patient.active
address	string	An address in any kind of address/part of the patient	Patient.address
birthdate	date	The patient's date of birth	Patient.birthDate
family	string	A portion of the family name of the patient	Patient.name.family
gender	token	Gender of the patient	Patient.gender
given	string	A portion of the given	Patient.name.given
identifier	token	A patient identifier	Patient.identifier
language	token	Language code (irrespective of use value)	
link	reference	All patients linked to the given patient	
name	string	A portion of either family or given name of the patient	Patient.name

Parameter Type

Our last search used this one

Parameter types

- For each type there are specific prefixes and modifiers

number, date and quantity:
Search for `[param]=gt[value]` retrieves resources where `[param]` has a value greater than `[value]`

```
http://acme.org/fhir/Patient?name:contains=eve
```

Ok I get it…or not?

```
http://server.org/fhir/Patient/                106 hits
http://server.org/fhir/Patient?gender=male      34 hits
http://server.org/fhir/Patient?gender=female    67 hits
```

Total: 34 + 67 = 101

```
http://server.org/fhir/Patient/                106 hits
http://server.org/fhir/Patient?gender=male      34 hits
http://server.org/fhir/Patient?gender=female    67 hits
http://server.org/fhir/Patient?gender:missing=true 5 hits
```

Total: 34 + 67 + 5 = 106

Search result parameters

- Including other resources

```
GET [base]/DiagnosticReport?
    _include=DiagnosticReport:subject:Patient

GET [base]/Patient?
    _revinclude=Observation:subject
```

Source resource type

Parameter of type *reference*

Type of target resource (optional)

Chained searches

- How do I find Observations for a patient, searching using his name?

```
GET [base]/Observation?subject.name=jim
```

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

QUESTIONS?

The APIs

.Net and Java

(more are available)

THE MODEL

```
using Hl7.Fhir.Model;
```

hapi-fhir-structures-dstu3-2.4.jar

org.hl7.fhir.dstu3.model

A FHIR Resource

Name	Flags	Card.	Type	Description & Constraints
Observation	I		DomainResource	Measurements and simple assertions *SHALL only be present if Observation.value[x] is not present* *Component code SHALL not be same as observation code*
identifier		0..*	Identifier	Unique Id for this particular observation
status	?! Σ	1..1	code	registered | preliminary | final | amended + ObservationStatus (Required)
category		0..1	CodeableConcept	Classification of type of observation Observation Category Codes (Example)
code	Σ	1..1	CodeableConcept	Type of observation (code / type) LOINC Codes (Example)
subject	Σ	0..1	Reference(Patient | Group | Device | Location)	Who and/or what this is about
encounter		0..1	Reference(Encounter)	Healthcare event during which this observation is made
effective[x]	Σ	0..1		Clinically relevant time/time-period for observation
effectiveDateTime			dateTime	
effectivePeriod			Period	
issued	Σ	0..1	instant	Date/Time this was made available
performer	Σ	0..*	Reference(Practitioner |	Who is responsible for the observation

A FHIR Resource in C#

```
public partial class Observation : Hl7.Fhir.Model.DomainResource
```

status	?! Σ	1..1	code	registered | preliminary | final | amended + ObservationStatus (Required)

