



TerminoDiff – Detecting Semantic Differences in HL7 FHIR CodeSystems

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Medical Informatics Europe 2022

Motivation

- Interoperability in healthcare informatics is on the rise
- Structural standards like HL7 FHIR, openEHR
- Use of standard terminology like SNOMED CT, ICD-x, LOINC, etc.

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Aktualisierungsliste ICD-10-GM Version 2021

Kapitel X
Krankheiten des Atmungssystems
(J00-J99)

Sonstige Krankheiten der Pleura
(J90-J94)

J83.- Pneumothorax
Exkl.: Pneumothorax:

- angeboren oder perinatal (P25.1)
- [iatrogen \(J95.80\)](#)
- traumatisch (S27.0)
- tuberkulös (aktuelle Krankheit) (A15-A16)

Pyopneumothorax (J86.-)

Kapitel XI
Krankheiten des Verdauungssystems
(K00-K93)

Sonstige Krankheiten des Darmes
(K55-K64)

K55.- Gefäßkrankheiten des Darmes
Exkl.: Enterocolitis necroticans beim Fetus und Neugeborenen (P77)
[Gastrointestinale Blutung \(K92.0-K92.2\)](#)

K57.- Divertikulose/Divertikelkrankheit des Darmes
Inkl.: Divertikel | Dünndarm, Dickdarm
Divertikulitis |
Divertikulose |


Exkl.: Angeborenes Darmdivertikel (Q43.8)
Appendixdivertikel (K38.2)
Meckel-Divertikel (Q43.0)

K57.0- Divertikulose/Divertikelkrankheit des Dünndarmes mit Perforation und Abszess
Divertikulose/Divertikelkrankheit des Dünndarmes mit Peritonitis
Exkl.: Divertikulose/Divertikelkrankheit sowohl des Dünndarmes als auch des Dickdarmes mit Perforation und Abszess (K57.4-)

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SNOMED CT April 2022 International Edition - SNOMED International Release notes



Remodel 10942006 |Plication (procedure)

10942006 |Plication (procedure) and subtypes underwent structural quality improvement including addition of intermediate primitives and stated attribute-value pairs, where applicable.

Inactivation of 28289002 |Injection of therapeutic agent (procedure)

28289002 |Injection of therapeutic agent (procedure) was inactivated due to the ambiguous nature of 'therapeutic agent'. The subtypes were either treated similarly or remodeled to the appropriate place in the hierarchy.

Situation With Explicit Context

Inactivation of Administrative Concepts

The following situation hierarchy concepts have been inactivated due to the lack of unambiguous meaning and reproducible use case among healthcare systems:

- 394827008 |Personal administration (situation)
- 394824001 |Private prescription (situation)
- 182819002 |Replacement therapy (situation)
- 394822002 |Prescription types (situation)
- 394829006 |Past medication (situation)
- 182817000 |Drug prescription (situation)
- 703955006 |Prescription telephone order (situation)

Sonstige Krankheiten des Darmes (K55-K64)

K55.- Gefäßkrankheiten des Darmes

Exkl.: Enterocolitis necroticans beim Fetus und Neugeborenen (P77)
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K57.- DivertikuloseDivertikelkrankheit des Darmes

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Exkl.: Divertikulose|is sowohl des Dünndarmes als auch des Dickdarmes mit Perforation und Abszess (K57.4-)

