Oliver Krauss, Andreas Schuler

HL7® FHIR® - Arsonists

14.03.2023 - Wien

Introduction to Fast Healthcare Interoperability Resources - FHIR®

Contact

Oliver Krauss
oliver.krauss@fh-hagenberg.at
+43 (0)50804-27195

Andreas Schuler
andreas.schuler@fh-hagenberg.at
+43 (0)50804-27121

Outline

Outline

New in FHIR®

(for those of who worked on R4)

- Resource becomes ResourceType
- new Datatypes
  - CodeableReference allows coding or reference for same field
  - Medical products, RatioRange, ProductShelfLife, MarketingStatus
- new Resources
  - Subscriptions have been extended
  - Medication drastically refined, now less Resource Types
  - Evidence based medicine, refined

Whats happening in the community?

FHIR® Shorthand

Domain-specific language (DSL) to write FHIR® Implementation Guides. has become normative.

FHIR® GraphQL

Already in R4!

FHIR for FAIR - Findable, Accessible, Interoperable and Reusable

Guidelines for preparation of data sets → IG see `FHIRforFAIR`

CDA IG in FHIR

End of the PDF standards `http://hl7.org/cda/stds/core/draft1/`

Maturity Levels

- CapabilityStatement 3 N
- StructureDefinition 5 N
- ImplementationGuide 1

- Numbers beside the resources in documentation:

Level:

- Details: https://www.hl7.org/fhir/resource.html#maturity
- 0 = Resource has been defined and published
- 1 = The Working Group (WG) has released the resource for implemenation (now it's in documentation)
- 2 = Resource has been successfully tested and exchanged between at least 3 different systems at a Connectathon
- 3 = DSTU-Quality-Guidelines and has been balloted
- 4 = Has been tested in multiply prototypes and released by the WG
- 5 = Has been implementdd in at least 2 countries and 5 different systems
- Normative = Working Group and FHIR® Management Group (FMG) provided Ballot, and normative ballot passed successful

FHIR® Roadmap

R4 Q3—4 2018

Extensions, Normative, country-specific profiles

R4B Mai 2022

Higher maturity, smaller changes to resouces and datatypes

R5++

Every 18 Months - Normative, ”soon” (since 2019)

Argonaut

Own STU Versioning

Current Topics:

- IHE profiles (!= FHIR® profiles)
  - ATNA on FHIR → Audit Trail and Node Authentication
  - MHD → Mobile access to Health Documents
  - MHDS → Mobile Health Document Sharing
  - mACM → Mobile Alert Communication Management
  - mCSD → Mobile Care Service Discovery
  - mXDE → Mobile Cross-Enterprise Data Extraction
  - MMA → Mobile Medication Administration
  - mRDF → Mobile Retrieve Form for Data Capture
- In workshop:
  - Profiles as developer
  - ImplementationGuide as developer
  - Operations framework

Outline

FHIR® Profiling

Motivation

- 80/20 rule
  - 80% are modeled through FHIR®
  - 20% through extensions
- Many different use cases in healthcare
  - Basic set of resources and operations
  - Extensions of the FHIR® specification to model specific use cases

FHIR® Profiling

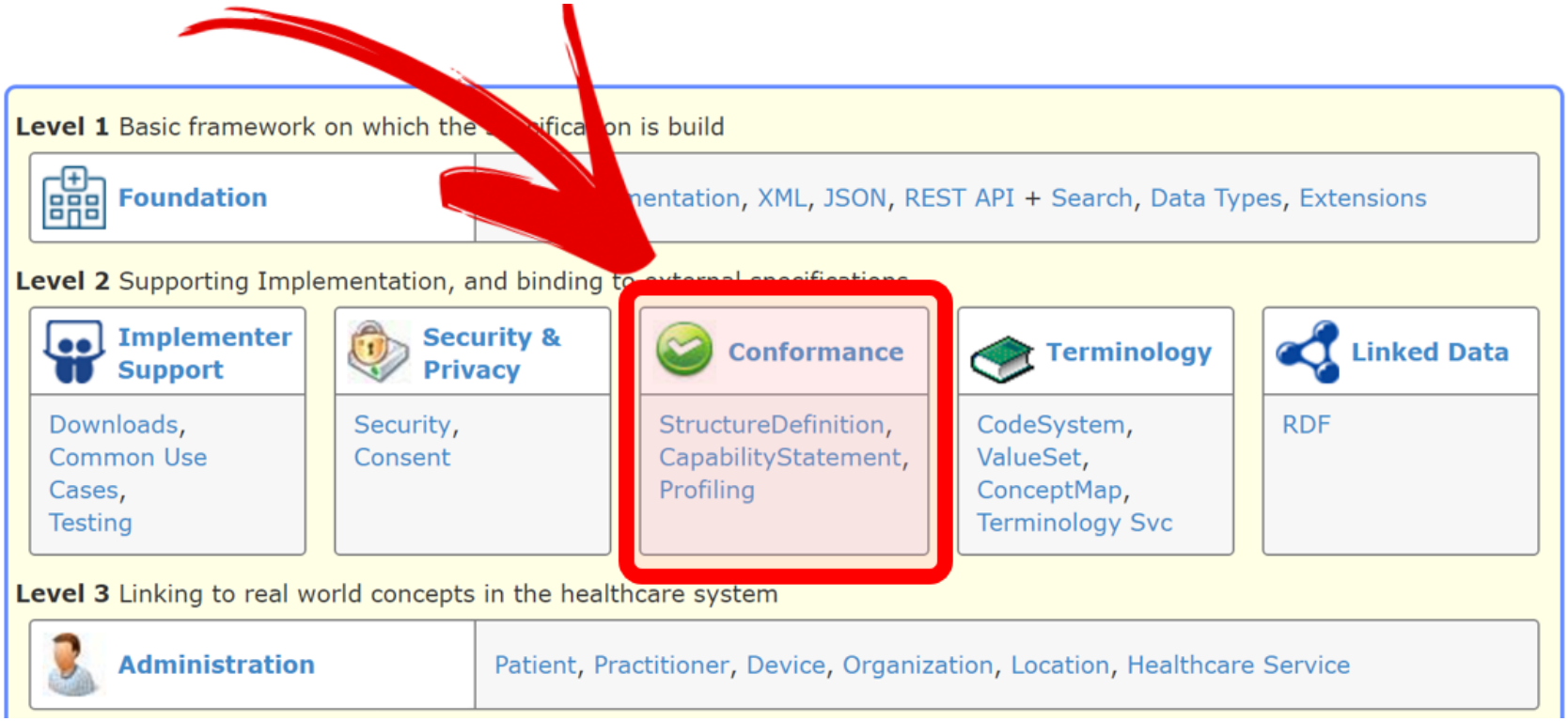
Goals

- What to use profiles for?
- Describe use cases and contexts based on the FHIR® base resources
  - Structured description
  - Machine-recognizable
  - Requirement for resource-validation
  - Available through releases in public repositories

Outline

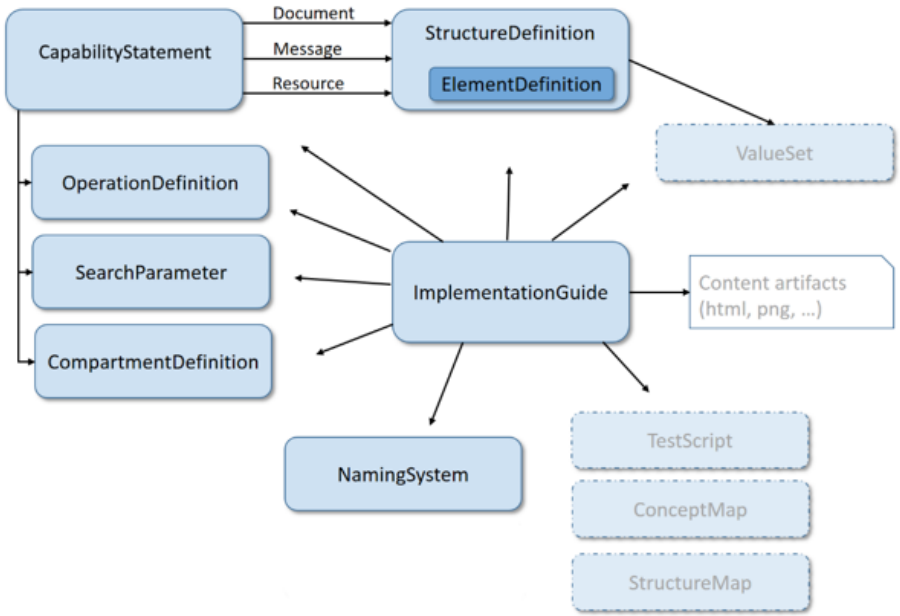
What is it about?

- The Conformance Module contains resources for
  - Metadata of data types and resources
  - Definition of API features of the FHIR® specification
- Is used to extend the base specification



Resources

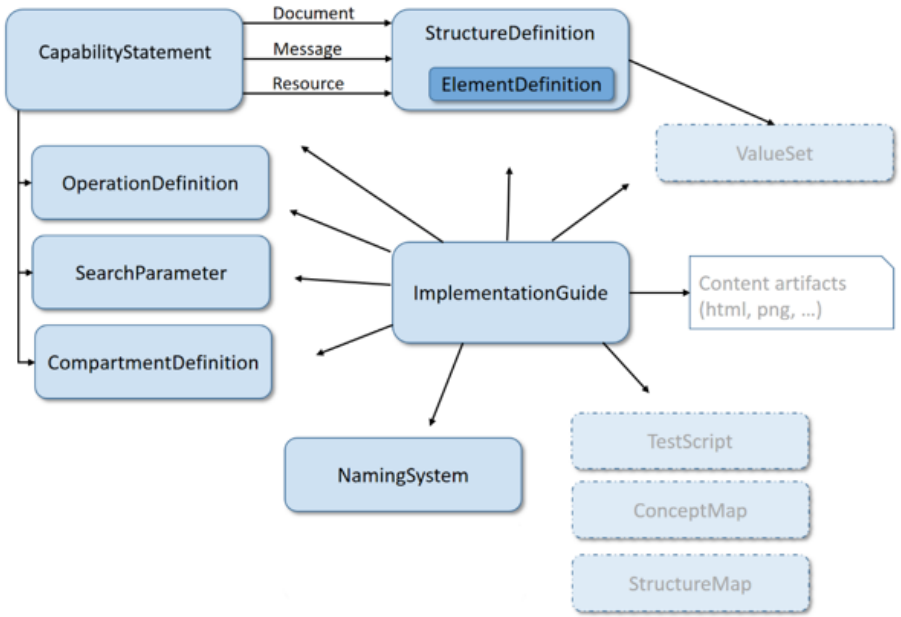
- CapabilityStatement
- StructureDefinition
- ImplementationGuide
- SearchParameter
- MessageDefinition
- OperationDefinition
- Compartment Definition
- StructureMap
- GraphDefinition
- DataElement



[1]

Content of this workshop

- CapabilityStatement
- StructureDefinition
- ImplementationGuide
- SearchParameter
- MessageDefinition
- OperationDefinition
- CompartmentDefinition
- StructureMap
- GraphDefinition
- DataElement



[1]

Outline

CapabilityStatement

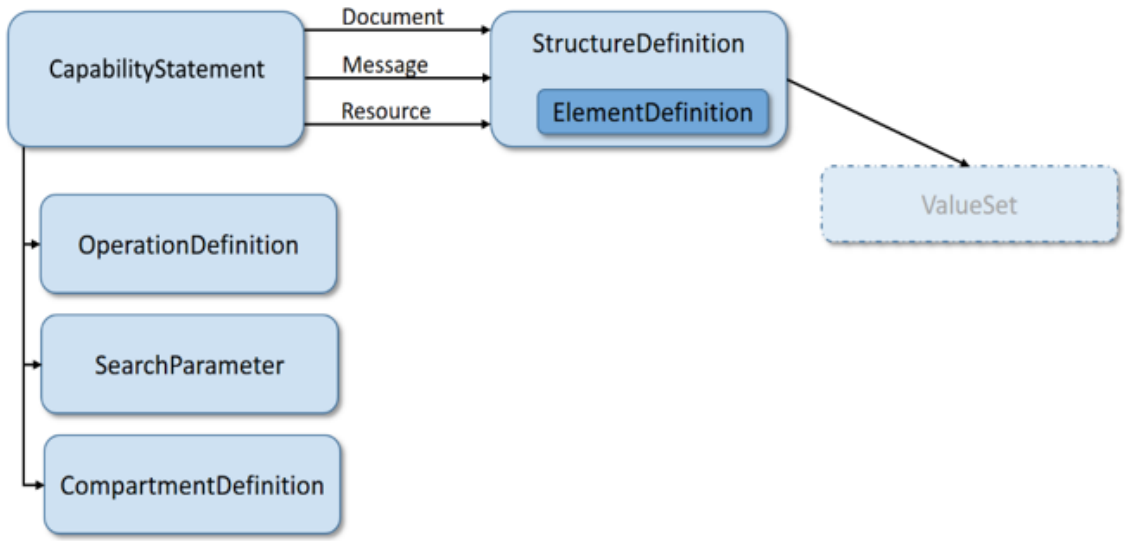
- To describe a behaviour and the functionality of a specific FHIR®server
  - UC1: Which functionality does the FHIR®server provide
  - UC2: To describe a software solution
  - UC3: To define what a specific implementation should accomplish

Information

CapabilityStatement is not a completely new resouce. In fact the resouce ConformanceStatement was reneamed to CapabilityStatement.

