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HL7® FHIR® - Starter

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Introduction to Fast Healthcare Interoperability Resources - FHIR®

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Outline

Outline

Paradigms in Healtcare Standards I

Message based

- Events being submitted
- HL7® v2

Document based

- Physician note, report, ...
- HL7®v3, HL7®CDA®

Paradigms in Healtcare Standards II

Use case based

- Radiology, patient summary, ...
- DICOM®, HL7®CCD®, My health Record, ..

Resource based

- Patient, medication, vitalsigns, ...
- HL7®FHIR®

The good vs. the bad - Paradigm

Good:

- Information is split in parts
- resources can change independently
- Lightweight transmission

Bad:

- Information not connected
- No processes
- Multiple transmissions for multiple ressource.

HL7® FHIR® I

Fast Healthcare Interoperability Ressources (FHIR®)

- Focus on developers
- Development according to use cases
- Leverage modern communication technology
- Olter standards not easy to use with mobile
- Open Source

HL7® FHIR® II

80/20 rule

- 80% of use cases addressed
- 20% adaptable
- Course → core components
- new datatypes
- Ressources extensible and restricable
- API extensible (search, operations, ...)

HL7® FHIR® III

Lifecycle

- Current R4: http://hl7.org/fhir/
- Future R5: http://build.fhir.org/
- $\sim$ 18 months cycle
- Ressources have a maturity level

Which FHIR® Version is right for me?

The newest one! Since R4 *normative* ressources exist. Those are backward compatible (or not - some austrian profiles are R3)

FHIR® - more than just ressources

- Messaging
- Documents
- Operations
- Workflows
- Reference implementation
- Infrastructure
- Community Extensions (CDSHooks FHIRCast ...)
- .....
- Some topics in Arsonists course

Advantages / Disadvantages - Standard

Good:

- Resources + API
- Infrastructure, frameworks, community
- Information connected with FHIR® Documents
- Active development
- Extensible for your needs
- Easy to get into

Bad:

- Stability
- Hard to master

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Example 1 easy The standard

- Overview: http://hl7.org/fhir/
- Documentation: http://hl7.org/fhir/documentation.html
- Ressources: http://hl7.org/fhir/resourcelist.html
- What are the numbers next to the resources for?

Result of example 1 easy Maturity Levels

- Patient N
- Practitioner 3
- PractitionerRole 2

  - 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 implementd in at least 2 countries and 5 different systems
- `Normative` = normative ballot passed successful

Outline

XML vs. JSON I

XML:

- Default representation
- Easily readable
- Heavy weight
- Bad for mobile devices

JSON:

- Set in URL parameters
  _format=json
- Fields in HTTP Header
  Accept: application/fhir+json
- Lightweight
- harder to read

XML vs. JSON II

Example 2 easy XML vs. JSON

Our testserver: `http://hapi.fhir.org/baseR4`

Why do you see JSON when the server returns XML?

Try to retrieve JSON instead of XML.

XML vs. JSON III

Result of example 2 easy XML vs. JSON

HAPI recognizes the browser-request and renders html?

JSON: *_format=json*

Structure of a Resource

```
<Patient xmlns="http://hl7.org/fhir">                          Resource
   <id value="1"/>                                             ID part of Identity
   <meta>
      <versionId value="1"/>
      <lastUpdated value="2019-03-16T10:52:40.520+00:00"/>     Metadata
   </meta>
   <text>
      <status value="generated"/>
      <div xmlns="http://www.w3.org/1999/xhtml">
        Peter James <b>Chalmers</b>                            Human Readable Text
      </div>
   </text>
   <identifier>
      <use value="usual"/>
      <system value="urn:oid:1.2.36.146.595.217.0.1"/>         Identifier != Identity
      <value value="12345"/>
   </identifier>
   <active value="true"/>
   <name>
      <use value="official"/>
      <family value="Chalmers"/>
      <given value="Peter"/>                                   Content of Resource
      <given value="James"/>
   </name>
   ...
</Patient>
```

