FHIR: A Quick Recap (1)

- FHIR offers a model for Healthcare concepts
- For example, Patient:

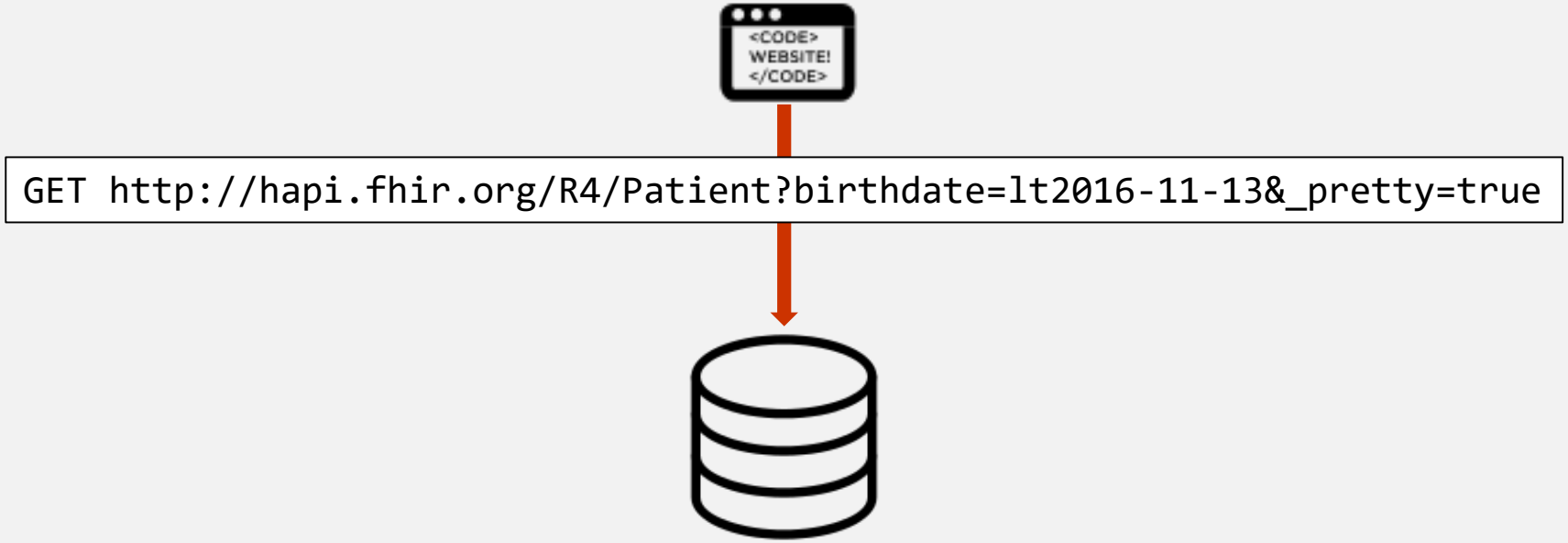
Structure

Name	Flags	Card.	Type	Description & Constraints
Patient			DomainResource	Information about an individual or animal receiving health care services Elements defined in Ancestors: id, meta, implicitRules, language, text, co
identifier	Σ	0..*	Identifier	An identifier for this patient
active	?! Σ	0..1	boolean	Whether this patient's record is in active use
name	Σ	0..*	HumanName	A name associated with the patient
telecom	Σ	0..*	ContactPoint	A contact detail for the individual
gender	Σ	0..1	code	male | female | other | unknown AdministrativeGender (Required)
birthDate	Σ	0..1	date	The date of birth for the individual
deceased[x]	?! Σ	0..1		Indicates if the individual is deceased or not
deceasedBoolean			boolean	
deceasedDateTime			dateTime	
address	Σ	0..*	Address	Addresses for the individual
maritalStatus		0..1	CodeableConcept	Marital (civil) status of a patient Marital Status Codes (Extensible)
multipleBirth[x]		0..1		Whether patient is part of a multiple birth
multipleBirthBoolean			boolean	
multipleBirthInteger			integer	
photo		0..*	Attachment	Image of the patient

FHIR: A Quick Recap (2)

- The standard specifies a RESTful API for interacting with that model
- For example, a search:

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



FHIR: A Quick Recap (3)

