SU-TermServ Onboarding

2024-02-02

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Agenda

1. Team and project introduction
2. FHIR Terminology Module overview
3. FHIR Terminology Services overview
4. Technical Details
5. Administrative details
6. Literature recommendations
7. Q&A

Team and project introduction

- MII “2b” project in the consolidation and extension phase of the MII: *advancing the harmonization of health data and IT solutions at the university hospital sites in cooperation with the NUM*
- Project funded from 2023-2026
- Three partner sites:
  - University of Lübeck - PI Josef Ingenerf
  - University of Cologne - PIs Oya Beyan and Andreas Beyer
  - Hanover Medical School - PI Michael Marschollek
- **Goal**: provide and support a central terminology server to DICs and the MII/NUM in general, to support semantic interoperability
  - Support for CDS designers in the MII for the development of the CDS
  - Support for DICs to provide a reference server for terminology used in MII/NUM

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MEDICAL INFORMATICS INITIATIVE GERMANY

SU-TermServ

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Semantic interoperability through terminology (servers)

- Data from primary systems (generally) is not interoperable by default, even if accessible in standardized formats and aligned to a defined data model
- Coded data often captured in *local* coding systems
  - Laboratory data: order number codes only for hospital (network)
  - eCRFs in network studies: not always captured using standard codes - but great opportunities for improvement!
- Utilization of standard terminology/-ies is one of the most pressing challenges for achieving semantic interoperability
- Only semantically interoperable data is usable by others.
- Terminology servers are a piece of the infrastructural puzzle to achieve semantic interoperability in defined contexts

Terminology for terminologies

- Not all terminological resources are, strictly speaking, *terminologies*
- Differentiation of different levels based on hierarchical structure (mono-hierarchical vs poly-hierarchical), type of relationships (is-a vs part-of), possibility of combinations (mono-axial vs. multi-axial vs. formal logic)
- Different use cases for each type of terminological artefact
- We are going to say *terminologies* anyways.

Controlled vocabularies	HL7v2 Coding Tables	Flat list of values
(Statistical) classifications	ICD-10	Monoaxial and monohierarchical system of (disjunct) classes
Systematic Nomenclatures **Terminologies** Thesauri	SNOMED II LOINC MeSH	**Terminologies**: multiaxial, polyhierarchical
Formal Terminologies	SNOMED CT	**Terminologies**: multiaxial, polyhierarchical, based on formal definitions of meaning

Common *terminologies* in use in Germany

- **ICD-10-GM** and **ICD-10-WHO**: statistical classifications used mandatorily for coding of morbidities (-GM) and mortalities (-WHO)—derived from international standard
- **OPS**: statistical classification used mandatorily for coding of procedures performed
- **Alpha-ID, Orpha-Codes**: used for coding rare diseases
- **LOINC**: Terminology for representing order identifiers, mainly used in lab settings
- **SNOMED CT**: formal terminology with rich relationships between 360'000 concepts
- **ATC**: classification for pharmaceutical agents
- **PZN**: controlled (??) vocabulary for identifying concrete pharmaceutical products approved for use in Germany
- **UCUM**: grammar for representing interpretable units of measure
- **Artifacts defined by HL7** for use in HL7 v2, HL7 v3, CDA and FHIR: generally controlled vocabularies or classifications
- Artifacts **internal to hospitals**: often simple controlled vocabularies ("catalogs"), sometimes classifications (e.g. lab order numbers)

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FHIR Terminology Module overview