Figure: General Structure of a FHIR® Resource

Identity — ID

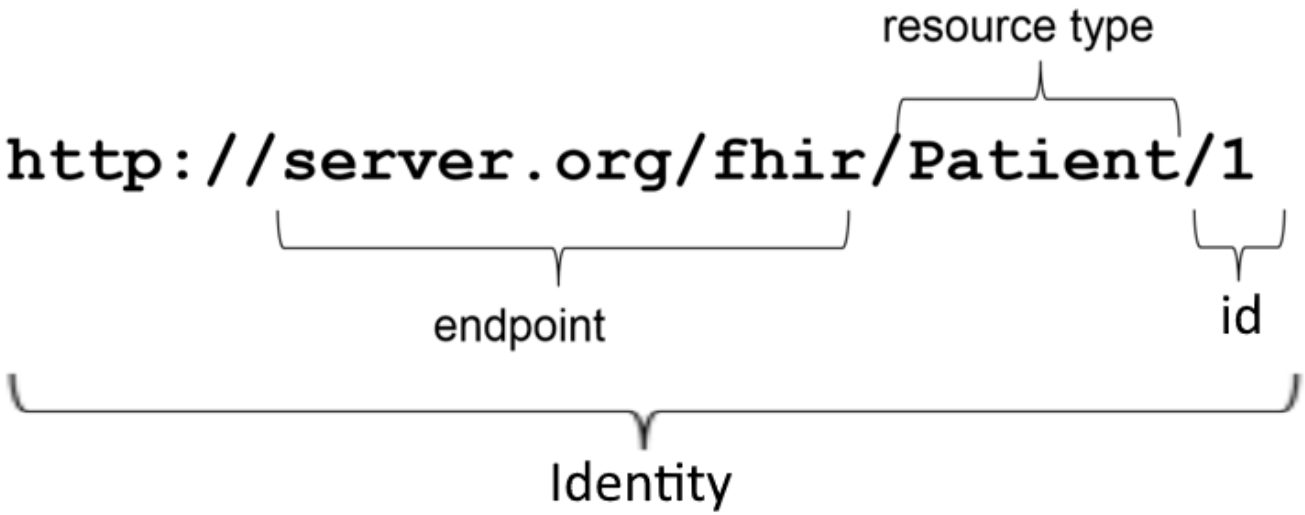


Figure: ID is part of the Identity[1]

- ID is part of the Identity
- ID = Identification on Server
- Identity = Unique URI
- Identity = FHIR® Endpoint + Resource Type + ID

Metadata

- Only managed by server
- versionId = Resources have a version history
- lastUpdated = Creation date of the version in versionId
- source = Original source of the ressource
- profile = profiles additionally to the base profile $\rightarrow$ Arsonists
- security = Labels for security layers
- tag = any information the resource needs to be tagged with

Human readable text

- Should be shown in any FHIR® System
- Must have enough information to make the resource understandable on its own
- Does not necessarily contain all of the structured data (inverse to CDA)

Identifier != Identity

This wrong information finds itself in many FHIR® tutorials:

Figure: LIES - not the identifier[1]

- Identifier often field in resource
- Logical identification of a resource in other systems
- Usually more than one identifier
- Ex.: SSNR → Identifier

Ressourcentypen I

FHIR® Resource

- Is a *DomainResource*
- defines the human readable narrative
- *DomainResource* = relevant for medical or organizational processes
- *DomainResource* is extensible (see Arsonists course)

Ressourcentypen II

DomainResource

- is a *Resource*
- Defines metadata and identity
- *Resource* has its own REST Resource Endpoint
- Ex.: `http://hapi.fhir.org/baseR4/Bundle`
- *Resource* = relevant for technical work
- *Resource* is NOT extensible

Element I

Fields in Resources

consist of *Element*s:

- 1 Element = 1 field
- *Backbone Element* = implicit grouping of fields
- *primitive datatypes* = extensible but not definable
- *complex datatypes* = extensible and defineable

Element II

Example 3 easy Data Types

http://hl7.org/fhir/datatypes.html

- Why are some datatypes not green?
- Can a complex datatype use other complex datatypes?
- Can a complex datatype use Resources?

Element III

Result of example 3 easy Data Types

http://hl7.org/fhir/datatypes.html

- The color defines the *MarurityLevel*
- Yes → CodeableConcept.Coding = Coding
  http://hl7.org/fhir/datatypes.html{#}codeableconcept
- Indirectly → Reference

Element IV

Reference

Pointer / Link to Resource

- Identifier:
  - SHOULD reference FHIR® Resource
  - Reference to identifier
  - Use when FHIR® Resource unknown
  - Use when other service is involved
  - Ex.: Identifier for PIXm request

Element V

Reference contd.