- FHIR has had several releases
  - FHIR DSTU1 (Released 2014)
  - FHIR DSTU2 (Released 2015)
  - FHIR R3 (Released 2017)
  - FHIR R4 (Released 2019)

- The concepts from this presentation apply to all versions
- For our purposes: DSTU / STU / R are interchangeable

API background

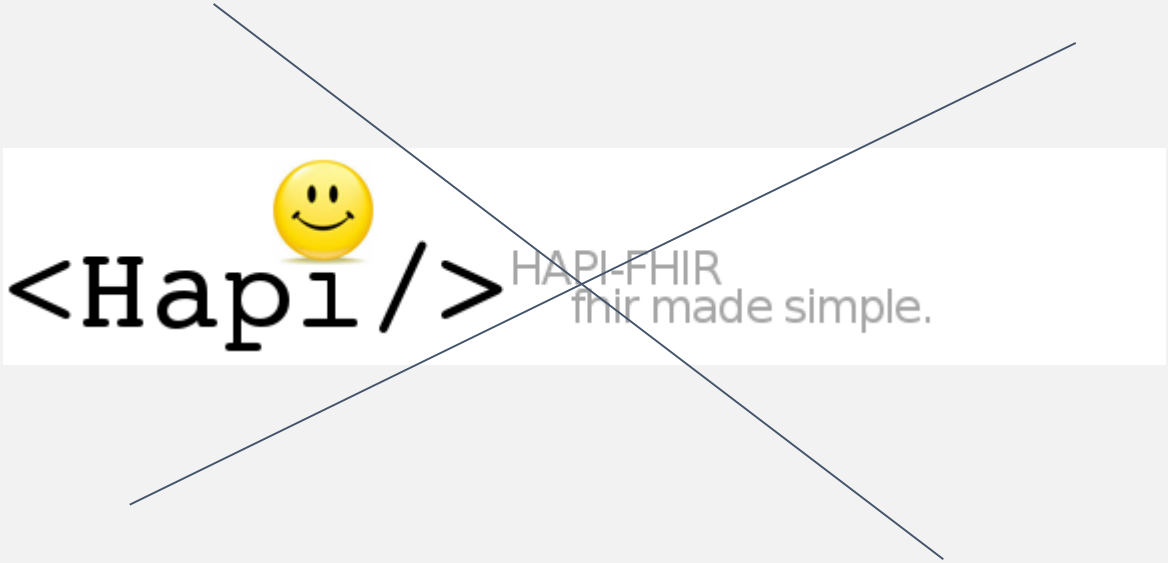
Java

- HAPI started in 2001 as an HL7 v2 Library
- Built to support a simple web portal, now used in applications around the world

HL7 v2 - http://hl7api.sourceforge.net
FHIR - http://hapifhir.io

- HAPI is now the Java Reference Implementation

HAPI FHIR - Meet our new mascot!



The model

Structures JARs

- HAPI supports multiple versions of FHIR via different "structures JARs"