CapabilityStatement

- A CapabilityStatement consists of
  - `StructureDefinition` (Profile)
    - Documents
    - Messages
    - Resources
  - `OperationDefinition`
  - `SearchParameter`
  - `CompartmentDefinition`



[1]

CapabilityStatement

- Example: Request CapabilityStatement

GET [base]/metadata

```
{
  "resourceType": "CapabilityStatement",
  "status": "active",
  "date": "2017-03-14T12:48:07-04:00",
  "publisher": "Not provided",
  "kind": "instance",
   ...
}
```

Outline

Benefit

- Logical clustering of resources

CompartmentDefinitions provide

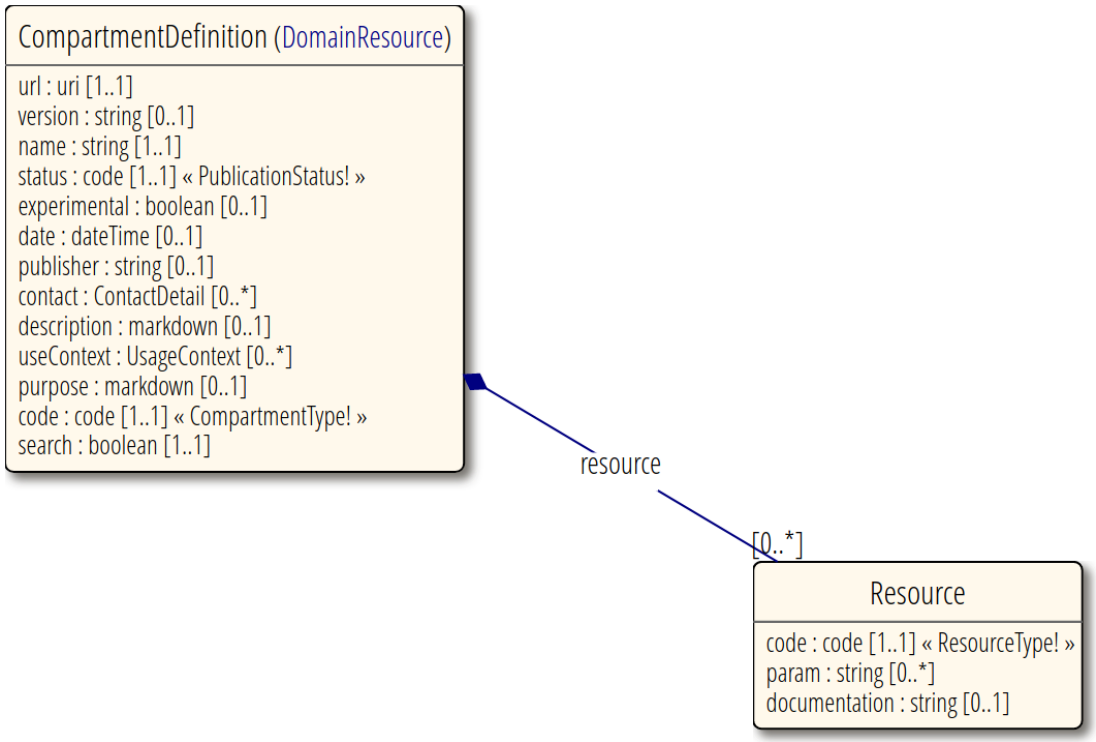
- fast access to sets of resources
- the basis for a fast implementation of access controls for resources

Note

At present, CompartmentDefinitions can only be defined by HL7 International. This is because their existence creates significant impact on the behavior of servers.[2]

Defined Resources

- Patient
- Encounter
- RelatedPerson
- Practitioner
- Device



Usage of CompartmentDefinition

Example 1 easy

- Query all `Observations` of a patient

  GET [base]/Patient/[id]/`Observation`

  corresponds to `CompartmentDefinition`

  GET [base]/Observation?subject=[id]

  GET [base]/Observation?performer=[id]

Outline

Applicaton Areas of StructureDefinition

- Areas of application of a `StructureDefinition` are defined with these elements
  - `kind`
  - `type`
  - `baseDefinition`
  - `url`

```
{
  "url": the identity of this structure definition,
  "kind": (complex-type | resource),
  "type": the type being constrained (if it's a constraint)
  "baseDefinition": the structure definition from which this is derived
}
```

Definition of a Datatype

Example 2 easy

- Definition of a new datatype
- `Element` is used as `baseDefinition`

```
{
  "resourceType": "StructureDefinition",
  "url": "http://hl7.org/fhir/StructureDefinition/Quantity",
  "name": "Quantity",
  "kind": "complex-type",
  "baseDefinition": "http://hl7.org/fhir/StructureDefinition/Element"
}
```

Definition of a Datatype (ConstrainedType)

Example 3 easy

- Definition of a new datatype based on an existing one
- as `baseDefinition` the respective datatype is used. In this case this is `Quantity`

```
{
  "resourceType": "StructureDefinition",
  "url": "http://hl7.org/fhir/StructureDefinition/Money",
  "name": "Money",
  "kind": "complex-type",
  "type": "Quantity",
  "baseDefinition": "http://hl7.org/fhir/StructureDefinition/Quantity"
}
```

Definition of a Resource

Example 4 easy

- Definition of a new resource
- `baseDefinition` uses `DomainResource`

```
{
  "resourceType": "StructureDefinition",
  "url": "http://hl7.org/fhir/StructureDefinition/Patient",
  "name": "Patient",
  "kind": "resource",
  "baseDefinition": "http://hl7.org/fhir/StructureDefinition/DomainResource"
}
```

Definition of a Resource (Constrained Resource)

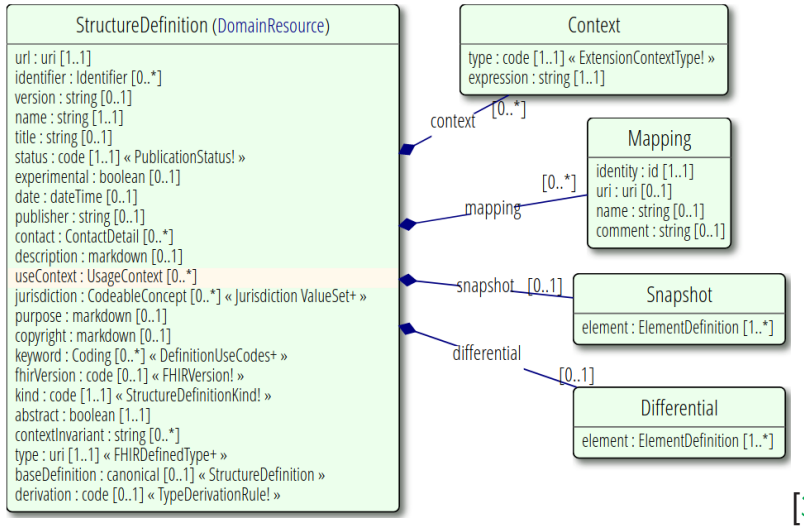
Example 5 easy

- Definition of a new resource
- `baseDefinition` uses any base resource e.g. `Patient`

```
{
  "resourceType": "StructureDefinition",
  "url": "http://hl7.org/fhir/StructureDefinition/clinicaldocument",
  "name": "Clinical Document Profile for Composition",
  "kind": "resource",
  "type": "Composition",
  "baseDefinition": "http://hl7.org/fhir/StructureDefinition/Composition"
}
```

Creation of a StructureDefinition I

- Creation of a profile on the basis of the resource `StructureDefinition`
  - Describes the structure of a resource or data type
  - Contains the element-definitions of a resource or data type
- Identity through a unique canonical URL
  - =Address where to find the profile
  - Example:`http://hl7.org/fhir/StructureDefinition/Patient`



[3]

Creation of a StructureDefinition II

- Example 6 easy
  - Creation of a StructureDefinition for *AustrianPatient*
  - On the basis of the *Patient* profile

Element	Value
name	AustrianPatient
url	http://aist.hagenberg.at/AustrianPatient

- Various possibilities
  - Create the XML file manually
  - With Forge by Firely
  - With SUSHI

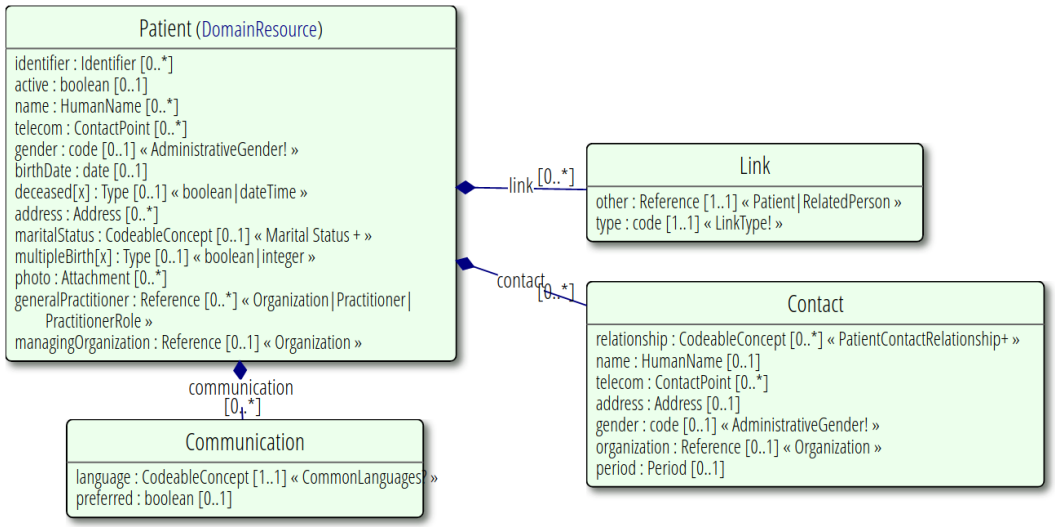
Creation of a StructureDefinition III

– Result of example 6 easy

```
<StructureDefinition xmlns="http://hl7.org/fhir">
  ...
  <url value="http://aist.hagenberg.at/AustrianPatient"/>
  <name value="AustrianPatient"/>
  <status value="draft"/>
  ...
  <kind value="resource"/>
  <constrainedType value="Patient"/>
  <abstract value="false"/>
  <base value="http://hl7.org/fhir/StructureDefinition/Patient"/>
  <differential>
    ...
  </differential>
</StructureDefinition>
```

Change of Cardinalities I

- Elements of a resource entail a data type and a cardinality
- The cardinality determines how often (minimum/maximum) a specific element may occur
- Concerning cardinality
- `StructureDefinition` enables change of cardinalities of resources



[4]

Change of Cardinalities II

- Example 7 easy
  - The **AustrianPatient** has to hold at least three **identifier**
  - The **AustrianPatient** may hold various **identifier** -elements

Information

Cardinalities can only get restricted, meaning that an existing cardinality can't be extended in minimum, nor in maximum direction.
See the open-closed principle of object-oriented coding languages:
"Modules should be both open (for extension) and closed (for modification)."