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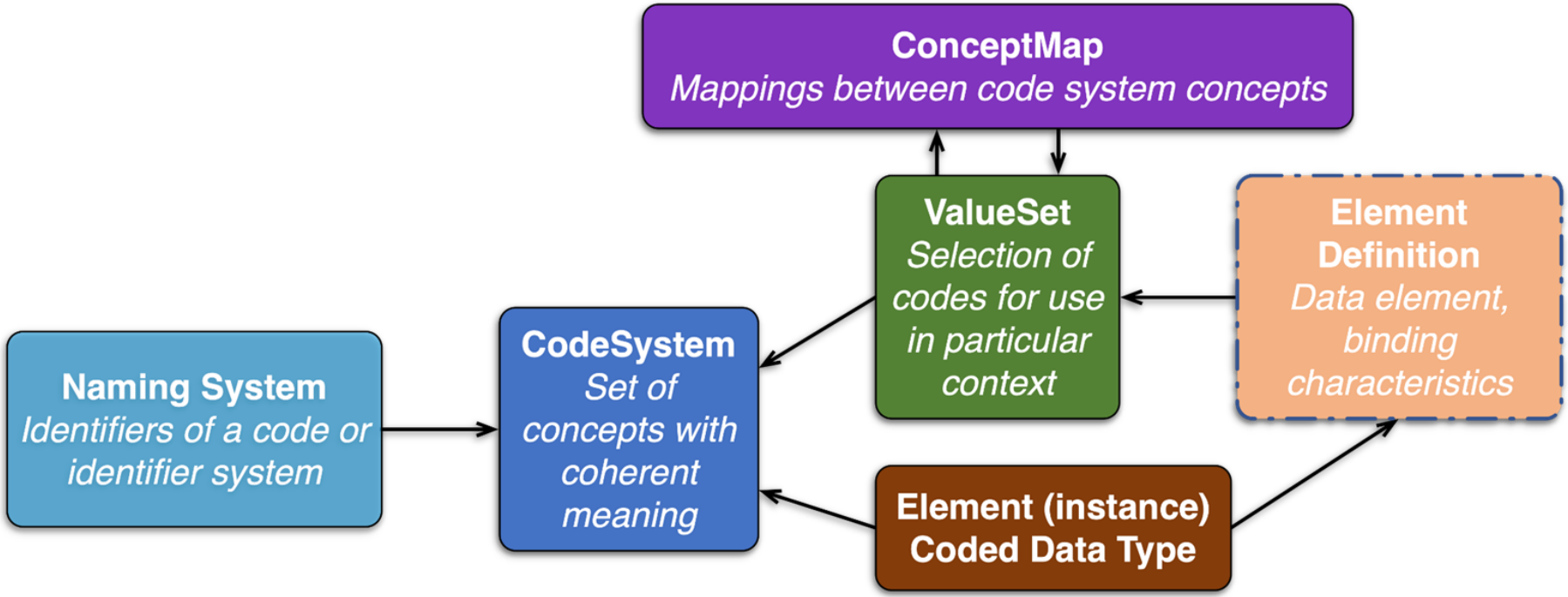
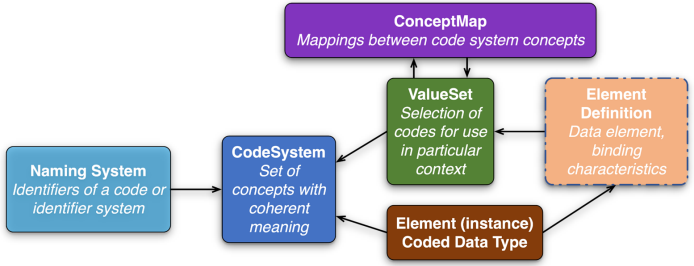


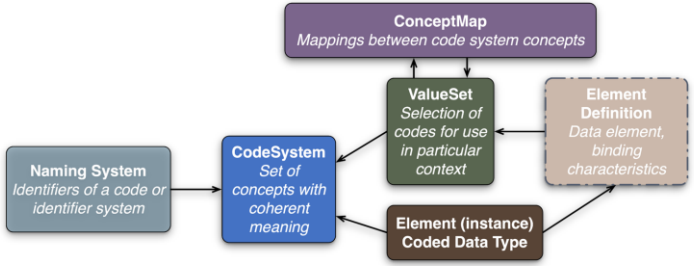
Simplified from: https://www.hl7.org/fhir/terminology-module.html