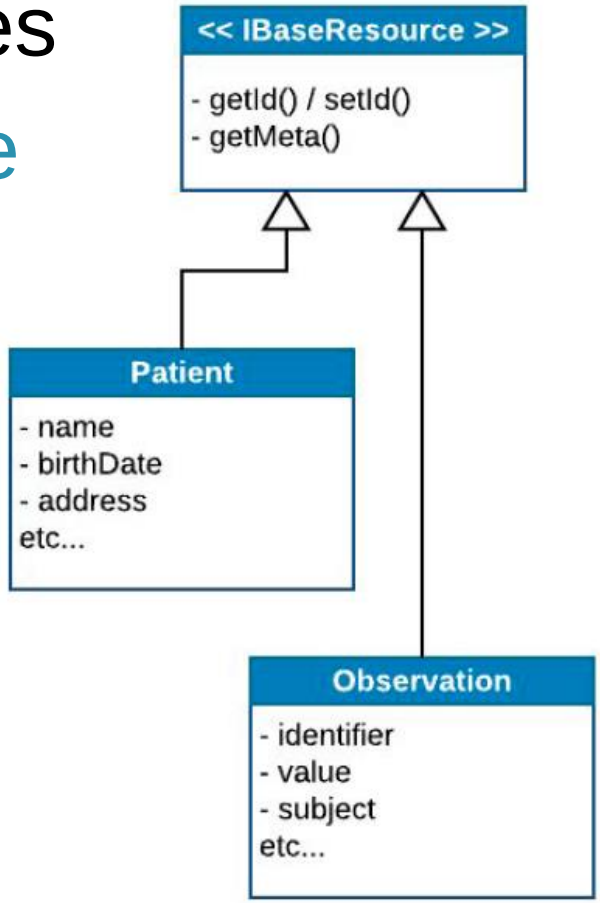
```
/// <summary>
/// Codes providing the status of an observation.
/// (url: http://hl7.org/fhir/ValueSet/observation-status)
/// </summary>
public enum ObservationStatus {Registered, Preliminary, Final, …}
```

```
var obs = new Observation();
obs.Status = Observation.ObservationStatus.Preliminary;
```

A FHIR Resource in Java

Resource definition classes implement IBaseResource

```
// Create a resource instance
Observation obs = new Observation();
obs.setStatus(ObservationStatus.FINAL);
```

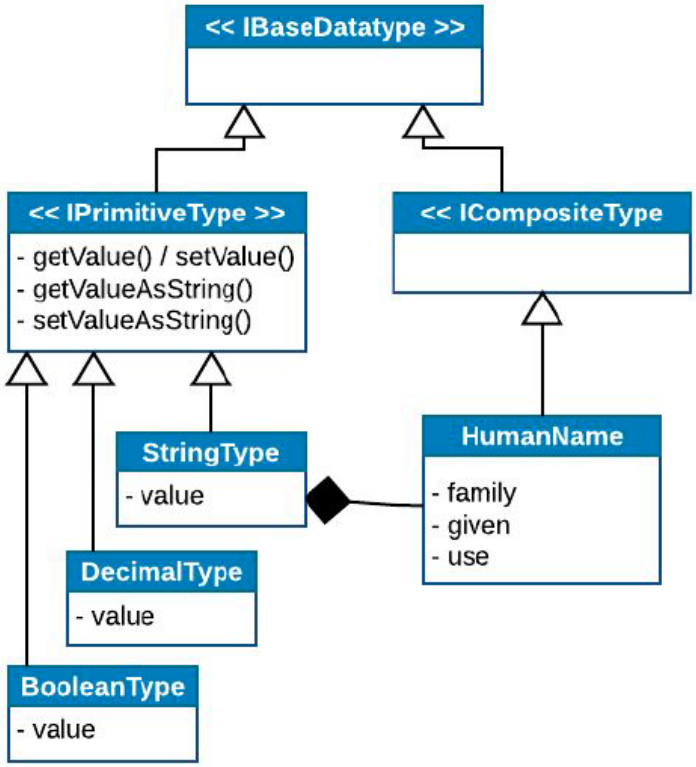


Datatypes (C#)

- Primitive classes are named FhirType
  - For datatypes with same name in C#
- Primitive types include:
  FhirString, FhirBoolean
- Composite types include:
  Address, Ratio, HumanName

Datatypes (Java)

- Primitive classes are named [name]Type
- Primitive types include: StringType, BooleanType
- Composite types include: Address, Ratio, HumanName