Change of Cardinalities III

- Result of example 7 easy

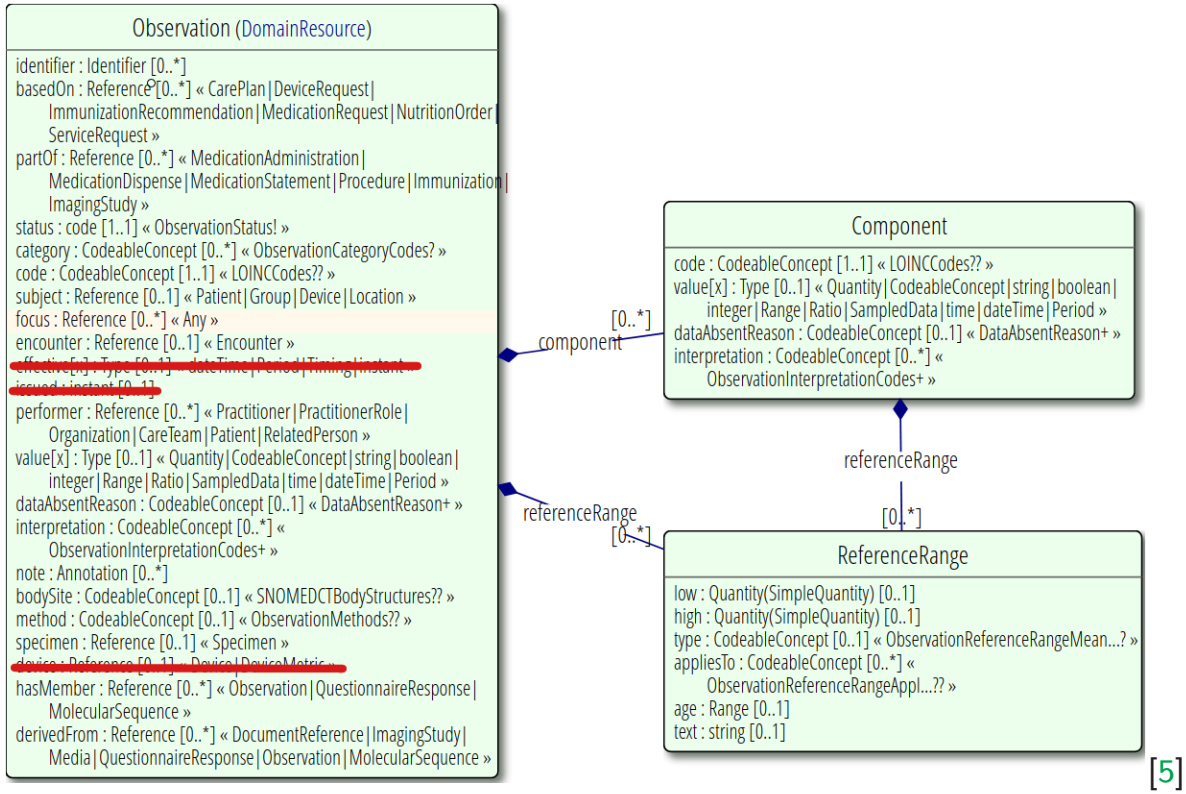
```
...
<element>
  <path value="Patient.identifier"/>
  <min value="3"/>
  <max value="*"/>
   <base>
     <path value="Patient.identifier"/>
     <min value="0"/>
     <max value="*"/>
    </base>
   <type>
<code value="Identifier"/>
  </type>
  <isSummary value="true"/>
</element>
...
```

New cardinality

Cardinality of the basis **(Patient Profile)**

Remove Elements I

- The elements of a resource can get removed
- Set the maximum cardniality of the element to '0'

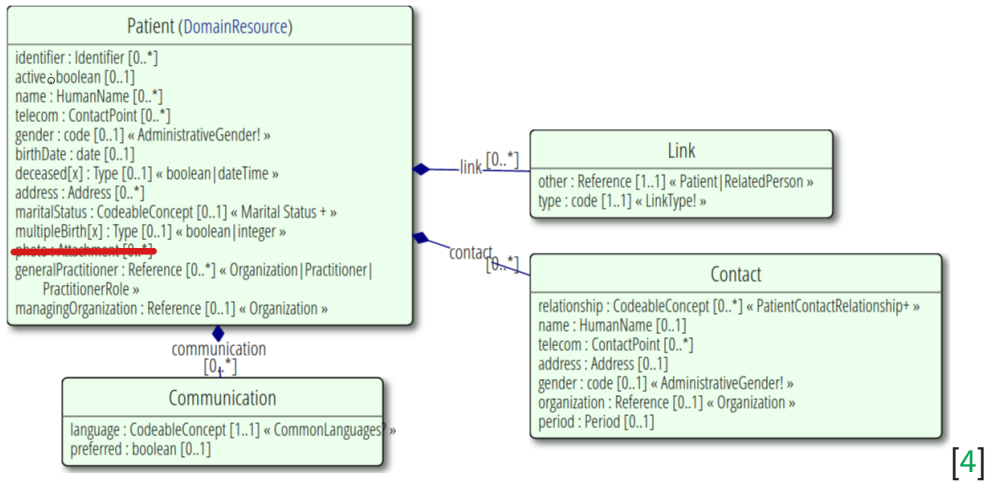


[5]

Remove Elements II

- Example 8 **easy**

  - The element *photo* should get removed for the AustrianPatient



[4]

Information

Once elements are marked as removed in a profile, it's not possible to use them again in a derived profile!

Remove Elements III

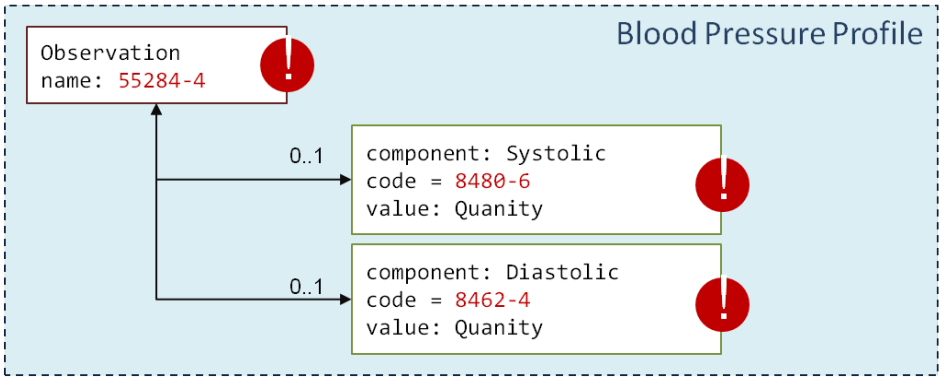
- Result of example 8 easy

Patient.photo (0..0)

```
...
<path value="Patient.photo"/>
<min value="0"/>
<max value="0"/>
<base>
  <path value="Patient.photo"/>
  <min value="0"/>
  <max value="*"/>
</base>
<type>
  <code value="Attachment"/>
</type>
...
```

Set Fixed Values I

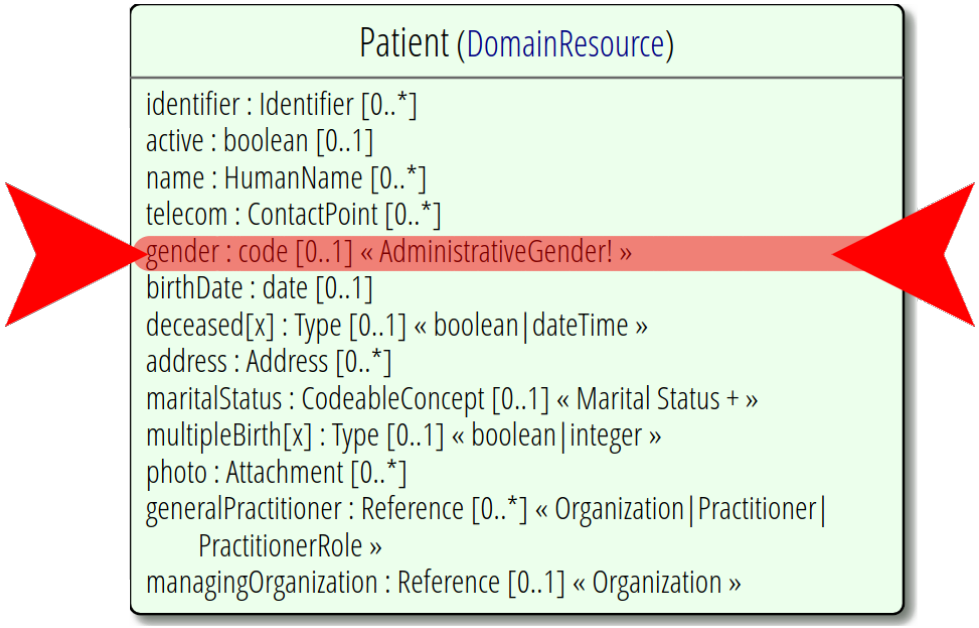
- Assign a fixed value to an element via **StructureDefinition**
- Scope of application:
  - Set a fixed value of Observations codes to model a blood pressure monitor



Set Fixed Values II

- Example 9 easy

  - What changes need to be made in the profile **AustrianPatient** , if the code of the element **gender** should be set to fixed value `female`?



[4]

Set Fixed Values III

– Result of example 9 easy

```
...
<element>
  <path value="Patient.gender"/>
  <min value="0"/>
  <max value="1"/>
  <base>
    <path value="Patient.gender"/>
    <min value="0"/>
    <max value="1"/>
  </base>
  <type>
    <code value="code"/>
  </type>
  <fixedCode value="female"/>
  <isSummary value="true"/>
  <binding>
    <strength value="required"/>
    <description value="The gender of a person used for
          administrative purposes."/>
    <valueSetReference>
      <reference value="http://hl7.org/fhir/ValueSet/
      administrative-gender"/>
    </valueSetReference>
  </binding>
</element>
...
```

Code female comes from this ValueSet.