- ID: MUST point to FHIR® Resource
  - Absolute: `http://hapi.fhir.org/baseR4/Patient/1`
  - Relative: `Patient/1`
  - Version Specific: `Patient/1/_history/2`
  - Canonical:
    `http://hl7.org/fhir/ValueSet/my-valueset|0.8"`
  - Local: `{#}1`

Element VI

Canonical URLs

- FHIR® Resources are defined in FHIR® Resources (StructureDefinition)
- Profiles and StructureDefinitions exist in multiple FHIR® Versions
- Some Resources have a version in addition to the Meta-VersionId

Canonical URL guarantees receiving the correct Version

Element VII

Canonical FHIR® Version

Ex.: http://hl7.org/fhir/4.0/StructureDefinition/Patient

DSTU1	0.0
DSTU2	1.0
STU3	3.0
R4	4.0.1
R5	5.0

* 5.0 not yet defined!

Element VIII

Contained Resources

- Any reference can be contained
- Resource in field *Contained*
- Reference points with *#Nr* to contained
- Endless recursion allowed

When should you use Contained Resources?

Contained Resources break (nearly) all advantages of FHIR® and should only be used with a good reason. e.x. when having to minimize separate requests. Usually (nearly every time) a better solution is using FHIR® Document (https://www.hl7.org/fhir/documents.html) or Bundles.

Element IX

Example for Contained:

```
<Condition xmlns="http://hl7.org/fhir">
  <contained>
    <Practitioner>
      <id value="p1"/>
      <name>
        <family value="Person"/>
        <given value="Patricia"/>
      </name>
    </Practitioner>
  </contained>
  <!-- other attributes -->
  <asserter>
    <reference value="#p1" />
  </asserter>
  <!-- other attributes -->
 </Condition>
```

Element X

Cardinalities

Every field has a cardinalty

- 0..0 Field not allowed anymore (only occurs in Profiles)
- 0.. field optional
- 1.. field must be filled (rare)
- ..* field repeats

Element XI

[x] marks the spot

Ex.: http://hl7.org/fhir/patient.html.deceased

- below the field are multiple options
- A resource can only have *one* of those options
- Field in Resource has full name
- Ex.: Patient.deceasedBoolean

Element XII

Example 4 easy Lets make a patient

Please create a Patient with the following:

- Your name here + Your Nickname
- SSNR 1234
- Your birth date
- Patient has a Twin
- The patient is being managed by Organization/2

Element XIII

Result of example 4 easy Lets make a patient

```
<Patient xmlns="http://hl7.org/fhir">
   <identifier>
      <use value="official"/>
      <type><coding>
            <system value="http://hl7.org/fhir/v2/0203"/> <code value="SS"/>
         </coding></type>
      <system value="urn:oid:1.2.36.146.595.217.0.1"/>
      <value value="1234"/>
   </identifier>
   <name>
      <use value="official"/> <family value="Krauss"/> <given value="Oliver"/>
   </name>
   <name>
      <use value="nickname"/> <given value="Oliver"/>
   </name>
   <birthDate value="1989-08-08">
      <extension url="http://hl7.org/fhir/StructureDefinition/patient-birthTime">
         <valueDateTime value="1974-12-25T14:35:45-05:00"/>
      </extension>
   </birthDate>
   <multipleBirthInteger value="1"/>
   <managingOrganization><reference value="Organization/2"/></managingOrganization>
</Patient>
```

Element XIV

Intermission: Extensions

```
<extension url="http://hl7.org/fhir/StructureDefinition/patient-birthTime">
    <valueDateTime value="1974-12-25T14:35:45-05:00"/>
</extension>
```

- Extensions are standalone extensions or belong to a profile
- Important: An extension never has a regular name. It is *identified over URL*