FHIR Terminology Module



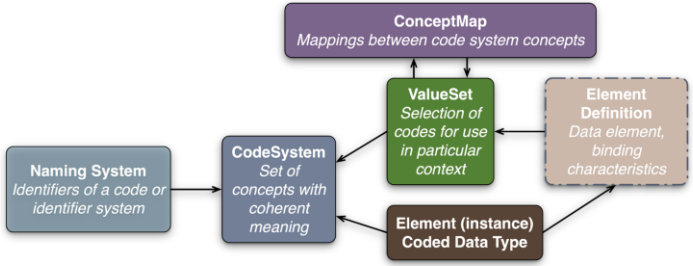
- Simple conceptual model for representing terminological artifacts
- Based on three (four) resource types: *CodeSystem*, *ValueSet*, *ConceptMap*, (NamingSystem)
- Used throughout the entirety of the HL7 FHIR Model
  - Both for coded data elements in further knowledge artifacts (e.g. profiles)
  - And in instances for representing e.g. a patients' administrative gender
- Common to all knowledge artifacts:
  - Use of a canonical URI—does not change over lifetime of the resource; is globally unique; should be a resolvable URL, but doesn't need to be
  - Further identifiers possible (e.g. OIDs)
  - Business `version` element for managing lifecycle of the resource
  - Metadata elements like `name`, `title`, `publisher`, `copyright`, `status`, `description`, …
- Codes are only defined within a CodeSystem, and can't stand alone
  - What is the code "C04"? Is it ICD-10-GM, or ICD-O, or ATC, or …

CodeSystem (CS)



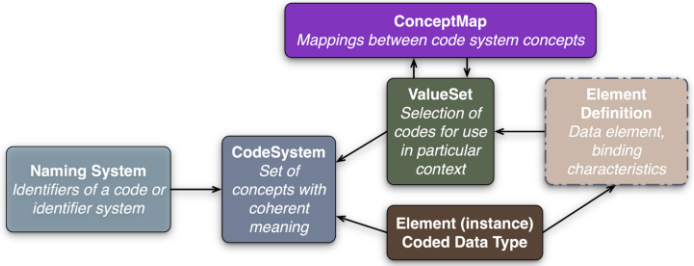
- "The CodeSystem resource is used to **declare the existence of and describe** a code system [...] and its **key properties**, and optionally define a part or all of its **content**" (FHIR CodeSystem)
- Defines the existence of a concept
  - Concepts are assigned unique (within the CS) codes
  - Concepts can declare optional properties (`parent`, `child`, and user-defined further properties)
  - Concepts have a display, and can have optional designations (e.g. translations)
- CS supports different values for `hierarchyMeaning`:
  - `grouped-by`
  - `is-a`
  - `part-of`
  - `classified-with`
- Some CodeSystem resources do not contain the concepts they define
  - SNOMED CT, LOINC: not representable as a FHIR CodeSystem, too complex

ValueSet (VS)



- "A ValueSet resource instance specifies **a set of codes** drawn from **one or more code systems**, intended for **use in a particular context**. Value sets link between CodeSystem definitions and their **use in coded elements**." (FHIR ValueSet)
- 2 aspects:
  - `compose`: "A definition of which codes are **intended** to be in the value set"
  - `expansion`: "The **list** of codes that are actually in the value set under a given set of conditions"
- 2 styles of defining the `compose`:
  - *Extensional:* Explicit list of codes to include
  - *Intensional*: Use of rules
    - *Include all codes that are children of "X"*
    - *Include all SNOMED CT concepts that match an ECL constraint*
- Inclusions as well as exclusions supported
- Optional: pin *compose* statements to a CS version
  - Implications for the expansion of a resource if not stated

ConceptMap (CM)

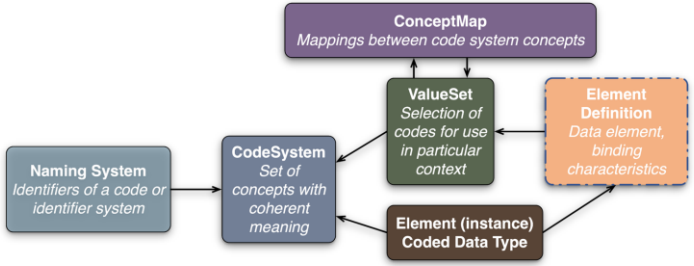


- "A **statement of relationships** from one **set of concepts** to one or more **other concepts**—either concepts in code systems, or data element/data element concepts, or classes in class models." (FHIR ConceptMap)
- "Mappings between code system concepts are **only intended to be defined in the context of a particular business usage**."
  - Scope of a CM (a mapping from CS to CS) defined in terms of a source and target VS
  - Usage context changes mappings, e.g. for "mapping from [SNOMED CT] to [ICD-10] for either data analysis or billing"
- All map elements have a `relationship`