FHIR Version

HAPI Version

Patient Resource Models

hapi-fhir-structures-dstu-2.5.jar

ca.uhn.fhir.model.dstu.resources.Patient

hapi-fhir-structures-dstu2-2.5.jar

ca.uhn.fhir.model.dstu2.resources.Patient

hapi-fhir-structures-dstu3-2.5.jar

org.hl7.fhir.dstu3.model.Patient

hapi-fhir-structures-r4-3.0.0.jar

org.hl7.fhir.r4.model.Patient

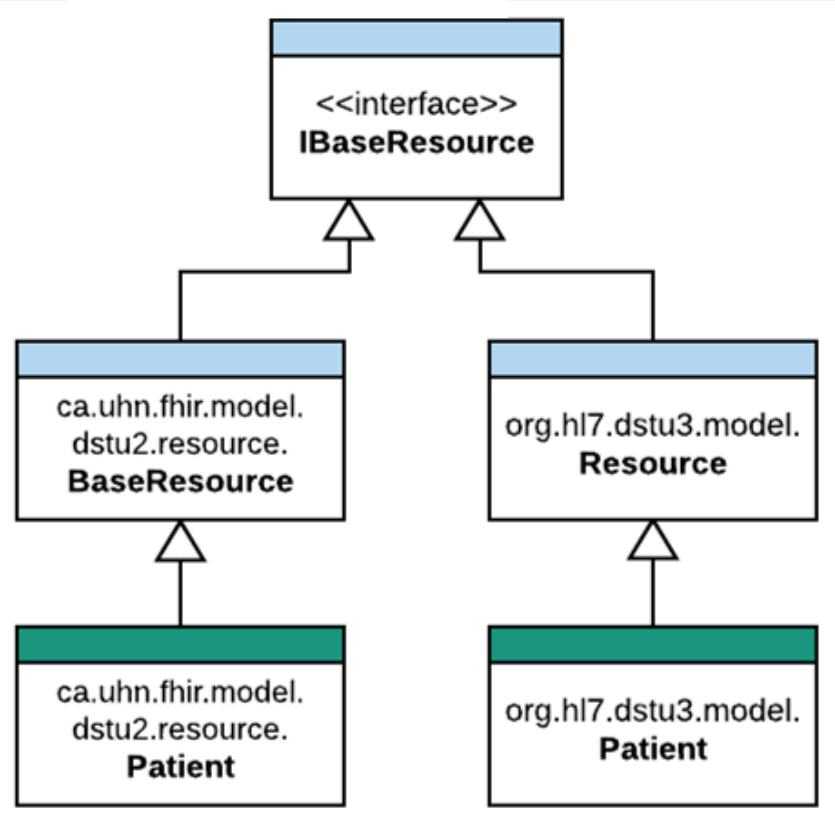
A FHIR resource

Name	Flags	Card.	Type	Description & Constraints
Observation	I		DomainResource	Measurements and simple assertions *+ If code is the same as a component code then the value element associated with the code SHALL NOT be present* *+ dataAbsentReason SHALL only be present if Observation.value[x] is not present* Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extension, modifierExtension
identifier	Σ	0..*	Identifier	Business Identifier for observation
basedOn	Σ	0..*	Reference(CarePlan | DeviceRequest | ImmunizationRecommendation | MedicationRequest | NutritionOrder | ProcedureRequest | ReferralRequest)	Fulfills plan, proposal or order
status	?! Σ	1..1	code	registered | preliminary | final | amended + ObservationStatus (Required)
category		0..*	CodeableConcept	Classification of type of observation Observation Category Codes (Preferred)
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
context		0..1	Reference(Encounter | EpisodeOfCare)	Healthcare event during which this observation is made
effective[x]	Σ	0..1		Clinically relevant time/time-period for observation
effectiveDateTime			dateTime	
effectivePeriod			Period	

A FHIR Resource class in HAPI

- Resource definition classes implement IBaseResource
- Enumerations are available for required value sets

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



Datatypes

In Java

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

In C#

Datatypes example

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

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

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

identifier	Σ	0..*	Identifier	Business Identifier for observation

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

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

Using datatypes

C#

```
// Add an "identifier" element
★ var identifier = new Identifier("http://example.org", "123456");
★ obs.Identifier.Add(identifier);
```

Java

```
// Add an "identifier" element
★ Identifier identifier = obs.addIdentifier();
★ identifier.setSystem("http://example.org").setValue("123456");
```

Primitives are not really primitive…

Patient (DomainResource)

identifier : Identifier [0..*]
active : boolean [0..1]

```
/// <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)

Why would you use the non-primitive version?

```
var name = new HumanName();
```

```
public string Family { get; set; }
```

```
name.Family = "Baltus-Bakker";
```

- Adding extensions cannot be done on primitives!

```
name.FamilyElement.AddExtension(
  "http://hl7.org/fhir/StructureDefinition/humanname-partner-name",
  new FhirString("Baltus"));
```

Choice properties

value[x]	Σ	0..1	Actual result
valueQuantity		Quantity	
valueCodeableConcept		CodeableConcept	
valueString		string	
valueRange		Range	

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

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

Resource components

Observation

referenceRange	I	0..*	BackboneElement	Provides guide for interpretation *Must have at least a low or a high or text*
low	I	0..1	SimpleQuantity	Low Range, if relevant
high	I	0..1	SimpleQuantity	High Range, if relevant
meaning		0..1	CodeableConcept	Indicates the meaning/use of this range of this range Observation Reference Range Meaning Codes (Example)
age		0..1	Range	Applicable age range, if relevant
text		0..1	string	Text based reference range in an observation

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

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

Parsing/serializing