Interpreting the Delta

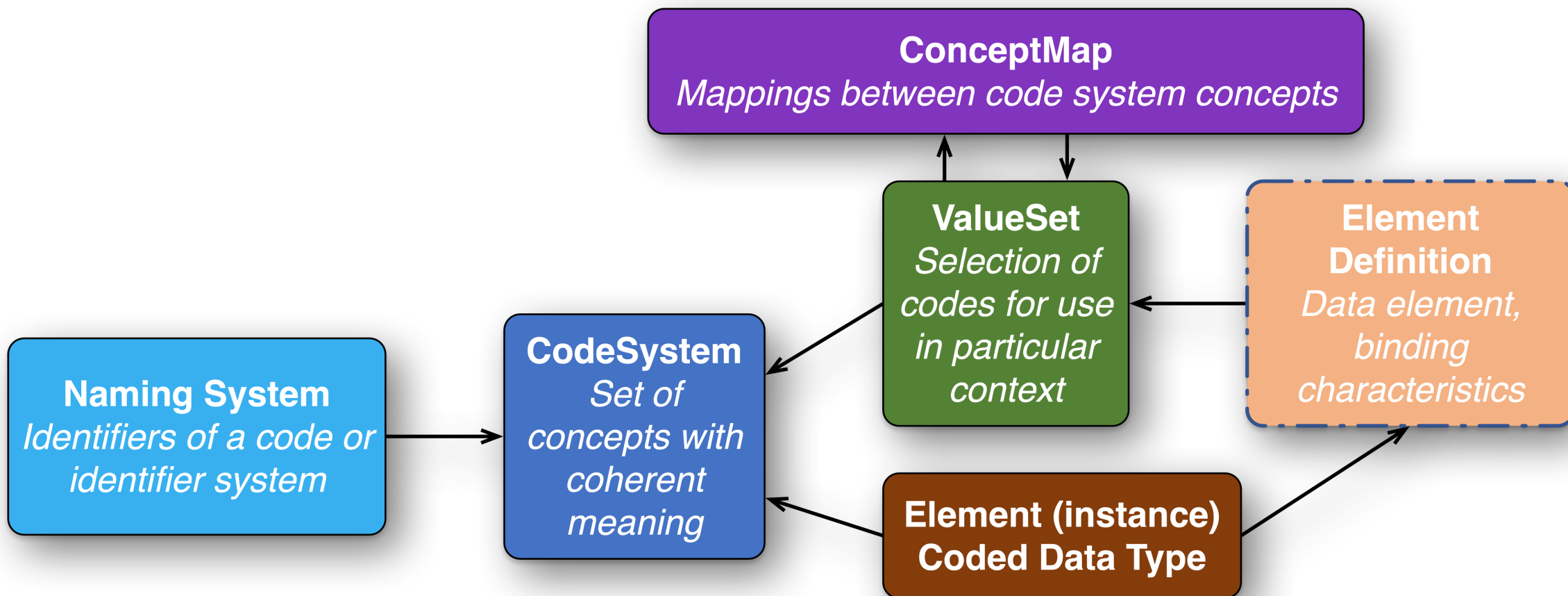
- Very different levels of quality for difference lists and maintenance in terminologies
 - ICD-10-GM has highly-informative PDF reports, but only simple CSV delta files
 - SNOMED CT maintains historical associations forever and can generate Delta packages between releases
- What about non-standard terminological resources?
 - Specifically, FHIR Terminology resources

```

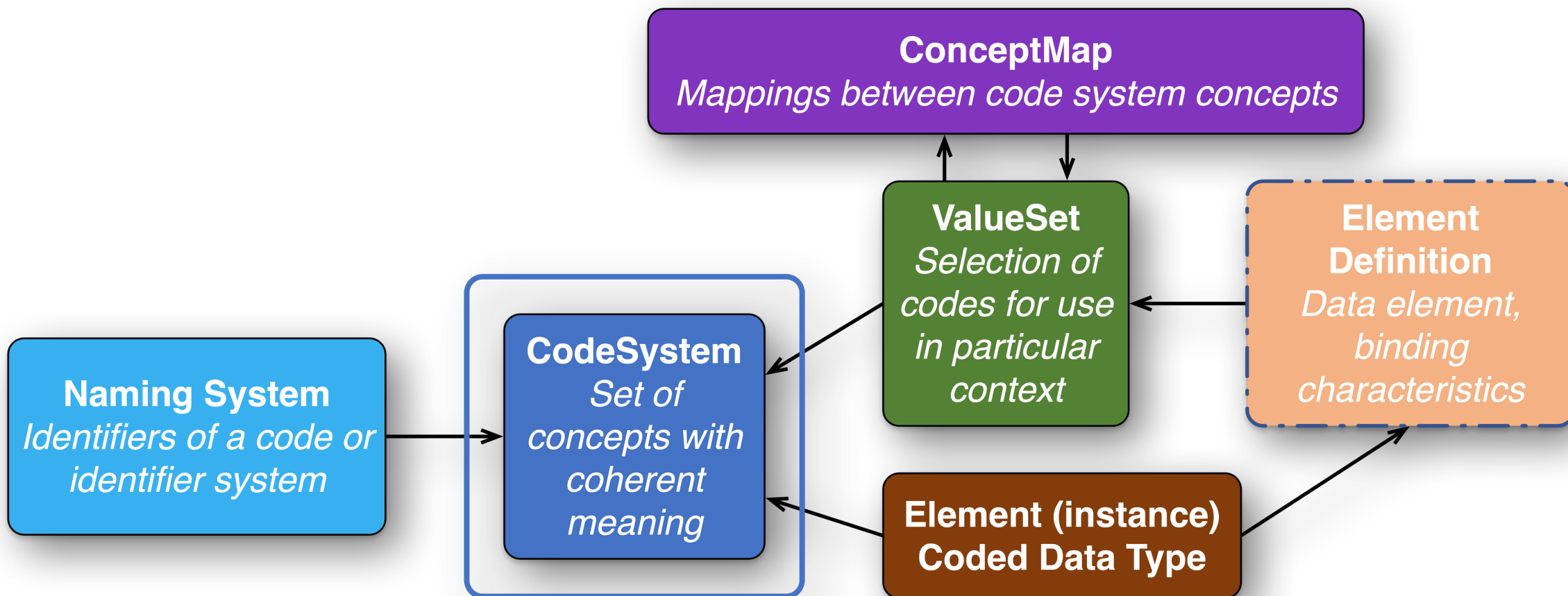
4563 K56.0;K56.0;A;A
4564 K56.1;K56.1;A;A
4565 K56.2;K56.2;A;A
4566 K56.3;K56.3;A;A
4567 K56.4;K56.4;A;A
4568 K56.5;K56.5;A;A
4569 K56.6;K56.6;A;A
4570 K56.7;K56.7;A;A
4571 K57.00;K57.02;A;
4572 K57.01;K57.03;A;
4573 K57.02;K57.02;A;
4574 K57.03;K57.03;A;
4575 K57.10;K57.10;A;A
4576 K57.11;K57.11;A;A
4577 K57.12;K57.12;A;A
4578 K57.13;K57.13;A;A
    
```