`related-to`	`equivalent`	`source-is-narrower-than-target`	`source-is-broader-than-target`	`not-related-to`

- Substantial changes between FHIR R4 and R5 in definition of CM resource

Use in Profiles

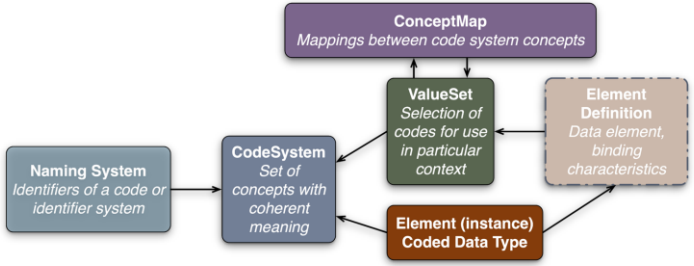


- Profiles/StructureDefinitions **bind** codeable data elements to value domains—i.e. ValueSets
- Bindings have different **binding strengths**

`required`	To be conformant, the concept in this element **SHALL** be from the specified value set.
`extensible`	To be conformant, the concept in this element **SHALL** be from the specified value set **if** any of the codes within the value set can apply to the concept being communicated. If the value set **does not cover** the concept (based on human review), alternate codings (or, data type allowing, text) may be included instead.
`preferred`	Instances are **encouraged** to draw from the specified codes for interoperability purposes but are **not required** to do so to be considered conformant.
`example`	Instances are not expected or even encouraged to draw from the specified value set. The value set merely provides **examples of the types of concepts** intended to be included.

Table from: https://hl7.org/fhir/terminologies.html

Use in FHIR instances



- Several data types with different semantics

`code`	The instance represents the code only. The system is implicit - it is defined as part of the definition of the element, and not carried in the instance.	`Patient.administrativeGender` `Observation.status`
`coding`	A datatype that has a code and a system element that identifies where the definition of the code comes from	*Generally within a `CodeableConcept`*
`CodeableConcept`	A type that represents a concept by plain text and/or one or more coding elements	`Observation.code`
`CodeableReference`	A type that can have either a reference to another resource, or a to a concept using a CodeableConcept	Rarely used

- Resources don't use ValueSets, but concrete codes from CodeSystems

Table from: https://hl7.org/fhir/terminologies.html

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FHIR Terminology Services

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FHIR Terminology Services

- Operations to interact with and query the terminology resources
- Using HTTP requests
  - GET – `{server_url_for_specific_resource_type}/${operation}?{parameter}`
  - POST – `{server_url_for_specific_resource_type}/${operation}` + JSON/XML body

CodeSystem	ValueSet	ConceptMap
$lookup $subsumes $validate-code *$find-matches*	$validate-code $expand	$translate *$closure*

CodeSystem – $lookup

- Lookup information for a specific code
- Required parameters
  - system – url of CodeSystem
  - code – relevant code
- Example (GET):
  - {server_url}}/CodeSystem/$lookup?system=http://fhir.de/CodeSystem/bfarm/icd-10-gm&code=E11.9

Response:

```
{ "resourceType": "Parameters",
  "parameter": [
    { "name": "code",
      "valueCode": "E11.9“},
    { "name": "display",
      "valueString": "Diabetes mellitus,
                      Typ 2: Ohne Komplikationen"},
    { "name": "name",
      "valueString": "Icd10Gm“},
    { "name": "system",
      "valueUri": "http://fhir.de/CodeSystem/bfarm/icd-10-gm"},
    { "name": "version","valueString": "2024“},
    { "name": "property", "part": […]}
  ]
}
```

See: https://build.fhir.org/codesystem-operation-lookup.html

CodeSystem – $subsumes

- Query the hierarchical relationship between two codes
- Results
  - codeA ***equivalent*** codeB – E11.9 und E11.9
  - codeA ***not-subsumed*** codeB – E11.9 und A00
  - codeA **subsumes** codeB – E11 und E11.9
  - codeA ***subsumed-by*** codeB – E11.9 und E11
- Required parameters
  - `system` – url of CodeSystem
  - `codeA` – relevant code
  - `codeB` – relevant code
- Example (GET):

