Working with FHIR Terminology Services – From a Coder's Perspective

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What I'm Going To Talk About Today

- Interactive creation with Snapper is not always sufficient, and resources want to be consumed
- Accessing FHIR APIs is easy and powerful
- We will do the following today:
  - List resources on the server
  - Validate that a code is contained by a CodeSystem/ValueSet
  - List all codes in a CodeSystem/ValueSet for selection by the user
  - Expansion of SNOMED CT Expression Constraint Language expressions
  - Conversion of a table in a relational DB to FHIR CodeSystem & Mapping to LOINC
- Demonstration of common patterns implemented in Python
  - Some implementations also in Java/Spring Boot, for demonstrating usage patterns

Convention

- https://github.com/itcr-uni-luebeck/fhir-term-samples
- Python Dependencies (via `python -m venv`):
  - `fhir.resources`
  - `requests`
  - `rich, questionary`
- Java Dependencies (via Gradle):
  - `ca.uhn.hapi.fhir:{hapi-fhir-structures-r4, hapi-fhir-client}:5.4.1`
    - `org.apache.httpcomponents:httpcomponents-client`
  - `org.projectlombok:lombok`
  - Spring Boot 2.5.2
- **Cave: You may need to URL-encode request parameters!**

Authentication

- Provide DFN certificate for every request (unless on IP allow list)
- "Workaround" – Use your reverse proxy to handle authentication transparently!
  - also great for adding a cache like Varnish in front of the SSL termination for speed and reliability…

```
location /onto/ {
    proxy_pass              https://terminology-highmed.medic.medfak.uni-koeln.de:443/;
    proxy_ssl_certificate               /etc/pki/ontoserver/certs/cert-with-chain.pem;
    proxy_ssl_certificate_key           /etc/pki/ontoserver/certs/private.pem;
    proxy_ssl_protocols                 TLSv1.2 TLSv1.3;
    proxy_ssl_ciphers                   HIGH:!aNULL:!MD5;
    proxy_ssl_trusted_certificate       /etc/pki/ontoserver/chain/chain.pem;
    proxy_ssl_verify                    on;
    proxy_ssl_verify_depth              5;
}
```

File: nginx/nginx-standalone-proxy/koeln-proxy.conf; nginx/varnish-nginx/

Authentication in Python

```python
import requests
from fhir.resources.capabilitystatement import CapabilityStatement

endpoint = "https://terminology-highmed.medic.medfak.uni-koeln.de/fhir/metadata"
sess = requests.Session() # create a persistent session/connection
cert_file = "../joshua_dfn.pem" # contains both certificate and private key
#cert_file = ("../joshua_dfn.crt", "../joshua_dfn.key") # two files for public/private key
sess.cert = cert_file # applies to all request initiated from the session
response = sess.get(endpoint) # issue the actual request (without preparing it)
conformance = CapabilityStatement(**response.json()) # parse as FHIR
software = conformance.software # access structure of FHIR resource
print(f"{software.name} version {software.version}")

#############
# Ontoserver® version 6.2.3
#############
```

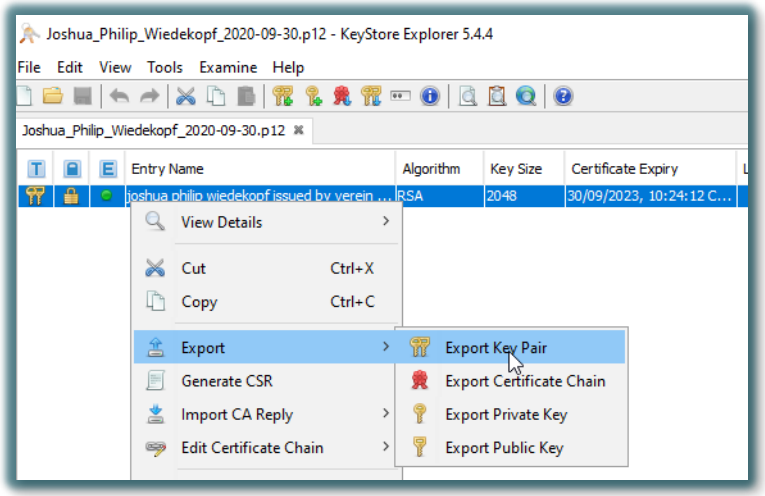
File: python/authz/test-authorization.py