| id | effectiveTime | active | moduleId | conceptId | languageCode | typeId | term | caseSignificanceId | group |
|----|--------------------|--------|-------------------|-----------|--------------|-------------------|--|--------------------|-------|
| 1 | | | | | | | | | |
| 2 | 1655016 20220430 | 0 | 90000000000207008 | 341009 | en | 90000000000013009 | Reaction to blood group incompatibility in transfusion | | |
| 3 | 1656015 20220430 | 0 | 90000000000207008 | 341009 | en | 90000000000013009 | Incompatible blood transfusion | | |
| 4 | 10797012 20220430 | 0 | 90000000000207008 | 5883007 | en | 90000000000013009 | Adolescent change of voice | | |
| 5 | 18423015 20220430 | 1 | 90000000000207008 | 10601006 | en | 90000000000013009 | Leg pain | | |
| 6 | 29464017 20220430 | 1 | 90000000000207008 | 17426009 | en | 90000000000013009 | Bahiagrass | | |
| 7 | 32813019 20220430 | 0 | 90000000000207008 | 19479007 | en | 90000000000013009 | Muscle flap of head and neck | | |
| 8 | 96801012 20220430 | 0 | 90000000000207008 | 58249006 | en | 90000000000013009 | Lactobacillus casei ss. pseudoplantarum | | |
| 9 | 109042010 20220430 | 0 | 90000000000207008 | 65635008 | en | 90000000000013009 | Myocutaneous flap of head and neck | | |
| 10 | 126250019 20220430 | 1 | 90000000000207008 | 76009000 | en | 90000000000013009 | Upper | | |