  Response:

  - {{server_url}}/CodeSystem/$subsumes?

    system=http://fhir.de/CodeSystem/bfarm/icd-10-gm&
    codeA=E11&
    codeB=E11.9

```
{ "resourceType": "Parameters",
  "parameter": [
    { "name": "outcome",
                "valueCode":
"subsumes"}
  ]
}
```

See: https://build.fhir.org/codesystem-operation-subsumes.html

CodeSystem – $validate-code

- Check a code for correctness
- Required parameters
  - `url` – url of CodeSystem
  - `code` – relevant code
- Example (GET):
  - {{server_url}}/CodeSystem/$validate-code?url=http://fhir.de/CodeSystem/bfarm/icd-10-gm&code=XXX

Response:

```
{ "resourceType": "Parameters",
  "parameter": [
                { "name": "result", "valueBoolean":
false },
    { "name": "issues",
      "resource": {
        "resourceType": "OperationOutcome",
        "issue": [
          { "severity": "error",
            "code": "code-invalid",
            "details": {
              "text": "The provided code \"XXX\"
                                is not known to belong
to
                          the provided code system
                          \"http://fhir.de/CodeSystem
                                  /bfarm/ icd-10-gm\""
            },
        "location": ["code"]
        }
    ]
},…]}
```

See: https://build.fhir.org/codesystem-operation-validate-code.html

ValueSet – $validate-code

- Check a code for correctness
- Required parameters
  - `url` – url of ValueSet
  - `code` – relevant code
  - `system` – url of ValueSet
- Example (GET):
  - `{{server_url}}/CodeSystem/$validate-code?url=http://fhir.de/CodeSystem/bfarm/icd-10-gm&code=XXX&system=http://fhir.de/ValueSet/bfarm/icd-10-gm`

See: https://build.fhir.org/valueset-operation-validate-code.html

Response:


```
{ "resourceType": "Parameters",
  "parameter": [
                { "name": "result", "valueBoolean":
false },
    { "name": "issues",
      "resource": {
        "resourceType": "OperationOutcome",
        "issue": [
          { "severity": "error",
            "code": "code-invalid",
            "details": {
              "text": "The provided code \"XXX\"
                                is not known to belong
to
                        the provided code system
                        \"http://fhir.de/CodeSystem
                                /bfarm/ icd-10-gm\""
            },
        "location": ["code"]
        }
    ]
},…]}
```

ValueSet – $expand

- Best way to search for codes
- Various options

→ Expand of VS

- {{server_url}}/ValueSet/$expand?url=http://fhir.de/ValueSet/bfarm/icd-10-gm
- Result: entire VS with all 17'065 ICD-10 codes

→ Using string filter

- {{server_url}}/ValueSet/$expand?url=http://fhir.de/ValueSet/bfarm/icd-10-gm&filter=diabetes
- Result: 173 codes containing "diabetes" in the display name

→ Using filter operator (+ ECL)

- POST request – *descendent-of* filter

```
{ "resourceType": "Parameters",
  "parameter": [
    { "name": "valueSet",
      "resource": {
      "resourceType": "ValueSet",
      "compose": {
      "include": [
        { "system": "http://fhir.de/CodeSystem/bfarm/icd-10-gm",
          "filter": [
            { "property": "concept",
              "op": "descendent-of",
              "value": "E11.9" }
          ]}
]}}}]}
```

- Result: 2 codes that are subnodes of E11.9

See: https://build.fhir.org/valueset-operation-expand.html

ConceptMap – $translate

- Mapping code from one ValueSet into a code of another ValueSet

- Required parameters
  - url – url of ConceptMap
  - system – url of ValueSet of source code
  - target – url of ValueSet of target code
  - code – relevant code

- Example (GET):
  - {{server_url}}/ConceptMap/$translate?
    url=https://imi.uni-luebeck.de/fhir/ConceptMap/
    ICD-O-Topography_to_SNOMED&
    system=http://hl7.org/fhir/sid/icd-o-3&
    target=http://snomed.info/sct&
    code=C41.9