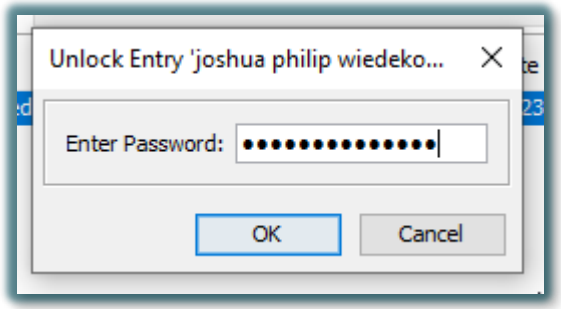
Python: Key Material

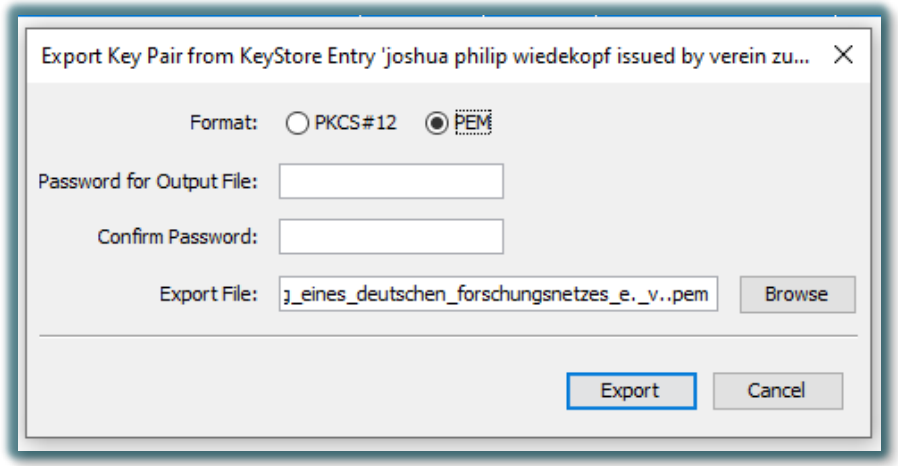
- Python expects OpenSSL/PEM format for key material
- Convert from PKCS#12 using OpenSSL

```
openssl pkcs12 -in path.p12 -out cert_with_key.pem -nodes
```

- Or use Keystore Explorer







Authentication in Java

```
URL keystorePath = ClassLoader.getSystemResource("keystore.jks"); //get keystore resource
char[] password = "pw".toCharArray(); //password of keystore and key (could as well be different)
try {
  SSLContext sslContext = SSLContexts.custom() //load key material, trust comes from system default
    .loadKeyMaterial(keystorePath, password, password).build();
  CloseableHttpClient client = HttpClients.custom().setSSLContext(sslContext).build();
  final FhirContext fhirContext = FhirContext.forR4(); //do this exactly once during app lifecycle
  final IRestfulClientFactory restfulClientFactory = fhirContext.getRestfulClientFactory();
  restfulClientFactory.setHttpClient(client); //all new clients will use custom HTTP Client

  final String serverBase = "https://terminology-highmed.medic.medfak.uni-koeln.de/fhir";
  IGenericClient fhirClient = fhirContext.newRestfulGenericClient(serverBase);
  CapabilityStatement capabilities = fhirClient.capabilities().ofType(CapabilityStatement.class)
    .execute(); //query the metadata and parse as CapabilityStatement (could be subclass)
  System.out.printf("%s %s%n", capabilities.getSoftware().getName(),
    capabilities.getSoftware().getVersion()); //access the nodes of the parsed capability statement
} catch (Exception e) { //… }
```

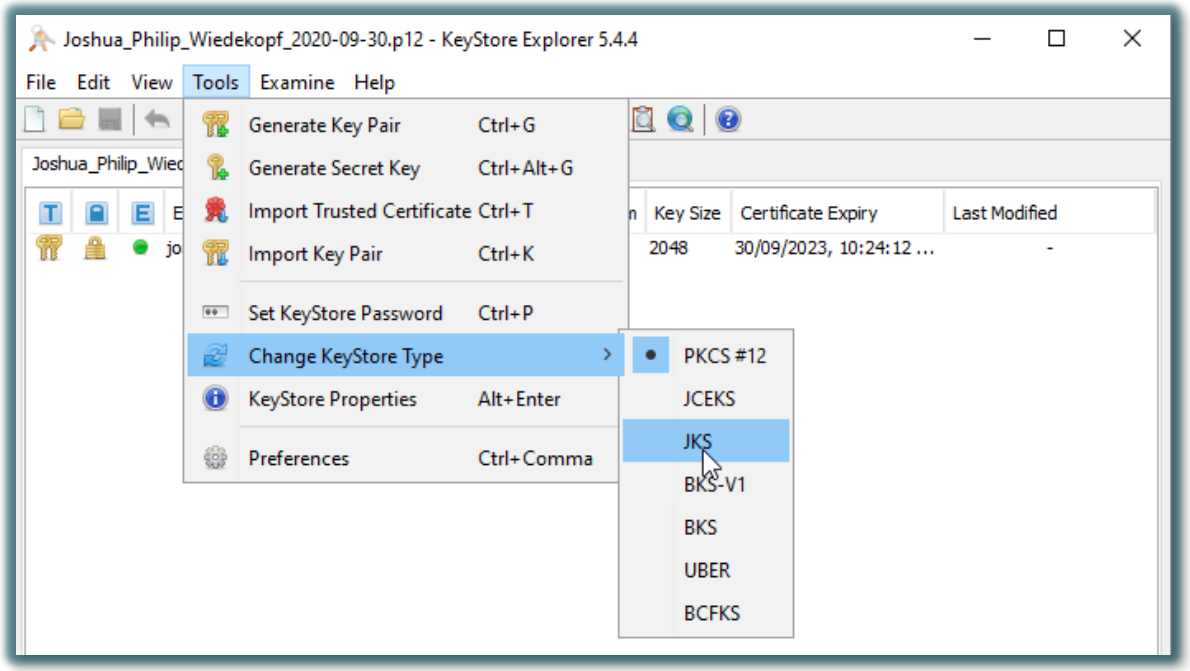
```
Ontoserver 6.2.3

BUILD SUCCESSFUL in 11s
```