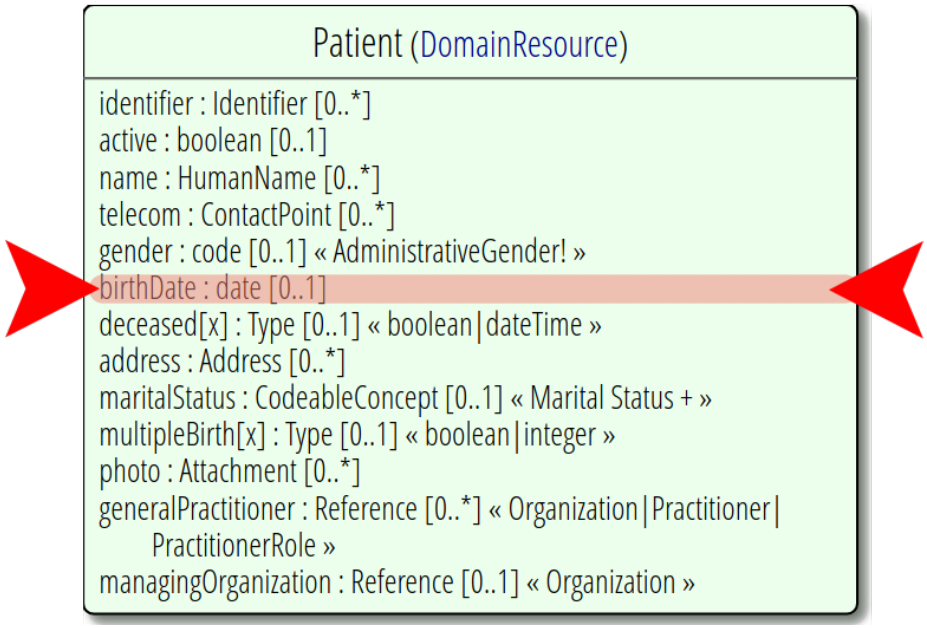
Define Element-Constraints I

- It's possible to define any constraints on elements
- To do this, XPath 2.0 expressions are used in DSTU2
- Since STU-3 an additional field allows the use of FHIRPath
- A constraint must provide the following elements
  - `key` : A unique key
  - `severity` : Declaration of a sevirity level (`ConstraintSeverity`)
  - `human` : A human-readable description
  - `xpath` : A valid XPath expression

Define Element-Constraints II

- Example 10 moderate

  - Define a constraint on **AustrianPatient** 's element **birthDate** to prohibit future birthdates



[4]

Define Element-Constraints III

– Result of example 10 moderate

```
<element>
  <path value="Patient.birthDate"/>
  <min value="0"/>
  <max value="1"/>
  <base>
    <path value="Patient.birthDate"/>
    <min value="0"/>
    <max value="1"/>
  </base>
  <type>
    <cod
  </type
  <constraint>
    <key value="key_check_birthdate"/>
    <severity value="error"/>
    <human value="check for correct birthdate"/>
    <expression value="/f:Patient/f:birthDate &lt;=current-date()"
          />
  </constraint>
<isSummary value="true"/>
...
</element>
```

XPath is dead, long live Fh n!

Fluent-Path

Define Element-Constraints IV

– Result of example 10 moderate

```
<element>
  <path value="Patient.birthDate"/>
  <min value="0"/>
  <max value="1"/>
  <base>
    <path value="Patient.birthDate"/>
    <min value="0"/>
    <max value="1"/>
  </base>
  <type>
    <cod
  </type>
  <constraint>
    <key value="key_check_birthdate"/>
    <severity value="error"/>
    <human value="check for correct birthdate"/>
    <xpath value="/f:Patient/f:birthDate &lt;=current-date()"/>
  </constraint>
<isSummary value="true"/>
...
</element>
```

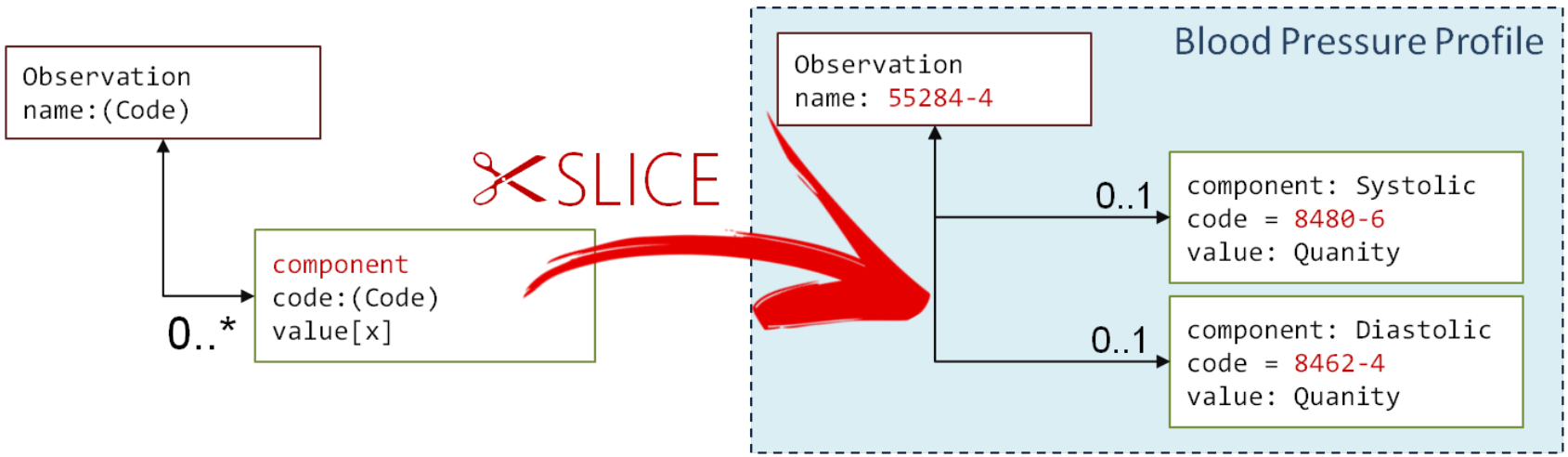
Since STU3 xPath OR expression

Slicing I

- In many cases resources contain elements that can appear more than once
  - The base profile of the Patient resource allows a list of **Patient.identifier (0..*)**
- Slices enable separating multiple occuring elements (lists) into sub-lists (**Slices**).
- Every Slice has different restrictions concerning
  - permitted elements
  - as well as constraints concerning data type, cardinality, allowed codes, ...
- One Slice retains additional semantics depending on one specific use case

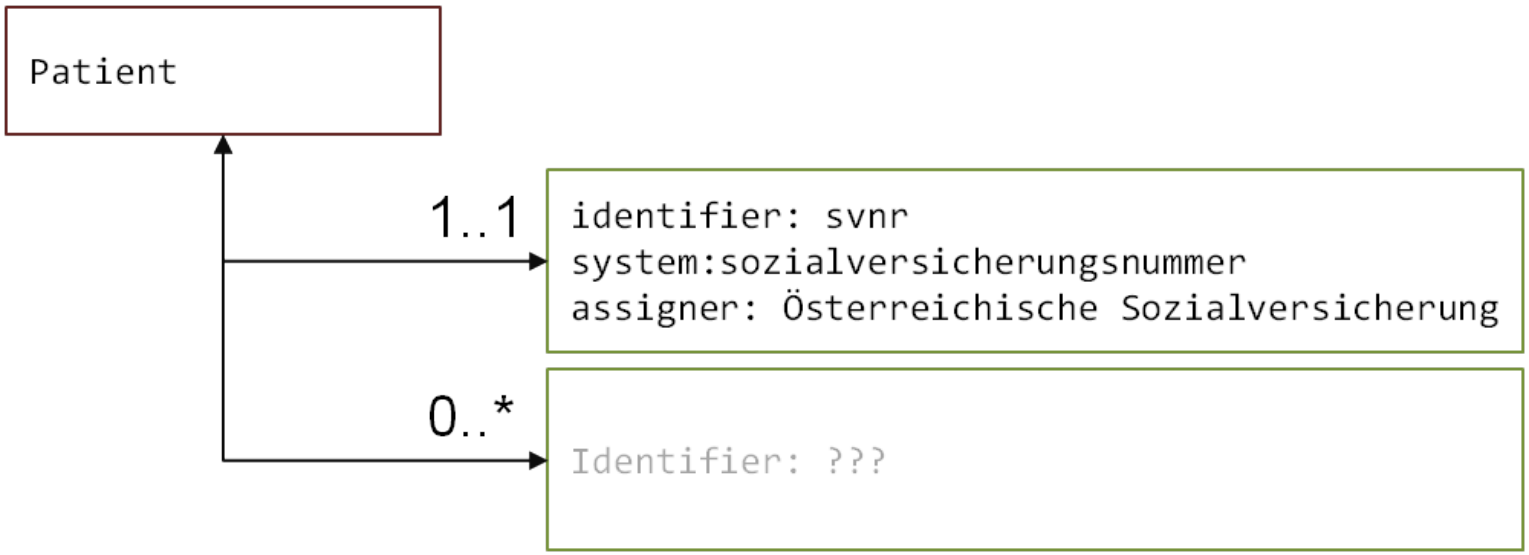
Slicing II

- Example: Blood Pressure Observation
  - One **Slice** is created for systolic and diastolic blood pressure each
  - The Slices are defined in the profile



Slicing III

- Example 11 **hard**
  - In future the AustrianPatient should also include a national insurance number
  - Adding further Patient.identifier elements should still be possible



Slicing IV

- Example 11 hard
  - Behavior of Slicing is defined in a seperate ValueSet `SlicingRules`

Code	Display	Definition
closed	Closed	No additional content is allowed other than that described by the slices in this profile.
open	Open	Additional content is allowed anywhere in the list.
openAtEnd	Open at End	Additional content is allowed, but only at the end of the list. Note that using this requires that the slices be ordered, which makes it hard to share uses. This should only be done where absolutely required.

Slicing V

– Result of example 11 hard

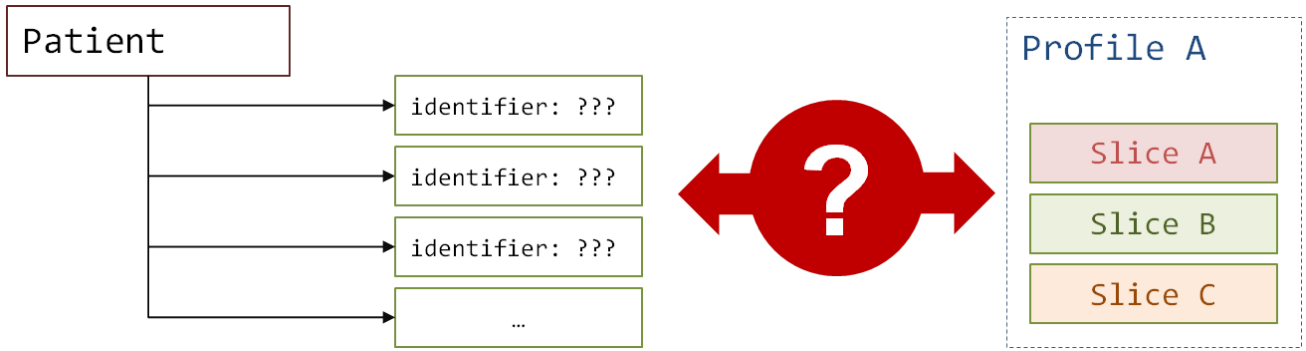
```
<element>
...
  <path value="Patient.identifier"/>
  <slicing>
    <rules value="openAtEnd"/>
  </slicing>
  <min value="1"/>
  <max value="*"/>
...
</element>
<element>
...
  <path value="Patient.identifier"/>
  <name value="svnr"/>
  <min value="1"/>
  <max value="1"/>
  <base>
    <path value="Patient.identifier"/>
    <min value="0"/>
    <max value="*"/>
  </base>
 ...
</element>
```

Rules for the behavior of Slicing

Slice for national insurance number

Discriminator I

- If a **StructureDefinition** contains Slices
  - Check every list-element of a specific resource against the rules defined in that particular Slice
  - Additional concept is needed to assign such list-elements efficiently to a Slice
  - Use of a discriminator (in FHIR®)
    - Differ between several Slices
    - Discriminator contains path of the described element