Response:

```
{ "resourceType": "Parameters",
  "parameter": [
     { "name": "result","valueBoolean": true},
     { "name": "match",
       "part": [
              { "name": "equivalence",
          "valueCode": "equivalent"},
         { "name": "concept",
              "valueCoding":
              { "code": "87100004",
                "display": "Topography unknown“,
              "system": "http://snomed.info/sct"}
             },
             { "name": "source",
               "valueString": "https://imi.uni-
               luebeck.de/fhir/ConceptMap/
               icd-o-topo-sct"
             }
]}]}
```

See: https://build.fhir.org/conceptmap-operation-translate.html

Operations with POST

- Use of several parameters possible
- Request:
  - {{server_url}}/ValueSet/$expand
  - JSON/XML
- Example:
  - Return all codes that are a subnode of “E11” and contain "nicht als entgleist bezeichnet" in their name

```
{ "resourceType": "Parameters",
  "parameter": [
    { "name": "filter",
      "valueString": "Nicht als entgleist bezeichnet“ },
    { "name": "valueSet",
      "resource": {
        "resourceType": "ValueSet",
        "compose":
          { "include": [
              { "system": "http://fhir.de/CodeSystem/bfarm/icd-10-gm",
                "filter": [
                  { "property": "concept",
                    "op": "descendent-of",
                    "value": "E11“
                  }
]}]}}}]}
```

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Technical details

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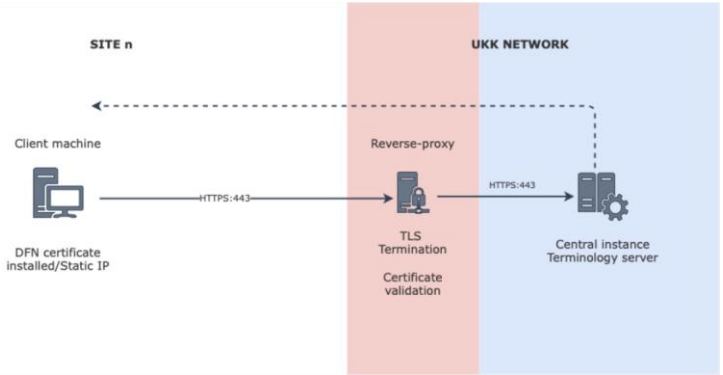
System setup

- Deployment via the Uniklinik Köln DIC
- Currently deployed at https://terminology-highmed.medic.medfak.uni-koeln.de/
- Deployment in conjunction with a HTTP caching proxy
- Read-only access enforced
- Access secured via two ways:
  - Mutual TLS via the Géant PKI (formerly DFN) – **preferred!**
  - IP Allowed-List



From: https://mii-termserv.de/assets/pdf/slides/workshop2023_june/session3_muhammad-adnan_ontoserver.pdf

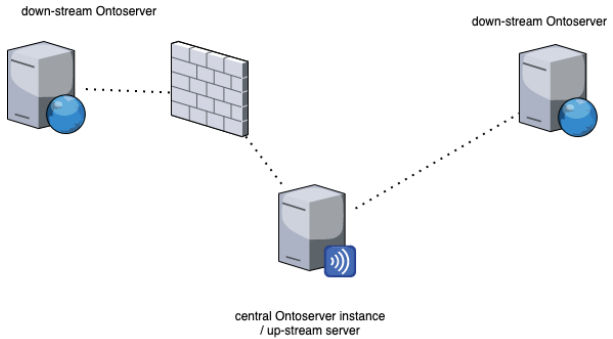
Setup of local servers

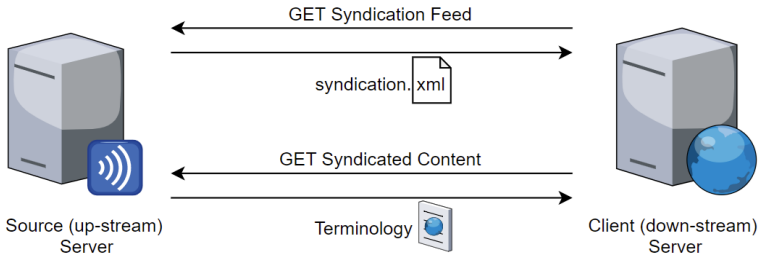
- Provision via a docker image; `docker-compose.yml` is available
- Ontoserver needs a lot of memory to index SNOMED CT from scratch, and not a lot if only using Syndication for this
- Syndication feed currently at: https://terminology-highmed.medic.medfak.uni-koeln.de/synd/syndication.xml
- Configuration of the software using environment variables in the `docker-compose.yml` file
- Documentation for all variables in the Ontoserver documentation