File: java/src/main/java/authentication/Authenticate.java

Java: Key Material

- Java works using *keystores* & *truststores*
- Using PKCS#12 is possible, or convert to JKS
  - Use Keystore Explorer



Spring Boot: Authentication – REST Template Bean

```
@SpringBootApplication public class Application {
  @Bean @SneakyThrows public RestTemplate fhirRestTemplate(FhirSslProps fhirSslProps,
  @Value("classpath:keystore.jks") Resource keystoreResource) { //inject resource/settings
    SSLContext sslContext = SSLContexts.custom().loadKeyMaterial(keystoreResource.getURL(),
      fhirSslProps.getKeystorePassword().toCharArray(),
      fhirSslProps.getKeyPassword().toCharArray()).build(); //load material from resource
    CloseableHttpClient httpClient = HttpClients.custom().setSSLContext(sslContext).build();
    ClientHttpRequestFactory clientRequestFactory =
      new HttpComponentsClientHttpRequestFactory(httpClient); //create a new request factory
    return new RestTemplate(clientRequestFactory); //and wrap it as a template
  }
  @Bean public FhirContext fhirContext() { return FhirContext.forR4(); } //create once, use often
  public static void main(String[] args) { SpringApplication.run(Application.class, args); }
}

@Data @ConfigurationProperties(prefix = "fhir.ssl") class FhirSslProps { //holder for SSL settings
  private char[] keystorePassword, keyPassword; //injected from application.yml
}
```

File: spring/src/main/java/de/uzl/itcr/fhir_term_samples/spring/Application.java

Spring Boot: Authentication – FHIR Service Bean

```
@Service public class FhirService {
  private final FhirContext fhirContext;
  private final RestTemplate fhirRestTemplate;
  private final URI endpoint = URI.create(
    "https://terminology-highmed.medic.medfak.uni-koeln.de/fhir".replaceAll("/$", ""));

  @SneakyThrows public <T extends Resource> T getResourceFromPath(String path, Class<T> clazz,
Object... variables) throws HttpClientErrorException {
    String resolved = String.format("%s/%s", endpoint, path);
    ResponseEntity<String> response = fhirRestTemplate.getForEntity(resolved,
      String.class, variables);
    if (response.getStatusCode().is2xxSuccessful())
      return fhirContext.newJsonParser().parseResource(clazz, response.getBody());
    throw new HttpClientErrorException(response.getStatusCode(),
      String.format("Error requesting %s", resolved.toString()));
  }
  //…Constructor…
}
```

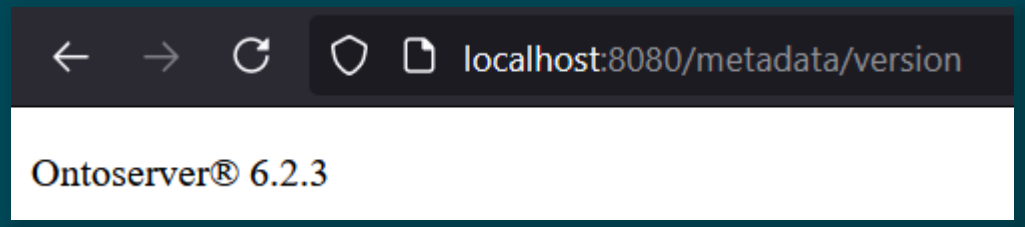
File: spring/src/main/java/de/uzl/itcr/fhir_term_samples/spring/FhirService.java