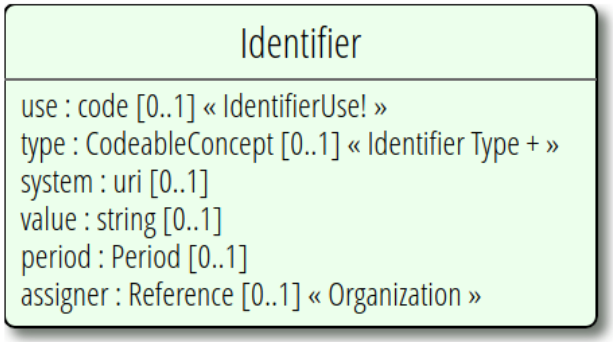
Discriminator II

- Example 12 hard
  - A Discriminator is needed for the previously created Slice. This Discriminator must differ between the national insurance number and other **Patient.identifier** elements

Discriminator III

– Result of example 12 **hard**

```
<element>
  ...
  <path value="Patient.identifier"/>
  <slicing>
    <type value="value"/>
    <discriminator value="assigner.reference"/>
    <rules value="openAtEnd"/>
  </slicing>
  <min value="1"/>
  <max value="*"/>
  <base>
    <path value="Patient.identifier"/>
    <min value="0"/>
    <max value="*"/>
  </base>
  <isSummary value="true"/>
  ...
</element>
```

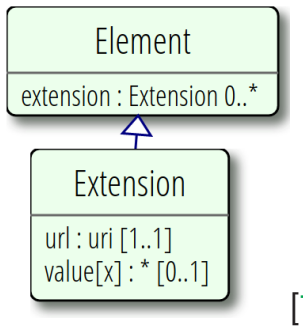


[6]

Outline

Extensions I

- The concept of extensions is fundamental in FHIR®
  (see 80/20 rule)
- Expansion of the base specification by additional elements
- All elements of resources and data types contain an additional, optional element **extension (0..*)**



[7]

Information

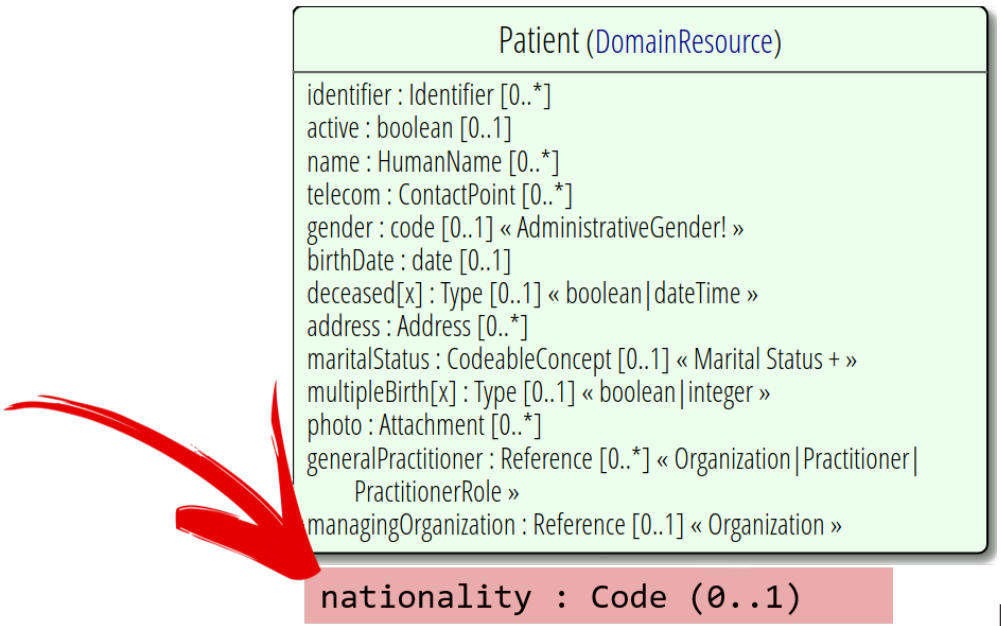
As Extensions also are elements, Extensions can be nested at will

Extensions II

- Extensions consist of
  - **url** : required, unique identifier of the Extension
  - **value[x]** : there are various types of Extensions (String, Integer, etc.)
- Extension can either use a **value[x]** -element or a further **extension** -element
- If an Extension is required to correctly process the resource → **modifierExtension**

Create an Extension I

- Example 13 **hard**
  - The **AustrianPatient** should get an additional element **nationality**



[4]

Create an Extension II

– Result of example 13 hard

Extension.url

```
<element>
  <path value="Extension.url"/>
  <representation value="xmlAttr"/>
  <min value="1"/>
  <max value="1"/>
  <base>
    <path value="Extension.url"/>
    <min value="1"/>
    <max value="1"/>
  </base>
  <type>
    <code value="uri"/>
  </type>
  <fixedUri value="http://aist.fh-hagenberg.at
        /Nationality"/>
</element>
```

Extension.value[x]

```
<element>
  <path value="Extension.valueCodeableConcept"
      />
  <min value="0"/>
  <max value="1"/>
  <base>
    <path value="Extension.value[x]"/>
    <min value="0"/>
    <max value="1"/>
  </base>
  <type>
    <code value="codeableConcept"/>
  </type>
</element>
```

Outline

Benefit

- Simplified search and filter queries for resources
- `SearchParameter` defines
  - the usage of the parameters on the client side
  - the interpretation of the perameters on the server side
  - how the *name* of a `SearchParameter` is mapped to an element

birthdate	Patient.birthDate
death-date	Patient.deceased.as(DateTime)

  - There is a registry for definied SearchParameter! [8]

Define your own SearchParameter

Example 14 moderate

- Define a search parameter for the `AustrianPatient` that queries all patienten of a specific `nationality`

  GET [base]/Patient?`nationality` =urn:iso:std:iso:3166|AT

system|code

> **Information**
>
> The name of a SearchParameter doesn't necessarily need to be equal with the name of a resource element.

Define your own SearchParameter

Result of example 14 moderate

```
<resource>
  <type value="Patient"/>
  <profile>
     <reference value="http://hl7.org/fhir/Profile/Patient"/>
  </profile>
  <interaction>
  <code value="read"/>
  </interaction>
  <interaction>
  <code value="vread"/>
  </interaction>
  <interaction>
  <code value="create"/>
  </interaction>
  <interaction>
  <code value="search-type"/>
  </interaction>
  <searchParam>
    <name value="nationality"/>
    <type value="token"/>
  </searchParam>
</resource>
```

Newly created SearchParameter

Excursion: Definintion in HAPI-FHIR

Result of example 14 moderate

- Annotate methods with @Search
- @RequiredParam defines name of parameter
- Overview of possible parameter types: http...

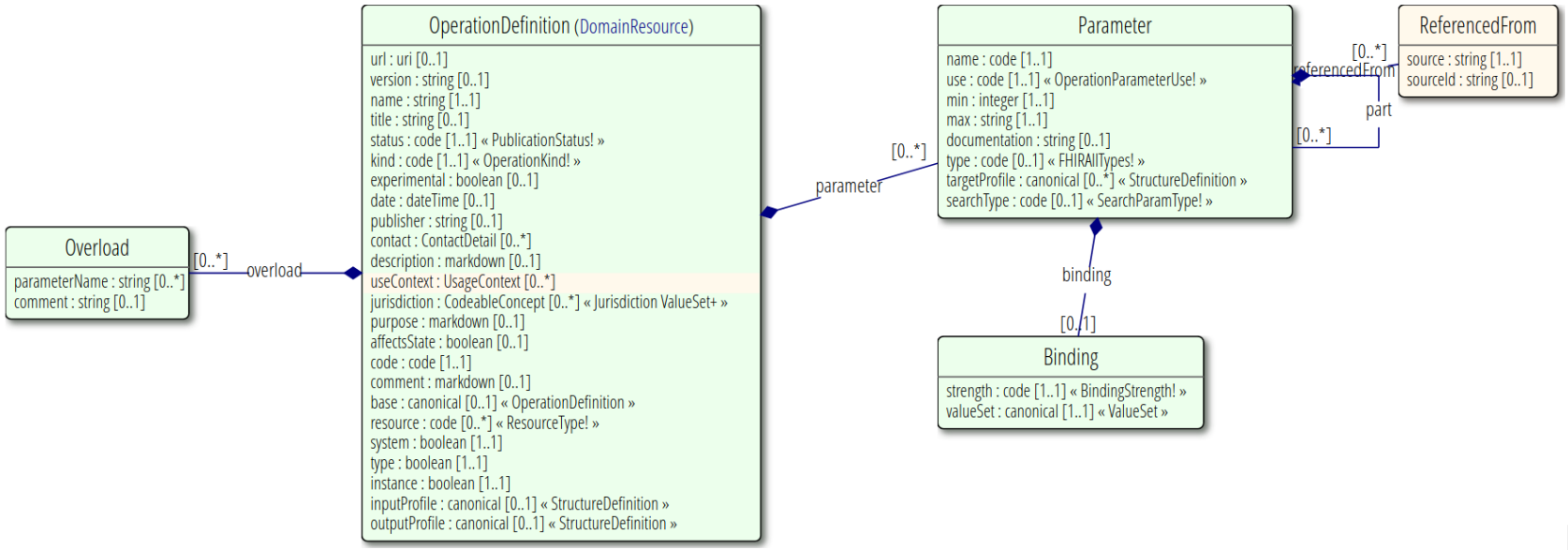
```
@Search public List<AustrianPatient> findPatientsForNationality
(@RequiredParam (name="nationality") TokenParam code) {
    String systemVal = code.getSystem();
    String codeVal = code.getValue();
    // Implement backend retrieval for AustrianPatient matching desired criteria
}
```

Outline

Operations R4 (== STU3)

- Everything starting with $ is Operation
  POST http://fhir.someserver.org/fhir/Patient/1/$everything
- Call these operations with POST or GET
  - POST – Operation may cause changes of the resource
  - GET – Idempotent Operations (any call generates exactly the same result) or Operations that don't change data
- Operations can get defined on different levels
  - Straight on the endpoint (`http://example.com/fhir`)
    - E.g. $extensions → Find all Extensions on the server
  - On a resource type (`http://example.com/fhir/Patient`)
    - E.g. $count → count all resources
  - On a specific instance (`http://example.com/fhir/Patient/1`)
    - E.g. $patientSummary → patient summary of the patient
  - On a specific version
    (`http://example.com/fhir/Patient/1/_history/3`)
    - E.g. $difference → difference between the current version

OperationDefinition



[9]

OperationDefinition (simplified) I

```
<OperationDefinition xmlns="http://hl7.org/fhir">
  <id value="Questionnaire-populate"/>
  <url value="http://hl7.org/fhir/OperationDefinition/Questionnaire-populate"/>
  <name value="Populate Questionnaire"/>
  ...
  <code value="populate"/>
  <system value="false"/>
  <type value="Questionnaire"/>
  <instance value="true"/>
  ...
</OperationDefinition>
```

Unique URL

Code → call with $populate

System → is the Operation applicable on the endpoint?