From: https://mii-termserv.de/assets/pdf/slides/workshop2023_june/session3_muhammad-adnan_ontoserver.pdf

Syndication

- Protocol to distribute terminology resources as a feed of resources
- Developed by CSIRO for Ontoserver, but currently being standardized as part of FHIR
- Automatic synchronization **not implemented**, loading resources has to be triggered manually
- Why?
  - Consistency across systems
  - Upstream as a single source of truth
  - Local availability of content - performance, uptime, scalability, security concerns

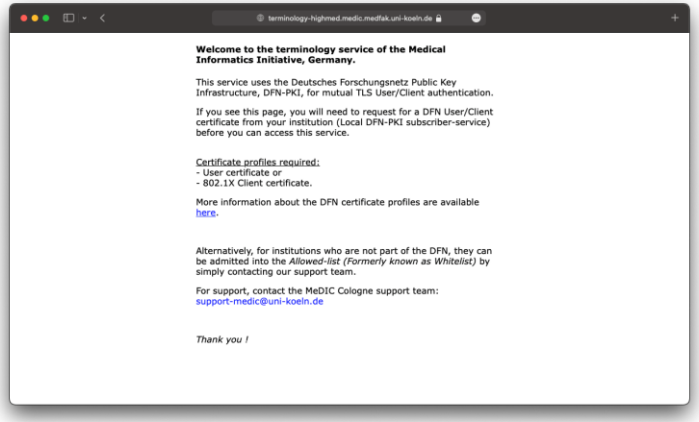


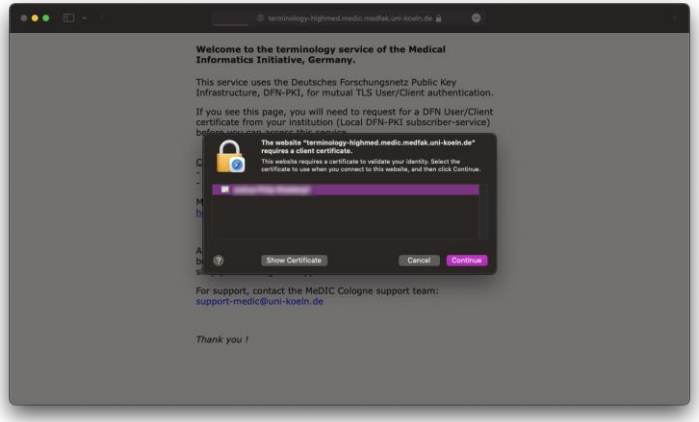


From: https://mii-termserv.de/assets/pdf/slides/workshop2023_june/session2_lukas-emmerich-terminologies_syndication.pdf

Technical access via DFN/GÉANT PKI

- Certificates in the GÉANT chain are granted via the partner institution
- Supported client certificate profiles:
  - Personal certificates for users
  - Certificates issued to servers/DNS names (can also be used for HTTPS communication)
- Further reading: https://doku.tid.dfn.de/de:dfnpki:start
- Certificate has to be provided to the OS/client system to access our Ontoserver
- Ontoserver: load into the container, set environment variables for Syndication





Client tooling

- Graphical tooling
  - Shrimp: Visual CodeSystem/ValueSet browser
    - SNOMED CT ECL browser
  - Snapper: Editor for TS resources
  - OntoCommand: UI for managing resources on the server, including syndication
- SDKs
  - FHIR API is easy to consume
  - General-purpose APIs for HTTP and JSON manipulation
  - Purpose-built APIs for some programming languages (HAPI FHIR @Java, fhir.resources @Python, …)