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

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>
```

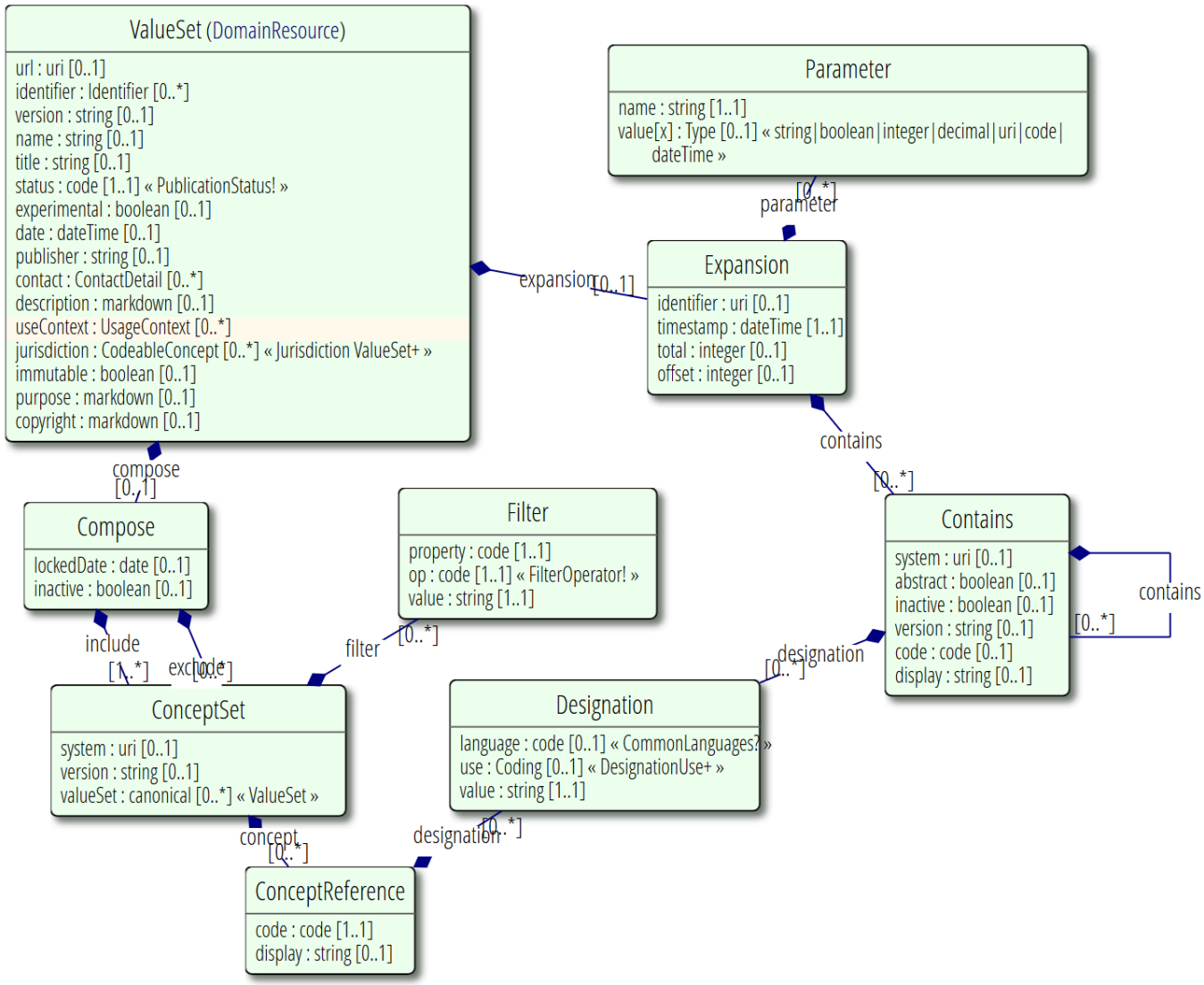
System Snomed

Code from Snomed

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



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 5 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 5 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>
```

FHIR® Profiling

- 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

```
<Patient xmlns="http://hl7.org/fhir">
   <id value="1"/>
   <meta>
      <profile value="http://hl7.at/fhir/3.0/StructureDefinition/AustrianPatient"/>
   </meta>
</Patient>
```

(Profile-Meta OPTIONAL, Details in FHIR® Arsonists)

Outline

API Overview

Operation	HTTP	Example
read all	GET	/Patient
read	GET	/Patient/@id
create	POST	/Patient + Body containing patient
update	PUT	/Patient/@id + Body containing patient
delete	DELETE	/Patient/@id
search	GET	/Patient?gender=M

Details - https://www.hl7.org/fhir/http.html

Read I

Server URL: `http://hapi.fhir.org/baseR4`

Example 6 easy Read all the things

- Search all Patients
- What is a Bundle?