Operation on resource type (0..*)

Operation on instance level

OperationDefinition (simplified) II

```
<OperationDefinition xmlns="http://hl7.org/fhir">
  ...
  <parameter>
    <name value="local"/>
    <use value="in"/>
    <min value="0"/>
    <max value="1"/>
    <documentation value="Human Readable Info on Parameter."/>
    <type value="boolean"/>
  </parameter>
  ...
</OperationDefinition>
```

Inparameter

Optional

Type → Simple — Complex Datatype, Ressource

OperationDefinition (simplified) III

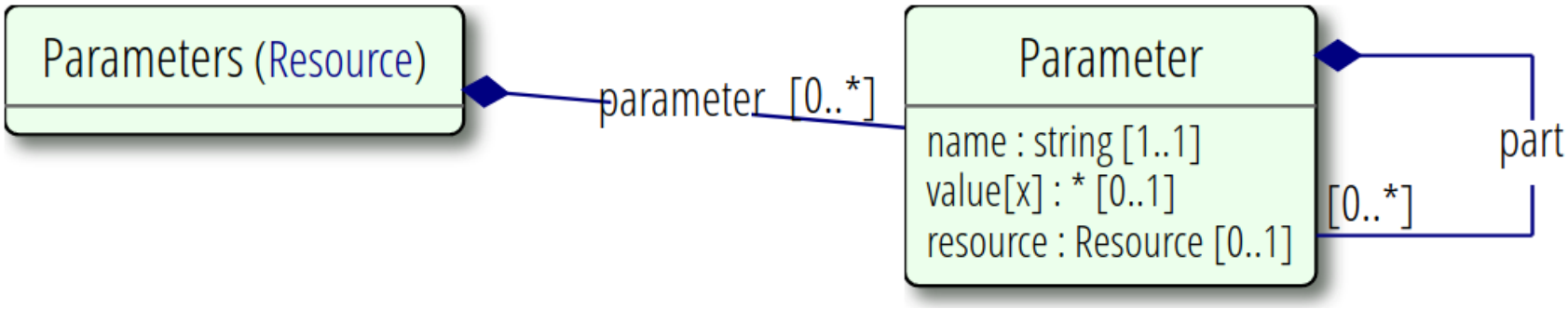
```
<OperationDefinition xmlns="http://hl7.org/fhir">
  ...
  <parameter>
    <name value="return"/>
    <use value="out"/>
    <min value="1"/>
    <max value="1"/>
    <documentation value="The partially (or fully)-populated set of answers for the specified
          Questionnaire"/>
    <type value="QuestionnaireResponse"/>
  </parameter>
  ...
</OperationDefinition>
```

Outparameter

Required

Operation Calls

- Call → without parameter GET or POST
- Call → with resource-parameters in body
- Answer → also resource-parameters
- Parameters:
  - Contains a list of parameters
  - Each parameter is data type OR resource
  - Described in OperationDefinition



[10]

Parameters

```
<Parameters xmlns="http://hl7.org/fhir">
  <id value="example"/>
  <parameter>
    <name value="start"/>
    <valueDate value="2010-01-01"/>
  </parameter>
  <parameter>
    <name value="end"/>
    <resource>
      <Binary>
        <contentType value="text/plain"/>
        <content value="VGhpcyBpcyBhIHRlc3QgZXhhbXBsZQ==">
      </Binary>
    </resource>
  </parameter>
</Parameters>
```

Start → Type parameter

End → Resource parameter

Digression: Operations in HAPI I

- Details: HAPI FHIR `Extended-Operations`
- On type level (in resource provider!):

```
@Operation (name="$everything",  idempotent=true)
public Bundle patientTypeOperation(
    @OperationParam (name="start") DateType theStart,
    @OperationParam (name="end") DateType theEnd) {

   Bundle retVal = new Bundle();
   // Populate bundle with matching resources
   return retVal;
   }
```

Operation $everything

GET + POST allowed

ReturnType

Parameters

Digression: Operations in HAPI II

- On instance level (in resource provider):

```
@Operation (name="$everything", idempotent=true)
public Bundle patientInstanceOperation(
   @IdParam IdType thePatientId,
   @OperationParam (name="start") DateType theStart,
   @OperationParam (name="end") DateType theEnd) {

   Bundle retVal = new Bundle();
   // Populate bundle with matching resources
   return retVal;
}
```

Parameters + ID

Digression: Operations in HAPI III

- On the endpoint (not in resource provider):

```
@Operation (name="$closure"   )
public ConceptMap closureOperation(
    @OperationParam (name="name") StringType theStart,
    @OperationParam (name="concept") List theEnd,
    @OperationParam (name="version") IdType theVersion) {

   ConceptMap retVal = new ConceptMap();
   // Populate bundle with matching resources
   return retVal;
}
```

Operation $closure

Only POST (no idempotence)

ReturnType

Parameter

Operations Example I

$merge

Example 15 moderate

- The operation merges two patients **with the same identifier**
- A patient will be validated by the user

Operations Example II

– Result of example 15 moderate

```
<OperationDefinition xmlns="http://hl7.org/fhir">
   <name value="merge"/>
   <status value="active"/>
   <kind value="operation"/>
   <idempotent value="true"/>
   <code value="merge"/>
   <resource value="Patient"/>
   <system value="false"/>
   <type value="false"/>
   <instance value="true"/>
   <parameter>
      <name value="with"/>
      <use value="in"/>
      <min value="0"/>
      <max value="1"/>
      <type value="id"/>
   </parameter>
</OperationDefinition>
```

Operations Example III

```
      <operation>
         <name value="merge"/>
         <definition>
            <reference value="OperationDefinition/Patient-i-merge"/>
         </definition>
      </operation>
   </rest>
</CapabilityStatement>
```

Outline

Benefit and Content I

- Definition of machine readable implementation guidelines
  - Focus on documentation
  - Automated transformation in human readable documentation
- ImplementationGuide provides
  - Contents
    - Logical statements, mostly *Conformance Modules*
  - Examples
    - For clarification of the application (every resource possible)
- Can define default profiles in case there was no explicit definition of other profiles in the ImplementationGuide
- ImplementationGuides can be extended from other ImplementationGuides

Benefit and Content II

FHIR® ImplementationGuide != IHE profiles — ~== ELGA implementation guides

- No actors
- No transactions
- OperationDefinition, SearchParameters are part of ImplementationGuide
- Use-Cases with description
- Sample resources
- Templates for resource creation

Benefit and Content III

Work in progress

Maturity Level 1 - Argonaut among the first users

Benefit and Content IV

ELGA: e-Medikation Example 16 moderate

- Profile - AustrianPatient for use in Austrian context
- Profile - PharmazentralMedication extension for Medication with PZN
- Profile - EMedikationMedicationStatement list of medications for patient
- SearchParameter - PZN for searching medications with PZN
- Operation - $listLongTermMedication Operation to extract long-term medication from eMedikation
- Questionaire - MedikamentenunverträglichkeitenQuestionaire Questionaire to log side effects when taking medication
- Endpoint - ELGAeMedikationEndpoint server Endpoint that hosts the eMedication of ELGA

Outline

Validation I

- Is a operation on a resource
- Option A) Without profile → checks against StructureDefinition of the base resource

POST [base]/Patient/$validate

```
{
    "resourceType":"Patient",
    ...
}
```

Answer:

```
{
    "resourceType":"OperationOutcome",
    "text":{
        ...
    },
    "issue":[{
            "severity":"information",
            "code":"informational",
            "diagnostics":"No issues detected during validation"
        }]
}
```

Validation II

- Option B) Post with validation against profile in metadata

POST [base]/Patient/$validate?profile=http://aist.fh-hagenberg.at/AustrianPatient

```
{
    "resourceType":"Patient",
        ...
    "meta":{
        "profile":"http://aist.fh-hagenberg.at/AustrianPatient",
        "profile":"http://example.com/ExamplePatient"
        ...
    },
        ...
}
```

Validation III

Answer with profile:

```
{"resourceType":"OperationOutcome",
    "text":{...},
    "issue":[{
            "severity":"error",
            "code":"processing",
            "diagnostics":"Element is unknown or does not match any slice",
            "location":["/parameter/resource/resource/id"]},
        { "severity":"error",
            "code":"processing",
            "diagnostics":"Element is unknown or does not match any slice",
            "location":["/parameter/resource/resource/meta"]},
        { "severity":"error",
            "code":"processing",
            "diagnostics":"Element is unknown or does not match any slice",
            "location":["/parameter/resource/resource/text"]},
        { "severity":"error",
            "code":"processing",
            "diagnostics":"Element '/parameter/resource/resource.identifier':
            minimum required = 1, but only found 0",
            "location":["/parameter/resource/resource"]}]}
```

Snapshot errors

AustrianPatient requires at least one identifier

Validation - Problems

- Validation only works against **StructureDefinitions** with Snapshot
- Generated Snapshots by Forge "forget" the derivation-hierarchy
  - See previous slide:
    - Patient derives from **DomainResource** → text-element is not in Snapshot
    - **DomainResource** derives from **Resource** → elements id and meta are not in Snapshot
- Resolving resources
  - 3 possibilities for FHIR® resources
    - Defined locally on the FHIR® server
    - Defined on external FHIR® server
    - Defined on external FHIR® server but local proxy used
  - No server has implemented resolution (only locally)
    - Snapshots contain references to ValueSets that exist in the FHIR® standard
    - ValueSets don't exist locally → Snapshot isn't valid

Validation – ValueSet Ref

- Binding in Snapshot refers to fhir/ValueSet → not locally on the server = not resolvable

```
<snapshot>
...
  <element>
    <binding>
      <strength value="required" />
      <description value="The type of an address (physical / postal)" />
      <valueSetReference>
        <reference value="http://hl7.org/fhir/ValueSet/address-type" />
      </valueSetReference>
    </binding>
  </element>
...
</snapshot>
```

Excursion: Profile Versioning I

Problem:

Profile ressources (StructureDefinition, Extension) are versioned $\rightarrow$

Resources link to profiles WITHOUT version

Which version does the patient have?

```
<StructureDefinition>
    <url value="=http://aist.fh-hagenberg.at/AustrianPatient" />
    <version value="1.0" />


<StructureDefinition>
    <url value="=http://aist.fh-hagenberg.at/AustrianPatient" />
    <version value="1.1" />

...

<Patient>
    <meta>
        <profile value="http://aist.fh-hagenberg.at/AustrianPatient">
    </meta>
```

Excursion: Profile Versioning II

Solution:

```
<Patient>
    <meta>
        <profile value="http://aist.fh-hagenberg.at/AustrianPatient|1.0">
    </meta>
```

- Not used in community
- ImplementationGuide → Parts of a resource can adhere to incompatible versions of profiles
- ImplementationGuide → Referenced resources may have incompatible version number
- Profil-Update → Resource update or downward compatibility?
- Profiles reference profiles

Excursion: Profile Versioning III

Possible Improvements

Currently discussed in community

- Related Profiles and Extensions grouped by ImplementationGuides
- Version Control with Dependency Management
- Synchronization with FHIRCast

Outline

Publish Profiles

- `FHIRRegistry` To make profiles available for the community, they are published in FHIR-Registries
- `Simplifier.net` is a FHIR-Repository that is freely and commercially available

> **Simplifier**
>
> Simplifier.net is a FHIR® registry. Within this registry you can create, upload, download, find and view FHIR® Conformance Resources. Simplifier.net offers functionality for management of FHIR® Resources and collaboration in teams.[11]

Publish Implementation Guides

- With your affiliate
- HL7AustriaGitHub Free publication of all IGs for members that will be balloted via HL7
- Automated build process
- Published at HL7AustriaWebpage

Source of information for FHIR®

- General
  - Zulip - https://chat.fhir.org/
  - FHIR® - build.fhir.org
  - JIRA - https://jira.hl7.org/secure/Dashboard.jspa
  - Community - http://community.fhir.org/
- Blogs:
  - http://motorcycleguy.blogspot.co.at/
  - http://www.healthintersections.com.au/
- GitHub:
  - https://github.com/ewoutkramer
  - https://github.com/jamesagnew
- Mailing lists:
  - http://www.hl7.org/myhl7/managelistservs.cfm
  - fhir@hl7.at

Appreciation

Thanks a lot to the FHIR® community, the active FHIR® bloggers and especially Ewout Kramer, Graham Grieve, Lloyd McKenzie and James Agnew for their documentation, examples and information that was used for parts of this workshop.

Bibliography I

[1] HL7 International. (2020), Fhir conformance module, [Online]. Available: http://hl7.org/fhir/conformance-module.html.

[2] ——, (2020), Resource compartmentdefinition, [Online]. Available: http://build.fhir.org/compartmentdefinition.html.

[3] ——, (2020), Fhir structuredefinition resource, [Online]. Available: http://hl7.org/fhir/structuredefinition.html.

[4] ——, (2020), Fhir patient resource, [Online]. Available: http://www.hl7.org/fhir/patient.html.