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Administrative aspects

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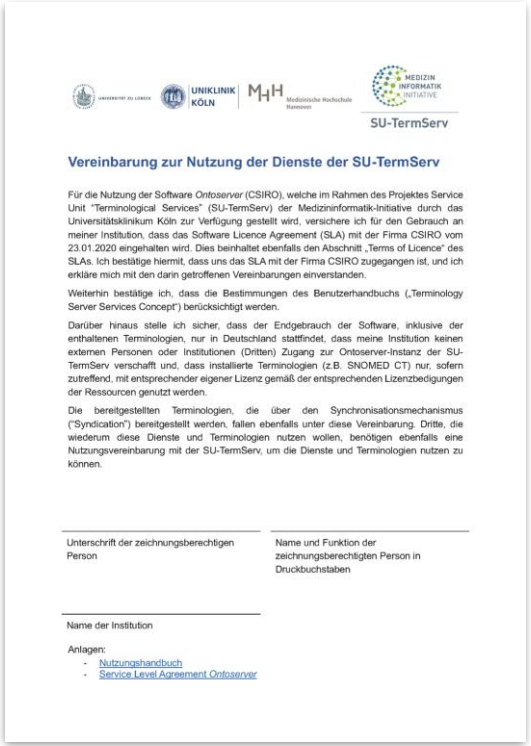
Getting access to the server

- Agreement between requesting institution and SU-TermServ mandatory, available on the website
- Write access is not granted, there is a workflow for requesting uploads



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Vereinbarung zur Nutzung der Dienste der SU-TermServ

Für die Nutzung der Software *Ontoserver* (CSIRO), welche im Rahmen des Projektes Service Unit "Terminological Services" (SU-TermServ) der Medizininformatik-Initiative durch das Universitätsklinikum Köln zur Verfügung gestellt wird, versichere ich für den Gebrauch an meiner Institution, dass das Software Licence Agreement (SLA) mit der Firma CSIRO vom 23.01.2020 eingehalten wird. Dies beinhaltet ebenfalls den Abschnitt „Terms of Licence" des SLAs. Ich bestätige hiermit, dass uns das SLA mit der Firma CSIRO zugegangen ist, und ich erkläre mich mit den darin getroffenen Vereinbarungen einverstanden.

Weiterhin bestätige ich, dass die Bestimmungen des Benutzerhandbuchs („Terminology Server Services Concept") berücksichtigt werden.

Darüber hinaus stelle ich sicher, dass der Endgebrauch der Software, inklusive der enthaltenen Terminologien, nur in Deutschland stattfindet, dass meine Institution keinen externen Personen oder Institutionen (Dritten) Zugang zur Ontoserver-Instanz der SU-TermServ verschafft und, dass installierte Terminologien (z.B. SNOMED CT) nur, sofern zutreffend, mit entsprechender eigener Lizenz gemäß der entsprechenden Lizenzbedingungen der Ressourcen genutzt werden.

Die bereitgestellten Terminologien, die über den Synchronisationsmechanismus ("Syndication") bereitgestellt werden, fallen ebenfalls unter diese Vereinbarung. Dritte, die wiederum diese Dienste und Terminologien nutzen wollen, benötigen ebenfalls eine Nutzungsvereinbarung mit der SU-TermServ, um die Dienste und Terminologien nutzen zu können.

Unterschrift der zeichnungsberechtigen Person

Name und Funktion der zeichnungsberechtigten Person in Druckbuchstaben

Name der Institution

Anlagen:
- Nutzungshandbuch
- Service Level Agreement *Ontoserver*

Contact details

- SU-TermServ Mailing List: team@mail.mii-termserv.de
- MII-Zulip Stream *SU-TermServ*
- Our website is our default communication stream

Literature recommendations

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- FHIR
  - FHIR Docs; Terminology Module; Using Codes in Resources
  - Resource documentation for CodeSystem, ValueSet, ConceptMap
  - Benson & Grieve: Principles of Health Interoperability, 4th ed. 2021 (including parts on SNOMED CT and LOINC)
  - Braunstein: Health Informatics on FHIR: How HL7's API is Transforming Healthcare, 2nd ed. 2022

- SNOMED CT
  - SNOMED CT Foundation Course
  - BfArM (National Release Center)
  - Ingenerf & Drenkhahn: Referenzterminologie SNOMED CT, 1st ed. 2024
  - SNOMED International Confluence

- LOINC
  - Learn LOINC

MEDICAL INFORMATICS INITIATIVE GERMANY

SU-TermServ

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A partnership between the University of Luebeck, the University of Cologne, and the Hannover Medical School

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