Primitives are not really primitive…


```
/// <summary>
/// Whether this patient's record is in active use
/// </summary>
public Hl7.Fhir.Model.Fhi

public bool? Active {  }
```

```
var pat = new Patient();

pat.ActiveElement = new FhirBoolean(true);

pat.Active = true;
```

Patient	setActive(boolean value)
Patient	setActiveElement(BooleanType value)

A FHIR Resource

code	Σ	1..1	CodeableConcept	Type of observation (code / type) LOINC Codes (Example)

```
public CodeableConcept Code { get; set; }
```

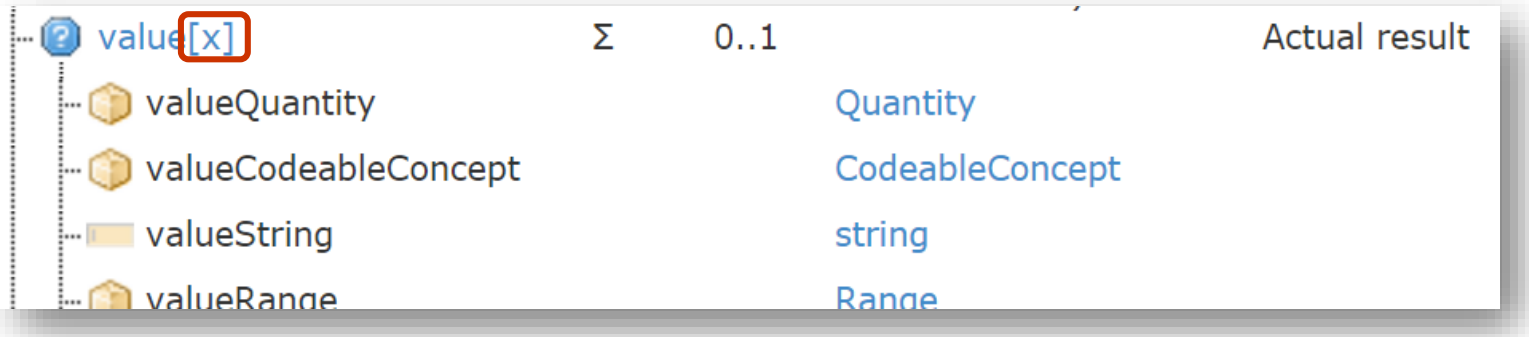
```
Observation                                    setCode(CodeableConcept value)
```

identifier		0..*	Identifier	Unique Id for this particular observation

```
public List<Identifier> Identifier{ get; set; }
```

```
List<Identifier>                               getIdentifier()
```

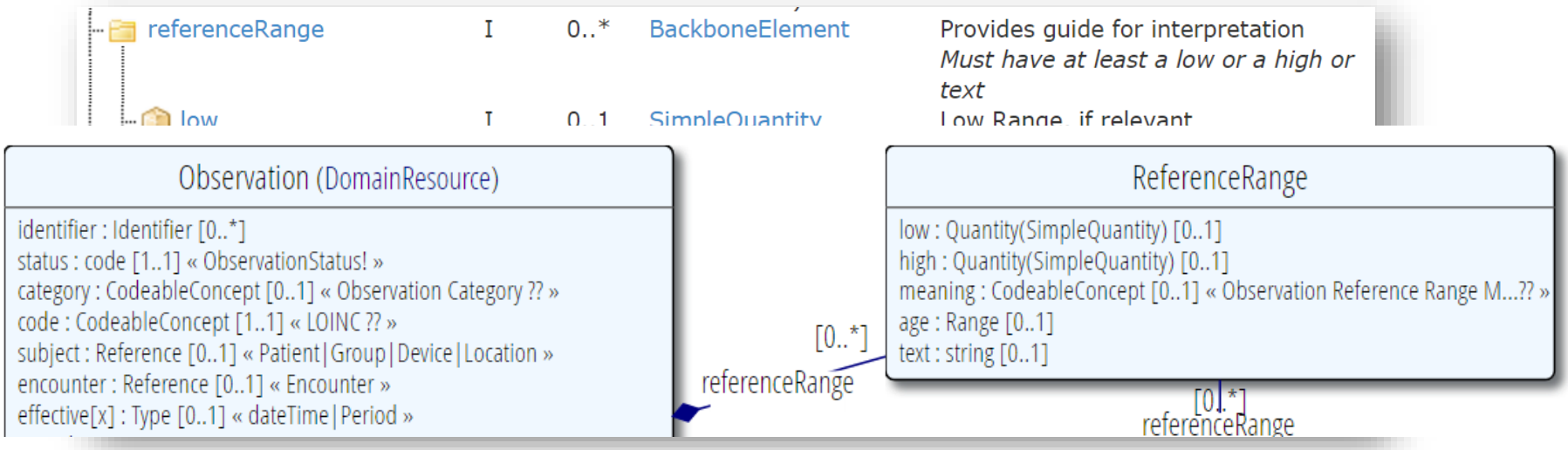
A FHIR Resource in C#




```
public Element Value { get; set;}
```

```
Observation                                    setValue(Type value)
```