[5] ——, (2020), Fhir observation resource, [Online]. Available: http://hl7.org/fhir/observation.html.

[6] ——, (2020), Fhir identifier, [Online]. Available: http://hl7.org/fhir/R4/datatypes.html#Identifier.

Bibliography II

[7] ——, (2020), Fhir exension, [Online]. Available: http://hl7.org/fhir/R4/extensibility.html#Extension.

[8] ——, (2020), Defined search parameters, [Online]. Available: http://build.fhir.org/searchparameter-registry.html.

[9] ——, (2020), Fhir operationdefinition, [Online]. Available: http://hl7.org/fhir/operationdefinition.html.

[10] ——, (2020), Fhir parameters, [Online]. Available: http://hl7.org/fhir/parameters.html.

[11] Furore Health Informatics. (2020), Simplifier.net, [Online]. Available: https://www.simplifier.net.

[12] HL7 International. (2020), Fhir valueset, [Online]. Available: http://hl7.org/fhir/valueset.html.

[13] ——, (2020), Fhir conceptmap, [Online]. Available: https://www.hl7.org/fhir/conceptmap.html.

Outline

Logical Model

5.4.6.4 Logical Models

StructureDefinitions are used to define the basic structures of FHIR: data types, resources, extensions, and profiles. The same definition structure can also be used to define any arbitrary structures that are a directed acyclic graph with typed nodes, where the primitive types are those defined by the FHIR specification.

This technique has many uses:

- Describing any arbitrary content model
- Describing existing HL7 content models (e.g. v2, CDA) using FHIR
- Describing common design patterns used in FHIR
- Defining a content model to support the mapping language

[3]

Use Cases

- Mappings
  - HL7 v2, v3, CDA, CCD, ...
  - Domain Objects
  - Concepts in profiles or implementation guides
- Validation of “any“ content
- Already used in:
  - Request Pattern http://build.fhir.org/request.html
  - HL7 Australia Implementation Guide Colorectal Report http://fhir.hl7.org.au/fhir/rcpa/colorectal.html#table

Outline

FHIRPath

- Path-based query and extraction language
- Similar to XPath
- Expressions are based on a hierarchically structured model
- Not only FHIR® but anything that can be defined as graph
- Everything is a collection
- HL7v3 FHIR®, vMR, CIMI, QDM

- More information, as well as the grammar for creating a FluentPath parser are available at
  https://github.com/ewoutkramer/fhir-net-fhirpath

- Currently under development - R2
- NOT Part of FHIR®

FHIRPath Examples

http://niquola.github.io/fhirpath-demo/#/

```
Patient.name.family|Patient.name.given
*.family.substring(0,3)|0|"Hans"
(*.*).count()
(4+5).count()
```

Outline

Structure Map

How do I make a resource out of anything (even another resource)?

- http://build.fhir.org/structuremap.html
- StructureMap maps concept A to concept B
- Unidirectional
- Machine readable and executeable
- Logical Model
  http://build.fhir.org/patient-mappings.html
- Other Resources (StructureDefinition!)

Mapping Language

Make Meta-Modelling great again!

- http://build.fhir.org/mapping-language.html
- http://build.fhir.org/mapping-tutorial.html
- Executable Part of a StructureMap
- Can be a mapping file (outside StructureMap)
- Type Independent
  - Can translate FHIR® simpletypes to others
- Strongly and weakly typed
  - Strong: based on StructureMap
  - Weak: acyclic graph with named fields (JSON, XML)
- Uses FHIRPath

Outline

Terminology – Codes

- Codes enable machine readability of elements / resources
- Codes in FHIR always belong to a **ValueSet**
  - Fixed set of values (not **ValueSet**)
  - Internet RFC
  - HL7 v3 code system
  - HL7 v2 table
  - Terminology sets / code systems like LOINC & SNOMED
  - **ValueSet** from a profile
- There are 4 possibilities to define codes in resources

Codes in Resources – Code

- **Code** (String) only represents the code itself. System is given implicitly
  - e.g. by fixed value in profile

```
<code value="G44.1" />
```

Code

Codes in Resources – Coding

- **Coding** (complex data type) only represents the code itself
- System is given explicitly

```
<code>
    <system value="http://hl7.org/fhir/sid/icd-10" />
    <code value="G44.1" />
</code>
```

System

Code

- **Coding** != element:

```
<problem>
  <system value="http://snomed.info/sct" />
  <code value="128045006:{363698007=56459004}" />
</problem>
```

Codes in Resources – CodeableConcept

- **CodeableConcept** (complex data type) represents the plain-text and any number of Codings

```
<concept>
    <coding>
        <system value="http://hl7.org/fhir/sid/icd-10"
       />
        <code value="R51"/>
    </coding>
    <coding>
        <system value="http://snomed.info/sct"/>
        <code value="25064002"/>
        <display value="Headache"/>
        <userSelected value="true"/>
    </coding>
    <text value="general headache"/>
</concept>
```

System ICD-10

Code from ICD-10

System Snomed

Code from Snomed

Free text

Codes in Resources – Quantity

- Quantity (complex data type) represents value
- Outlier!

```
<dose>
    <value value="3"/>
    <unit value="capsules"/>
    <system value="http://snomed.info/sct"/>
    <code value="385049006"/>
</dose>
```

System Snomed

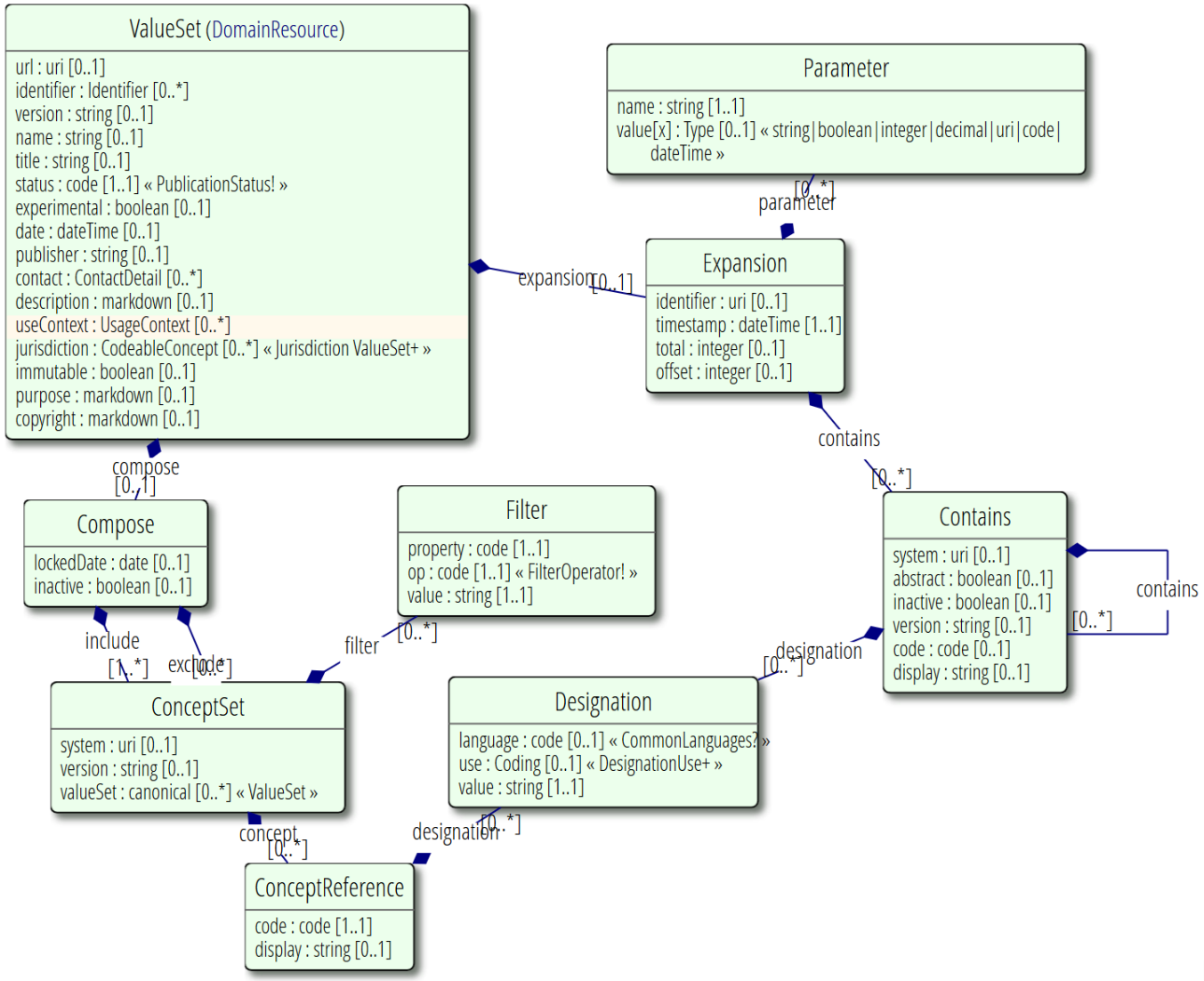
Code from Snomed

Outline

System and ValueSet

- The "system" of codes always belongs to a **ValueSet**
- A **ValueSet** doesn't need to be a resource
  - It's sufficient to specify an URL
- **ValueSet** != Code System
  - **ValueSet** :
    - A specific set of values (e.g. blood pressure) http://r.details.loinc.org/LOINC/35094-2.html?sections=Comprehensive)
    - Can use one or more code systems (optional)
    - Already is a resource
  - Code System
    - A system that defines codes (e.g. LOINC)
    - Must contain ValueSets to "cluster" the codes
    - In STU3 *code system* is planned to be a separate resource

ValueSet as Resource



[12]

ValueSet (Simplified) I

- 3 identifiers
  - `id` = Id on FHIR® server (different on every server!)
  - `url` = Unique ID of that **ValueSet** . Is always the same!
  - `identifier` = External reference on **ValueSet** (OID in HL7v3)

```
<ValueSet xmlns="http://hl7.org/fhir">
  <id value="example-inline"/>
   ...
  <url value="http://hl7.org/fhir/ValueSet/example-inline"/>
   ...
  <identifier>
    <system value="http://acme.com/identifiers/valuesets"/>
    <value value="loinc-cholesterol-inl"/>
  </identifier>
 ...
```

ValueSet (Simplified) II

- **ValueSet** can be:
  - Reference on an inline codeSytem that is defined in **ValueSet**
  - A "composition" of codes as codes or "selection-criteria"
    - **Selection Criteria:**
    - Import = Select entire ValueSet
    - Include = Select single values
    - Exclude = DESELECT values (only if there already are some by Import or Include)
    - Include & Exclude have filters with operations (= — is-a — is-not-a — regex — in — not-in)
  - Both
- Expanded Value Sets:
  - Didn't get extended
  - um alle Werte für die Datenverarbeitung zu beinhalten

ValueSet In-Line CodeSystem

```
<ValueSet xmlns="http://hl7.org/fhir">
  ...
  <codeSystem>
    <system value="http://acme.com/config/fhir/codesystems/cholesterol"/>
    <version value="4.2.3"/>
    <caseSensitive value="true"/>
    <concept>
      <code value="chol-mmol"/>
      <display value="SChol (mmol/L)"/>
      <definition value="Serum Cholesterol, in mmol/L"/>
      <designation>
        <use>
          <system value="http://acme.com/config/fhir/codesystems/internal"/>
          <code value="internal-label"/>
        </use>
        <value value="From ACME POC Testing"/>
      </designation>
    </concept>
        ...
  </codeSystem>
</ValueSet>
```