Spring Boot: Authentication – FHIR Service Bean

```
@Controller @RequestMapping("/metadata")
public class MetadataDemoController {
  private final FhirService fhirService; //inject FHIR service
  private final CapabilityStatement metadata; //request the metadata once, it won't change often

  @SneakyThrows public MetadataDemoController(FhirService fhirService) {
    this.fhirService = fhirService;
    this.metadata = fhirService.getResourceFromPath("metadata", CapabilityStatement.class);
  }

  @SneakyThrows @GetMapping("/version")
  public ModelAndView queryVersion(Map<String, Object> model) {
    model.put("data", String.format("%s %s",
      metadata.getSoftware().getName(), metadata.getSoftware().getVersion()));
      //write data to view model
    return new ModelAndView("simpleData", model);
  }
}
```



File: spring/src/main/java/de/uzl/itcr/fhir_term_samples/spring/metadata/MetadataDemoController.java

List Resources

- https://endpoint.de/fhir/{CodeSystem, ValueSet, ConceptMap}

Search Results (Bundle)

Bundle entries: 34

Type	Id	Title	URL	Version
CodeSystem	900000000000207008-20200309	SNOMED CT core	http://snomed.info/sct	http://snomed.info/sct/900000000000207008/version/20200309
CodeSystem	gecco-codesystem-ecrf-parameter-codes	Parameter Codes eCRF	https://www.netzwerk-universitaetsmedizin.de/fhir/CodeSystem/ecrf-parameter-codes	1.0.4
CodeSystem	atc	Anatomisch-therapeutisch chemische Klassifikation (ATC) Amtliche deutsche Fassung 2020	http://fhir.de/CodeSystem/dimdi/atc	2020
CodeSystem	ops2015	OPS	http://fhir.de/CodeSystem/dimdi/ops	2015
CodeSystem	ops2019	OPS	http://fhir.de/CodeSystem/dimdi/ops	2019
CodeSystem	LOINC-2.68	LOINC	http://loinc.org	2.68
CodeSystem	icd10gm2018	ICD-10	http://fhir.de/CodeSystem/dimdi/icd-10-gm	2018
CodeSystem	gecco-codesystem-frailty-score	Frailty Score	https://www.netzwerk-universitaetsmedizin.de/fhir/CodeSystem/frailty-score	1.0
CodeSystem	ops2021	OPS	http://fhir.de/CodeSystem/dimdi/ops	2021

https://terminology-highmed.medic.medfak.uni-koeln.de/fhir/CodeSystem/

Helper API

```python
from requests import Session

class FhirApi:
    def __init__(self, cert_file: str = "dfn.pem", endpoint: str = "https://terminology-…"):
        self.session = Session(); self.cert_file = cert_file; self.session.cert = self.cert_file
        self.endpoint = endpoint.rstrip("/") # remove slash at end to make sure that joining the path works

    def build_url(self, path: str) -> str:
        return self.endpoint + "/" + path.lstrip("/") # remove slash at beginning also

    def request_and_parse_fhir(self, path: str, resource):
        request_url = self.build_url(path)
        response = self.session.get(request_url)
        if response.status_code >= 200 and response.status_code < 300:
            try: # very simplistic error handling
                return resource(**response.json()) # parse with given class
            except Exception as e:
                raise ValueError(f"Parsing the response was not possible") from e
        else:
            raise SystemError(f"Error requesting from {request_url}, status code {response.status_code}")
```

File: python/get_session.py

List resources

```python
from get_session import FhirApi
from fhir.resources.bundle import Bundle

fhir_api = FhirApi() # use default settings
bundle : Bundle = fhir_api.request_and_parse_fhir("CodeSystem", Bundle)
# request a bundle of Code Systems
resources = [r.resource for r in bundle.entry] # we only care about the entries
resources.sort(key=lambda r: (r.name if r.title is None else r.title, r.version))
# order by name/title and version
for r in resources:
    name = r.name if r.title is None else r.title
    print(f" - '{name}' ({r.url}, version {r.version})")

# - 'AdministrativeGender' (http://hl7.org/fhir/administrative-gender, version 4.0.1)
# - 'Anatomisch-therapeutisch chemische Klassifikation (ATC) Amtliche deutsche Fassung
#   2020'(http://fhir.de/CodeSystem/dimdi/atc, version 2020)
```

File: python/list_resources.py

Code Validation within CodeSystems/ValueSets

- `https://endpoint.de/fhir/CodeSystem/$validate-code?code=A01&url=http://fhir.de/CodeSystem/dimdi/atc`
- `https://endpoint.de/fhir/ValueSet/$validate-code?url=https://www.netzwerk-universitaetsmedizin.de/fhir/ValueSet/known-exposure&system=http://snomed.info/sct&code=840546002`
- **Remember**: Concepts are identified by tuples of *(Canonical URL, Code)!*
- Try your best to not query instances by ID, like https://endpoint.de/fhir/ValueSet/1.2.276.0.76.11.520--20200608123231