A FHIR Resource in C#




```
public partial class ReferenceRangeComponent : BackboneElement
{ … }
```

```
public static class Observation.ObservationReferenceRangeComponent
extends BackboneElement
implements IBaseBackboneElement
```

C# example

```
static void Main(string[] args)
{
    // Create a resource instance
    var pat = new Patient();

    // Add a "name" element
    var name = new HumanName();
    name = name.WithGiven("Homer").WithGiven("J.").AndFamily("Simpson");

    pat.Name.Add(name);

    // Add an "identifier" element
    var id = new Identifier("http://acme.org/MRNs", "7000135");
    pat.Identifier.Add(id);
}
```

Java example

```
1: public class Example01_CreateAPatient {
2:   public static void main(String[] theArgs) {
3:       // Create a resource instance
4:       Patient pat = new Patient();
5:
6:       // Add a "name" element
7:       HumanName name = pat.addName();
8:       name.addFamily("Simpson").addGiven("Homer").addGiven("J");
9:
10:      // Add an "identifier" element
11:      Identifier identifier = pat.addIdentifier();
12:      identifier.setSystem("http://acme.org/MRNs").setValue("7000135");
13:
14:      // Model is designed to be chained
15:      pat.addIdentifier().setSystem("http://acme.org/MRNs").setValue("12345");
16:  }
17: }
```

REST INTERACTIONS

Using the FHIR Client

- See Publicly Available FHIR Servers for available test servers

```
var client = new FhirClient("http://acme.org/fhir");

// client options
client.PreferredFormat = ResourceFormat.Xml;
client.ReturnFullResource = true;
```

Create example C#

```
var pat = new Patient();
pat.Name.Add(new HumanName()
        .WithGiven("Homer").WithGiven("J.").AndFamily("Simpson"));
pat.Identifier.Add(new Identifier("http://acme.org/MRNs", "7000135"));
pat.Gender = AdministrativeGender.Male;

// Create a client
var client = new FhirClient("http://vonk.furore.com");

// Use the client to store a new resource instance
var outcome = client.Create<Patient>(pat);

// Print the ID of the newly created resource
Console.WriteLine(outcome.Id);
```

Create Example Java

```
public static void main(String[] theArgs) {
        Patient pat = new Patient();
        pat.addName().addFamily("Simpson").addGiven("Homer").addGiven("J");
        pat.addIdentifier().setSystem("http://acme.org/MRNs").setValue("7000135");
        pat.setGender(AdministrativeGender.MALE);

        // Create a context
        FhirContext ctx = FhirContext.forDstu3();

        // Create a client
        String serverBaseUrl = "http://fhirtest.uhn.ca/baseDstu3";
        IGenericClient client = ctx.newRestfulGenericClient(serverBaseUrl);

        // Use the client to store a new resource instance
        MethodOutcome outcome = client.create().resource(pat).execute();

        // Print the ID of the newly created resource
        System.out.println(outcome.getId());
```