Inline system with versioning

Concept defined in system

Purpose

ValueSet Composition

```
<ValueSet xmlns="http://hl7.org/fhir">
  ...
  <compose>
    <import value="http://hl7.org/fhir/ValueSet/v2-0136"/>
    <include>
      <system value="http://hl7.org/fhir/data-absent-reason"/>
      <concept>
        <code value="asked"/>
        <display value="Don't know"/>
      </concept>
    </include>
  </compose>
  ...
</ValueSet>
```

OPTION: Import entire ValueSet

OPTION: Select single / multiple values of ValueSet

ValueSet Composition Include

```
<ValueSet xmlns="http://hl7.org/fhir">
  ...
  <compose>
    <include>
      <system value="http://loinc.org"/>
      <filter>
        <property value="parent"/>
        <op value="="/>
        <value value="LP43571-6"/>
      </filter>
    </include>
  ...
</ValueSet>
```

Include filter

Select all values where „parent“ = LP43571-6

Information

Filter will probably be changed to FHIR® Path in STU3

ValueSet Composition Exclude

```
<ValueSet xmlns="http://hl7.org/fhir">
  ...
  <compose>
    <exclude>
      <system value="http://loinc.org"/>
      <concept>
        <code value="5932-9"/>
        <display value="Cholesterol [Presence] in Blood by Test strip"/>
      </concept>
    </exclude>
  ...
</ValueSet>
```

Exclude concept

ValueSet Expansion

```
<ValueSet xmlns="http://hl7.org/fhir">
  ...
  <expansion>
    <identifier value="urn:uuid:bf99fe50-2c2b-41ad-bd63-bee6919810b4"/>
    <timestamp value="2015-07-14T10:00:00Z"/>
    <contains>
      <system value="http://hl7.org/fhir/v2/0136"/>
      <code value="Y"/>
      <display value="Yes"/>
    </contains>
    <contains>
      <system value="http://hl7.org/fhir/v2/0136"/>
      <code value="N"/>
      <display value="No"/>
       ...
  </expansion>
  ...
</ValueSet>
```

Unique ID

Time when the Expansion was created

ALL values that are defined in the ValueSet

ValueSet A → ValueSet B

Resource **ConceptMap**

- Provides unidirectional mapping from A to B
  - Code system
  - Data elements
  - Classes / resources
- Mapping of **ValueSets** are specific to a context of use
- Mapping of concept A may have more than one destination in concept B
  - Because there are some equivalent destinations (ambiguity)
  - Because mappings may have dependencies
- Not every Concept must have a Mapping
  - But it should!

ValueSet DIY I

Where do you ge ta ValueSet from?

- Official HL7 documentation
  http://hl7.org/fhir/terminologies-valuesets.html
- Community FHIR® Register: Ex.:
  https://simplifier.net/search?category=ValueSet]
- Interns!

ValueSet DIY II

When can a selfmade ValueSet be used?

Defined by BindingStrength. Ex.:
http://hl7.org/fhir/observation.html

- Required: Shall NOT be changed
- Extensible: Must be used but additional codes are allowed
- Preferred: Should be usde but it can be replaced
- Example: Example that can be used but is not required
- Blank: free to use

Codes Example I

Example 17 easy Extending the Patient with Codes

Please create a Patient with the following:

- Add your gender
- Add your marital status

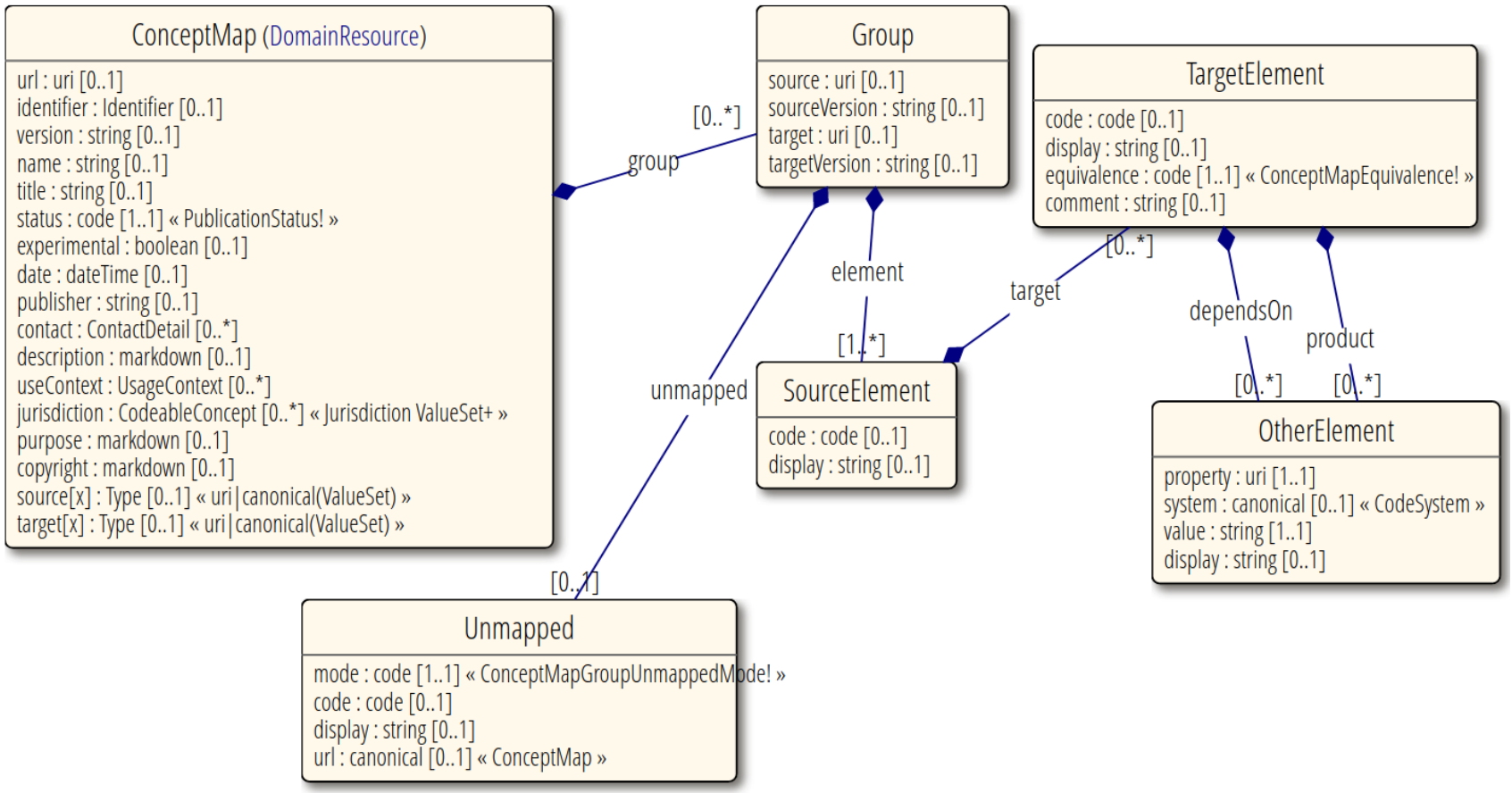
Codes Example II

Result of example 17 easy Extending the Patient with Codes

```
<Patient xmlns="http://hl7.org/fhir">
   ...
   <gender value="male"/>
   <maritalStatus>
     <coding>
       <system value="http://terminology.hl7.org/CodeSystem/v3-MaritalStatus"/>
       <code value="U"/>
       <display value="Unmarried"/>
     </coding>
   </maritalStatus>
</Patient>
```

Outline

ConceptMap



[13]

ConceptMap Use, Source, Target

```
<ConceptMap xmlns="http://hl7.org/fhir">
  ...
  <useContext>
    <text value="for CDA Usage"/>
  </useContext>
  ...
  <sourceReference>
    <reference value="http://hl7.org/fhir/address-use"/>
  </sourceReference>
  <targetReference>
    <reference value="http://hl7.org/fhir/v3/AddressUse"/>
  </targetReference>
  ...
```

Domain of use

Source: FHIR addresses

Target: HL7v3 addresses

ConceptMap Mapping ValueSet

```
<ConceptMap xmlns="http://hl7.org/fhir">
  ...
  <element>
    <codeSystem value="http://hl7.org/fhir/address-use"/>
    <code value="home"/>
    <target>
      <codeSystem value="http://hl7.org/fhir/v3/AddressUse"/>
      <code value="H"/>
      <equivalence value="equivalent"/>
    </target>
  </element>
```

Mapping

Source: home from FHIR

Target: H from HL7v3

Example equivalence code (string)

Equivalence is defined in separate `CodeSystem`

Degrees of Equivalence

Degree	**Meaning**
Equivalent	unabhängig von Kontext
Equal	aber nur im Kontext
Wider	Target is wider in meaning than the source concept
Subsumes	Target subsumes the meaning of the source concept
Narrower	Target is narrower in meaning that the source concept
Specializes	Target specializes the meaning of the source concept
Inexact	Similar but not totally overlapping (=Wider and Narrower)
Unmatched	No match for this concept in the destination concept system
Disjoint	No target, independent of context

Outline

Terminology Service

- Essential terminology server with operations
- Has its own capability statement - TerminologyCapabilities
- Abstracts **ValueSet** resources of health care applications
- Definition not completed yet (R4)
- Important operations:
  - Value Set expansion
  - Value Set validation (also Batch)
  - Concept Lookup
  - Translation (also Batch)
  - Application Search for Terminologies (Closures)
- Some operations can be executed for all **ValueSets**

ValueSet Expansion

- "Expand" the ValueSet

GET [base]/ValueSet/23/$expand?filter=abdo

```
HTTP/1.1 200 OK
[other headers]

<ValueSet xmlns="http://hl7.org/fhir">
    <id value="43770626-f685-4ba8-8d66-fb63e674c467"/>
    <expansion>
        <timestamp value="20141203T08:50:00+11:00"/>
        <contains>
            ...
        </contains>
    </expansion>
</ValueSet>
```

New UUID

Time of the expansion

All concepts of the ValueSet

ValueSet Validation

- Check whether concept is in ValueSet

GET [base]/ValueSet/23/$validate-code?system=http://loinc.org&code=1963-8&display=test

```
HTTP/1.1 200 OK
[other headers]
{
  "resourceType" : "Parameters",
  "parameter" : [
    {
    "name" : "result",
    "valueBoolean" : "false"
  },{
    "name" : "message",
    "valueString" : "The display \"test\" is incorrect"
  },{
    "name" : "display",
    "valueString" : "Bicarbonate [Moles/volume] in Serum"
  }]
}
```

ValueSet Lookup

- Request details of a concept

GET [base]/ValueSet/$lookup?system=http://loinc.org&code=1963-8

```
HTTP/1.1 200 OK
[other headers]
{
  "resourceType" : "Parameters",
  "parameter" : [{
    "name" : "name",
    "valueString" : "LOINC"
  },{
    "name" : "version",
    "valueString" : "2.48"
  },{
    "name" : "designation",
    "valueString" : "Bicarbonate [Moles/volume] in Serum"
  },{
    "name" : "abstract",
    "valueString" : "false"
  },{
      "name" : "designation",
    "part" : [{
      "name" : "value",
      "valueString" : "Bicarbonate [Moles/volume] in Serum "
    }]
  }]
}
```

ValueSet Translation

- Translate a concept in **ValueSet** A to concept in **ValueSet** B

GET [base]/ConceptMap/$translate?system=http://hl7.org/fhir/composition-status

&code=preliminary&valueSet= http://hl7.org/fhir/ValueSet/composition-status

&target=http://hl7.org/fhir/ValueSet/v3-ActStatus

```
HTTP/1.1 200 OK
[other headers]
{
  "resourceType" : "Parameters",
  "parameter" : [{
    "name" : "result",
    "valueBoolean" : "true"
    },{
      "name" : "outcome",
      "valueCoding" : {
        "system" : "http://hl7.org/fhir/v3/ActStatus",
        "code" : "active",
      }
    }]
}
```