```
using Hl7.Fhir.Serialization;
```

```
import ca.uhn.fhir.context.FhirContext;
```

The context (HAPI)

- The starting point for much of the HAPI-FHIR API is the `FhirContext` class
- FhirContext acts as a factory for the rest of the API, including the two parsers:
  - XmlParser
  - JsonParser
- FhirContext is designed to be created once and reused (important for performance!)

Parsing/serializing example Java

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

```
// 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);
```

Working with REST

```
using Hl7.Fhir.Rest;
```

```
import ca.uhn.fhir.rest.client.api.IGenericClient;
```

REST recap

- FHIR defines basic CRUD operations that can be performed on a FHIR compliant server *(*not a complete list)*

Name	HTTP URL
type create	POST http://base/[type]
instance read	GET http://base/[type]/[id]
instance update	PUT http://base/[type]/[id]
instance delete	DELETE http://base/[type]/[id]
type search	GET http://base/[type]?[params]

Using the FHIR client

- See Publicly Available FHIR Servers for available test servers

C#

```
var client = new FhirClient("https://vonk.fire.ly");
```

Java

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

Clients: Two Distinct Flavours in HAPI FHIR

Annotation

```
public interface SampleClient extends IRestfulClient {

  @Create
  MethodOutcome create(@ResourceParam Patient thePatient);

  @Read
  Patient read(@IdParam IdType theId);

}
```

- You create an annotated interface for your specific needs
- Similar to JAX-RS or Spring REST (but does not use these frameworks)

Generic/Fluent

```
MethodOutcome outcome = client
    .create()
    .resource(pat)
    .execute();
```

- Use chained method calls to do anything you need
- This is generally easier and more popular

Clients: Two Distinct Flavours in HAPI FHIR

Annotation

```
public interface SampleClient extends IRestfulClient {

 @Create
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 @Read
 Patient read(@IdParam IdType theId);

}
```

Docs:
http://hapifhir.io/doc_rest_client_annotation.html

Generic/Fluent

```
MethodOutcome outcome = client
    .create()
    .resource(pat)
    .execute();
```

Docs:
http://hapifhir.io/doc_rest_client.html

Create interaction example Java

```
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());
```

Searching

- FHIR defines a powerful search mechanism
- Searches are specially crafted URLs to express queries such as:
  - Find a Patient with the given Identifier
  - Find all Patients with given gender and DOB
  - Find all lab reports for a given patient identifier with an “abnormal” interpretation
- Searching is powerful!
  - Learn about it at http://hl7.org/fhir/search.html

Searching (2)

- For now, let's imagine a search for a Patient named "Test" whose birthdate is before 2014

```
GET http://fhirtest.uhn.ca/baseDstu3/Patient?name=Test&birthdate=lt2014-05-10
```

Example search in Java

```
// 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

Client interceptors (Java)

- Interceptors "wrap" each client operation and can:
  - Examine outgoing requests before they happen
  - Change outgoing requests before they happen
  - Examine incoming responses after they happen
- Interceptors recently changed and no longer require an interface
  - For example: `BasicAuthInterceptor` and `BearerTokenAuthInterceptor`
    - Add credentials to request
- See http://hapifhir.io/doc_rest_client_interceptor.html

Old Interceptor

```
public class CorsInterceptor extends
InterceptorAdapter {

 @Override
 public boolean incomingRequestPreProcessed(
      HttpServletRequest theRequest,
      HttpServletResponse theResponse) {

   return true;
 }
```

New Interceptor

```
@Interceptor
public class AuthorizationInterceptor {


@Hook(Pointcut.SERVER_INCOMING_REQUE
ST_PRE_HANDLED)
 public boolean checkAuthorization(
        RestOperationTypeEnum theOperation,
       IServerInterceptor.ActionRequestDetails
theProcessedRequest) {
   return true;
 }
```

Questions?

Starter Projects (.NET & HAPI FHIR)

https://github.com/FirelyTeam/fhirstarters

And now for some coding

Grab a quick coffee
and
return for the Let’s Build session!