Code Validation within CodeSystems

```python
# imports...
# request the list of code systems from API
# prompt user for CodeSystem and code interactively
request_path = f"CodeSystem/$validate-code?code={code}&url={url}&version={version}"
parameters: Parameters = fhir_api.request_and_parse_fhir(request_path, Parameters)
# retrieve the parameters as applicable from the Parameters class
result = next(p for p in parameters.parameter if p.name == 'result').valueBoolean
if result:
  display = next(p for p in parameters.parameter if p.name == "display").valueString
  print(f"The code '{code}' ('{display}') belongs to the CodeSystem.")
else:
  message = next(p for p in parameters.parameter if p.name == "message").valueString
  print(message)
```

File: python/validate_code.py

Code Validation within CodeSystems

```
(venv) →  python git:(main) ✗ python validate_code.py
? Code System to use? (Use arrow keys)
   AdministrativeGender (http://hl7.org/fhir/administrative-gender v4.0.1)
   Anatomisch-therapeutisch chemische Klassifikation (ATC) Amtliche deutsche Fassung 2020 (
   DICOM Controlled Terminology Definitions (http://dicom.nema.org/resources/ont
   FrailtyScore (https://www.netzwerk-universitaetsmedizin.de/fhir/CodeSystem/fr
   GenderAmtlichDE (http://fhir.de/CodeSystem/gender-amtlich-de v1.0.0-alpha1)
   HighmedMreKlassenLokal (http://highmed.org/CodeSystem/mre-klassen-lokal v1.0)
   HighmedResistenzklassenAntibiogrammEucast (http://highmed.org/CodeSystem/resi
   Highmeducc_arzneimittelgruppe (http://highmed.org/CodeSystem/usecase-cardio-a
   ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-gm v2015)
   ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-gm v2016)
   ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-gm v2017)
   ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-gm v2018)
   ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-gm v2019)
   ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-who v2019)
 » ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-gm v2020)
   ICD-O-3 (http://hl7.org/fhir/sid/icd-o-3 vErste Revision)
   LOINC (http://loinc.org v2.68)
   LOINC (http://loinc.org v2.69)
```


```
{
  "resourceType": "Parameters",
  "parameter": [ {
  "name": "result",
  "valueBoolean": false
  }, {
  "name": "message",
  "valueString": "The specified code 'A01' is not known
  } ]
}
```


```
? Code System to use? ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-gm v2020)
? Enter a code:  A01
The code 'A01' ('Typhus abdominalis und Paratyphus') belongs to the CodeSystem.
(venv) →  python git:(main) ✗ python validate_code.py
? Code System to use? ICD-10 (http://fhir.de/CodeSystem/dimdi/icd-10-gm v2020)
? Enter a code:  LOOK-MA-NO-ICD-CODE
The specified code 'LOOK-MA-NO-ICD-CODE' is not known to belong to the specified code
system 'http://fhir.de/CodeSystem/dimdi/icd-10-gm' as of '2020'
```

File: python/validate_code.py

…and within ValueSets

```
? ValueSet to use? AceInhibitorsATC (https://www.netzwerk-universitaetsmedizin.de/fhir/ValueSet/ace-inhibitors-atc v1.0)
? Code System of the code? http://fhir.de/CodeSystem/dimdi/atc version None
? Code: C09A
The code 'C09A' ('ACE-HEMMER, REIN') belongs to the ValueSet.
```

```
? ValueSet to use? BirthSex (https://www.netzwerk-universitaetsmedizin.de/fhir/ValueSet/birth-sex v1.0)
? Code System of the code? (Use arrow keys)
 » http://hl7.org/fhir/administrative-gender version None
   http://fhir.de/CodeSystem/gender-amtlich-de version None
```

```
? ValueSet to use? BirthSex (https://www.netzwerk-universitaetsmedizin.de/fhir/ValueSet/birth-sex v1.0)
? Code System of the code? http://hl7.org/fhir/administrative-gender version None
? Code: QUZ
The specified code 'QUZ' is not known to belong to the specified code system 'http://hl7.org/fhir/administrative-gender'
```

File: python/validate_code_valueset.py

Query Codes from ValueSets with Filter

- Querying the entire CodeSystem is generally not advised
- Use the expansion of the relevant ValueSet instead
- `http://endpoint.de/fhir/ValueSet/$expand`
  `?url=http://hl7.org/fhir/ValueSet/dicom-dcim`
  `&version=01`
  `&filter=frame`
- CodeSystems (often) have canonical URL assigned to implicit ValueSet with all concepts that can be used for $expand