Read/update/delete example C#

```
var pat = client.Read<Patient>("Patient/1");

pat.Name.Add(new HumanName()
        .WithGiven("Ewout").AndFamily("Kramer"));

client.Update<Patient>(pat);

client.Delete(pat);
client.Delete("Patient/12345");
```

Read/Update example Java

```
// Use the client to read back the new instance using the ID
Patient patient = client.read(Patient.class, "190002");

// Change the gender and send an update to the server
patient.setGender(AdministrativeGender.FEMALE);
MethodOutcome outcome = client.update().resource(patient).execute();
```

Search example C#

```
var q = new SearchParams()
                .Where("name=Ewout")
                .Include("Patient:organization")
                .LimitTo(10)
                .SummaryOnly()
                .OrderBy("birthdate",
                         Hl7.Fhir.Rest.SortOrder.Descending);

q.Add("gender", "male");

Bundle result = client.Search<Patient>(q);
```

Search example Java

```
public static void main(String[] theArgs) {
    FhirContext ctx = FhirContext.forDstu3();
    IGenericClient client = ctx.newRestfulGenericClient("http://fhirtest.uhn.ca/baseDstu3");

    // Log requests and responses (very verbose for testing!)
    client.registerInterceptor(new LoggingInterceptor(true));

    // Build a search and execute it
    Bundle response = client.search()
            .forResource(Patient.class)
            .where(Patient.NAME.matches().value("Test"))
            .and(Patient.BIRTHDATE.before().day("2014-01-01"))
            .count(100)
            .returnBundle(Bundle.class)
            .execute();

    // How many resources did we find?
    System.out.println("Responses: " + response.getTotal());

    // Print the ID of the first one
    System.out.println(response.getEntry().get(0).getResource().getId());
```

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http://fhirtest.uhn.ca/baseDstu3/Patient/82599/_history/1

Paging through Bundle (C# example)

```
while (result != null)
{
  foreach (var e in result.Entry)
  {
    Patient p = (Patient)e.Resource;
    // do something with the resource
  }

  result = client.Continue(result, PageDirection.Next);
}
```

PARSING/SERIALIZING

Parsing/Serializing C#


```
// Create a file-based reader for JSON
JsonTextReader reader =
            new JsonTextReader(new StreamReader(@"input.json"));

var parser = new FhirJsonParser();
var new_obs = parser.Parse<Observation>(reader);

// Serialize an in-memory observation to a JSON string
var jsonText =
       FhirSerializer.SerializeResourceToJson(new_obs);
```

Parsing/Serializing Java

```
// Create a JSON parser
IParser parser = ctx.newJsonParser();
Patient pat = parser.parseResource(Patient.class, resourceBody);

List<Identifier> identifiers = pat.getIdentifier();
String idSystemString = identifiers.get(0).getSystem();
String idValueString = identifiers.get(0).getValue();

System.out.println(idSystemString + " " + idValueString);

parser.setPrettyPrint(true);

String encode = parser.encodeResourceToString(pat);
System.out.println(encode);
```

- Java examples and source: https://github.com/jamesagnew/hapi-fhir/
- Docs: http://hapifhir.io/
- C# source: https://github.com/ewoutkramer/fhir-net-api/
- Starters: https://github.com/furore-fhir/fhirstarters

Exercise

https://github.com/furore-fhir/fhirstarters

- NHS-event folder
  - NHS-exercise.pdf
  - Or try the non-coding exercises:
    F054. REST_excercise.pdf
    and
    F074. Search_excercise.pdf

Events

FH'R Developer Days

Tutorials, guided hackathons, community track

15/17 Nov 2017

http://www.fhirdevdays.com/

The End –
Questions?