Read II

Result of example 6 easy Read all the things

- http://hapi.fhir.org/baseR4

Bundle

- Essentially an Array
- NO DomainResouce → no narrative
- Special Case - FHIR Document
- Mostly used in CRUD and search

Create Update I

Example 7 easy Write all the things

- Create your Patient WITHOUT Codes
- UPDATE your Patient WITH codes

Create Update II

Result of example 7 easy Write all the things

- POST `http://hapi.fhir.org/baseR4/Patient/`
- PUT `http://hapi.fhir.org/baseR4/Patient/ID`

Search I

Example 8 easy Search

- Search all male patients
- How do you find the Search Parameters?
- Can SearchParameters be combined?

Search II

Result of example 8 easy Search

- GET http://hapi.fhir.org/baseR4/Patient?gender=male
- All resources have search section: http://hl7.org/fhir/patient.html{#}search
- Yes → & combination in HTML parameters
- Warning: SearchParamaters are often inconsistent with the fields being searched

SearchParameters DYI

- Searchparamters are resources → http://hl7.org/fhir/searchparameter.html
- SearchParameter defines *what* can be searched and *which SearchParameters* are compatible

HAPI http://hapifhir.io/

HAPI automates simple SearchParameters if the fieldname equals the parameter name

Delete I

Example 9 easy Delete

- Delete your patient
- What happens when you read the patient after deletion?

Delete II

Result of example 9 easy Search

- 200 OK
- Resource was deleted at ...

History I

Example 10 easy The skeletons in the Closet

- What happens if you read the first version of your patient?
- What happens with the second and third version?

History II

Result of example 10 easy The skeletons in the closet

- The Resource still exists
- Since version 3 is the newest it is still deleted
- Resources can be restored with an Update
- Warning: many proprietay Interfaces don't support _history since it is hard to implement

Operations

- 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

- Operations can be defined by developers
- OperationDefinition: FHIR Arsonists
- List of existing operations:
  http://hl7.org/fhir/operationslist.html

Outline

Testserver

Testserver*

- User Interface - http://fhirtest.uhn.ca/
- Strict validation - http://test.fhir.org/r4
- Connectathon server - http://wildfhir4.aegis.net/fhir4-0-0-gui/index.jsf

*https://confluence.hl7.org/display/FHIR/Public+Test+Servers

Security* I

- not part of the API
- highly recommended
- Community - SMART on FHIR®: http://docs.smarthealthit.org/
  - Essentially Oauth2
- Security Checklist for Implementers: http://hl7.org/fhir/safety.html
- Metadata labels: http://hl7.org/fhir/security-labels.html

*http://hl7.org/fhir/security.html

Security* II

Auditing

- AuditEvent - required server-log on access
- Provenance - recommended log why a resource was changed
- Consent - Einwillgung eines Patienten für Datenzugriff, Operationen, ...

Validation

- Is a operation on a resource
- checks against StructureDefinition of the base resource

POST [base]/Patient/ID/$validate

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

Answer:

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

FHIR® for your UseCase

FHIR Facade - Interface in existing systems

- No synchronization problems
- IDs of ressources hard to maintain
- No additional systems
- Standard only used as needed

FHIR Server - as centralized data management

- Full FHIR® functionality (depending on server)
- Additional System to maintain
- Problems with duplicate data storage

FHIR® Server != interoperability

Without a specification how the communication works, and restrictions on codes and resources there can be no interoperability. That is what Profiles, Extensions and ImplementationGuides are for.

Publish Profiles

(Creating Profiles in the Arsonist course)

- 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
- In the future it also handles dependency management

> **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.[2]

Source of information for FHIR®

- General
  - Zulip - https://chat.fhir.org/
  - FHIR® - https://build.fhir.org
  - JIRA - https://jira.hl7.org/projects/FHIR
  - Community - http://community.fhir.org/
- Blogs:
  - http://motorcycleguy.blogspot.com/
  - 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

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