Code Validation within CodeSystems

```
# request the list of code systems with valueSet set, and ValueSets, from API
# prompt user for CS/VS, and for optional filter
request_path = f"ValueSet/$expand?version={version}&url={url}"
if filter.strip():
  request_path += f"&filter={filter}"
valueset: ValueSet = fhir_api.request_and_parse_fhir(request_path, ValueSet)
# prompt user for selection of a code from (filtered) list
lookup_path = f"CodeSystem/$lookup?code={sel_code}&system={sel_url}“
# lookup details of the selected concept
lookup: Parameters = fhir_api.request_and_parse_fhir(request_path, Parameters)
def print_parameter_value(param_name: str, parameters: Parameters, print_name = None):
  # rather easy print routine
print_parameter_value("name", lookup, "CodeSystem Name")
print_parameter_value("version", lookup, "CodeSystem Version")
print_parameter_value("display", lookup, "Code Display")
print_parameter_value("designation", lookup, "Code Designation")
```

File: python/validate_code.py

Query Codes from ValueSets with Filter

```
? Resource to use? CodeSystem http://dicom.nema.org/resources/ontology/DCM v
ersion 01
Selected CodeSystem http://dicom.nema.org/resources/ontology/DCM version 01
? Enter a filter, or leave blank frame
? Which code do you want to inspect? (Use arrow keys)
 » 'Referenced Frames'='121190' (http://dicom.nema.org/resources/ontology/DC
   'Frame Extracting Equipment'='109105' (http://dicom.nema.org/resources/on
   'Referenced Segmentation Frame'='121214' (http://dicom.nema.org/resources
   'Number of Frames'='121140' (http://dicom.nema.org/resources/ontology/DCM
   'Frame of Reference Identity'='125021' (http://dicom.nema.org/resources/o
   'Frame of Reference UID'='112227' (http://dicom.nema.org/resources/ontolo
   'Frame to Frame Analysis'='122499' (htt
   'Position Frame of Reference'='111708'
   'Enhanced Multi-frame Conversion Equipm
   'Acquisition frames corresponding to vo
   'Group of Frames for Display'='113036'
   'Total Number of Radiographic Frames'='
   'Spatially-related frames extracted fro
   'Volume corresponding to spatially-rela
   'Temporally-related frames extracted fr
```

```
? Resource to use? CodeSystem http://dicom.nema.org/resources/ontology/DCM v
ersion 01
Selected CodeSystem http://dicom.nema.org/resources/ontology/DCM version 01
? Enter a filter, or leave blank frame
? Which code do you want to inspect? 'Referenced Frames'='121190' (http://di
com.nema.org/resources/ontology/DCM)
CodeSystem Name: DICOM Controlled Terminology Definitions
CodeSystem Version: 01
Code Display: Referenced Frames
Code Designation: ['{"name": "use", "valueCoding": {"code": "display",
"system": "http://terminology.hl7.org/CodeSystem/designation-usage"}}',
'{"name": "value", "valueString": "Referenced Frames"}']
```

File: python/list_codes_valueset.py

Expand SNOMED CT ECL

- Consider availability of multiple SNOMED CT editions/versions
- https://endpoint.de/fhir/ValueSet/$expand?url=http://snomed.info/sct/32506021000036107/version/20210630/fhir_vs=ecl/%3C%3C%203050601100003610 7%20%7CAustralian%20product%7C%3A%207000001010000361 08%20%7ChasTP%7C%20%3D%201731100016810 5%20%7CPanadol%7C

AU edition

- << 30506011000036107 |Australian product|: 70000010100003610 8 |hasTP| = 17311000168105 |Panadol|
- Make sure to URL-encode your query parameter!

Expand SNOMED CT ECL

```
# request the list of all SNOMED CT version on this server
request_path = "CodeSystem?url=http://snomed.info/sct"
refset_re = r"sct\/(\d*)\/"
version_re = r"(\d*)$"
snomed_bundle = fhir_api.request_bundle(request_path)
# prompt user for selection of one edition, and version of that edition
print(f"Using version {version} for refset {edition}")
encoded_ecl = urllib.parse.quote(ecl) # ask for, and url-encode ECL string
expansion_url = f"ValueSet/$expand?url=http://snomed.info/sct/{edition}/version/{version}
?fhir_vs=ecl/{encoded_ecl}"
vs: ValueSet = fhir_api.request_and_parse_fhir(expansion_url, ValueSet)
print(f"There are {vs.expansion.total} concepts in the expression:")
if vs.expansion.total > 0:
    for concept in vs.expansion.contains:
        print(f" - {concept.code} |{concept.display}|")
```

File: python/expand_ecl.py

Expand SNOMED CT ECL

```
(venv) →  python git:(main) ✗ python expand_ecl.py
? Which edition of SNOMED CT to use? (Use arrow keys)
 » 'NA' (refset 999000031000000106)
   'SNOMED CT United Kingdom Edition reference set module' (refset 999000031000000106)
   'SNOMED CT United Kingdom composition module' (refset 83821000000107)
   'SNOMED Clinical Terms Australian extension' (refset 32506021000036107)
   'module van Nederlandse editie' (refset 11000146104)
```

```
   20190831                                                                    [15/2912]
   20210131
? Which version of the selected refset to use? 20210630
Using version 20210630 for refset 32506021000036107
? ECL Expression? << 30506011000036107 |Australian product|: 700000101000036108 |hasTP| = 173110001681
05 |Panadol|
Encoded ECL expression: %3C%3C%20305060110000361 07%20%7CAustralian%20product%7C%3A%2070000010100003610
8%20%7ChasTP%7C%20%3D%2017311000168105%20%7CPanadol%7C
There are 22 concepts in the expression:
 - 1510571000168109 |Panadol 500 mg suppository, 10|
 - 1510581000168107 |Panadol 500 mg suppository, 10, blister pack|
 - 12095011000036105 |Panadol 500 mg suppository, 24|
 - 18464011000036107 |Panadol 500 mg suppository, 24, strip pack|
```

File: python/expand_ecl.py

Conversion to FHIR Resources

Tables (2)		
lab_codes		CREATE TABLE "lab_codes" ("id" INTEGER, "code" TEXT NOT NULL UNIQUE, "display" TEXT NOT NULL, "unit" TEXT, "loinc" TEXT, PRIMARY KEY("id" AUTOINCREMENT))
id	INTEGER	"id" INTEGER
code	TEXT	"code" TEXT NOT NULL UNIQUE
display	TEXT	"display" TEXT NOT NULL
unit	TEXT	"unit" TEXT
loinc	TEXT	"loinc" TEXT
sqlite_sequence		CREATE TABLE sqlite_sequence(name,seq)

	id	code	display	unit	loinc
	Filter	Filter	Filter	Filter	Filter
1	1	leuke	Leukozyten	#	6690-2
2	2	htke	Hämatokrit	%	4544-3
3	3	nah	Natrium	mol	NULL
4	4	kt	Körpertemperatur	°C	8310-5
5	5	mche	Normoblasten	#	NOTLOINC

- Create CodeSystem for local codes
- ValueSet for mapped LOINC codes
  - Validation of all concepts, since they might be entered-in-error
- ConceptMap for mapping from Local → LOINC

File: legacydb.sqlite3

Conversion to FHIR Resources – Step 1: Query Database

```python
import sqlite3

# select everything from the db
sql = "SELECT code, display, unit, loinc FROM lab_codes;"
sqlconn = sqlite3.connect("../legacydb.sqlite3")
sqlconn.row_factory = sqlite3.Row # access rows using Row interface, instead of tuples
cur = sqlconn.cursor()
# list the available concepts from the DB as list of dict
# loads everything into memory. Propably not a good idea for all real applications...
defined_concepts : List[Dict[str, str]] = []
for row in cur.execute(sql):
    defined_concepts.append(dict(zip(row.keys(), row)))
    # this produces a list of dicts with the column names as keys
```

File: python/create_resources.py

Conversion to FHIR Resources – Step 2: Define Attributes

```
# query for attributes of the FHIR CodeSystem
cs_answers = questionary.form(
    url = questionary.text("Canonical URL of the CodeSystem?"),
    valueSet = questionary.text("Canonical URL of the implicit ValueSet?"),
    version = questionary.text("Version?", validate=NotEmptyValidator) # …).ask()
cs_answers.update({
    "id": cs_answers["name"], # the name is used as the ID for simplicity
    "content": "complete" # content will generally be complete for simple CS
})
code_system = CodeSystem(**cs_answers)
code_system.property = [CodeSystemProperty(**{"code": "unit", "type": "string"})]
```

File: python/create_resources.py

Conversion to FHIR Resources – Step 3: Create Concepts

```
code_system.concept = [
    CodeSystemConcept(**{
        "code": c["code"],
        "display": c["display"],
        "property": [
            CodeSystemConceptProperty(**{
                "code": "unit",
                "valueString": c["unit"]
                })
            ]
        }) for c in defined_concepts
    ]
```

File: python/create_resources.py

Conversion to FHIR Resources – Step 4: Enumerate & Validate LOINC

```python
# create valueset from user answers, as with CodeSystem
valueset_concepts = []
loinc_concepts = []
for concept in defined_concepts:
    loinc = concept["loinc"]
    if loinc is None:
        # loinc is nullable in DB
        continue
    valid, display = fhir_api.lookup_code_display("http://loinc.org", loinc)
    # requests http://endpoint.de/fhir/CodeSystem/$validate-code
    # ?system=http://loinc.org&code={code}
    if not valid:
        # skip the concepts that are invalid
        continue
    loinc_concepts.append({"code": loinc, "display": display})
```

File: python/create_resources.py

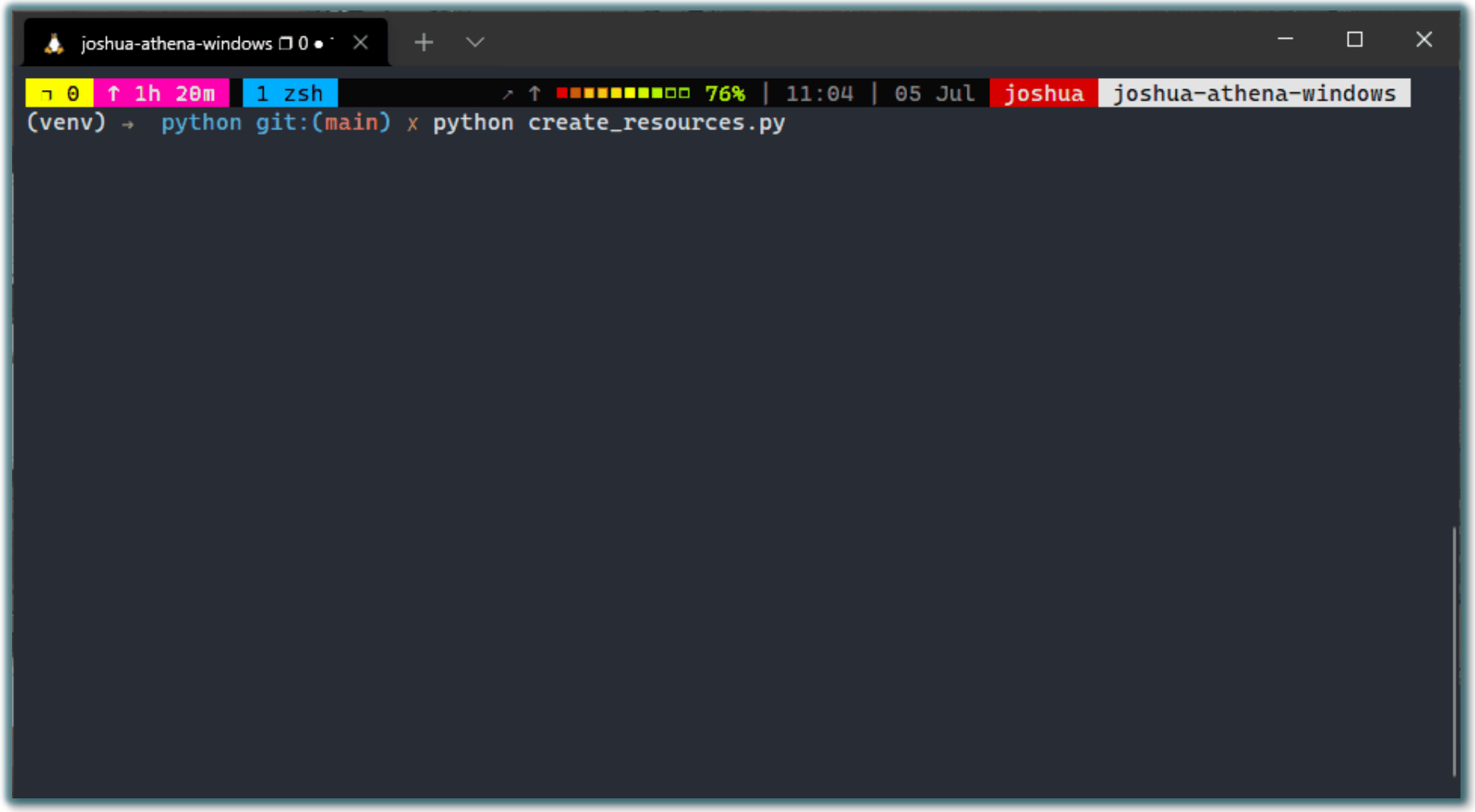
Conversion to FHIR Resources – Step 5: Create VS Compose

```
valueset.compose = ValueSetCompose(**{
    "include": [{
        "system": "http://loinc.org",
        "concept": [ValueSetComposeIncludeConcept(**c) for c in loinc_concepts]
    }]
})

# creating the ConceptMap is more of the same patterns!
```

File: python/create_resources.py

Conversion to FHIR Resources



File: python/create_resources.py

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