HL7 FHIR Terminology

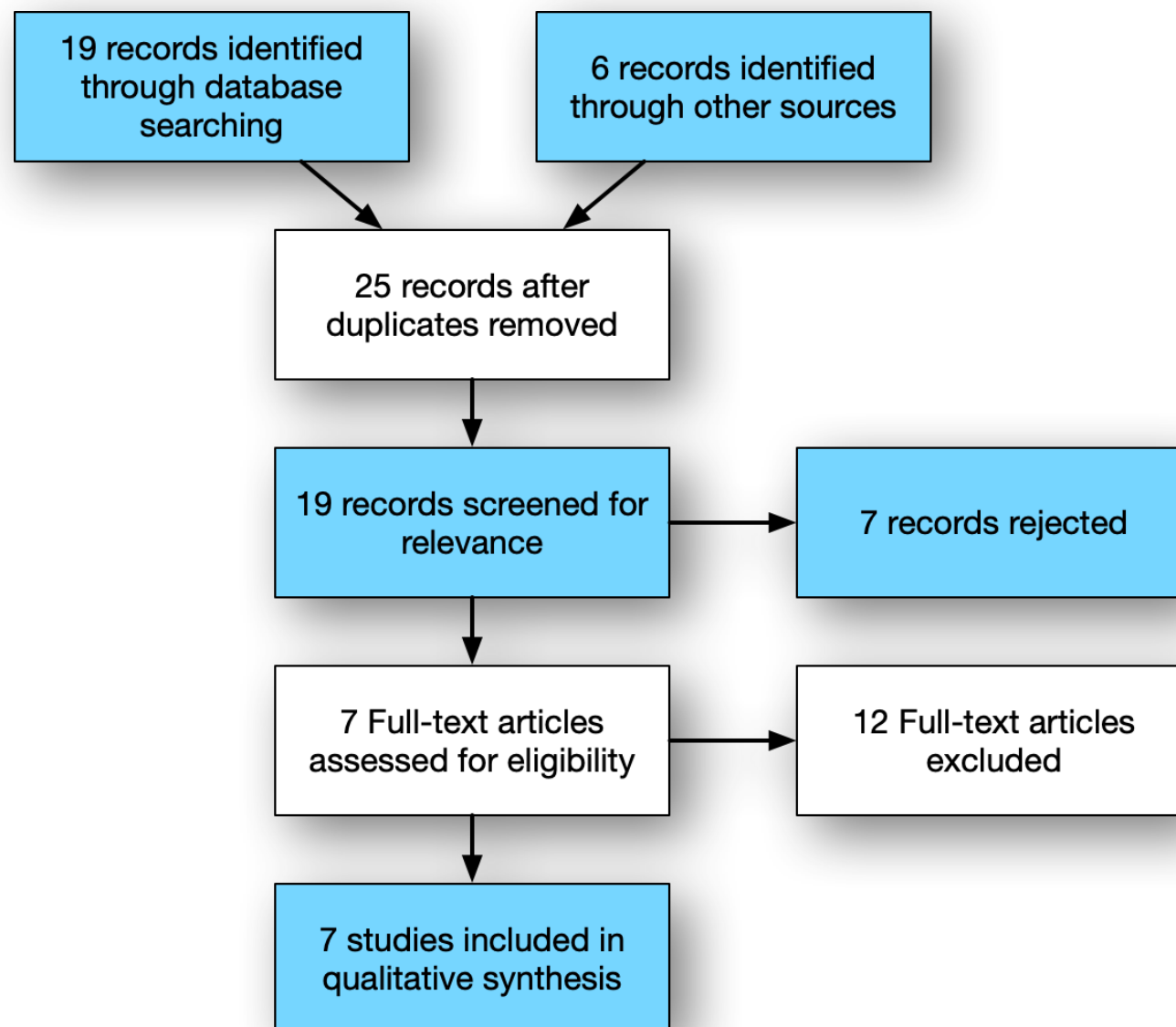


HL7 FHIR Terminology



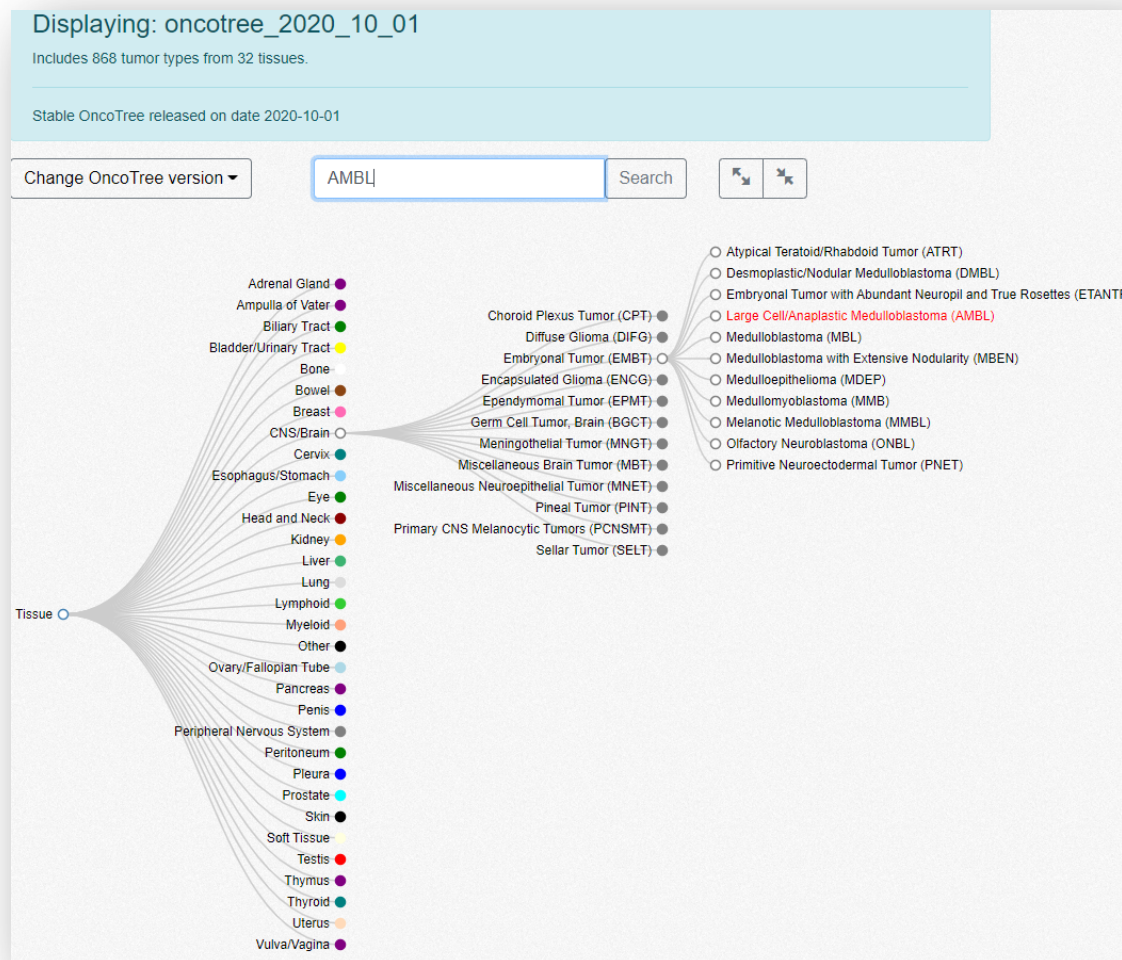
Related Work

- Scoping review
 - ("fhir" OR "ontology" OR "rdf" OR "terminology") AND ("diff" OR "change" OR "difference" OR "version")
- Few records found in general
- No related work for FHIR TS
 - Few publications regarding FHIR TS in general, currently
- Similar problems in domain of formal ontologies / semantic web



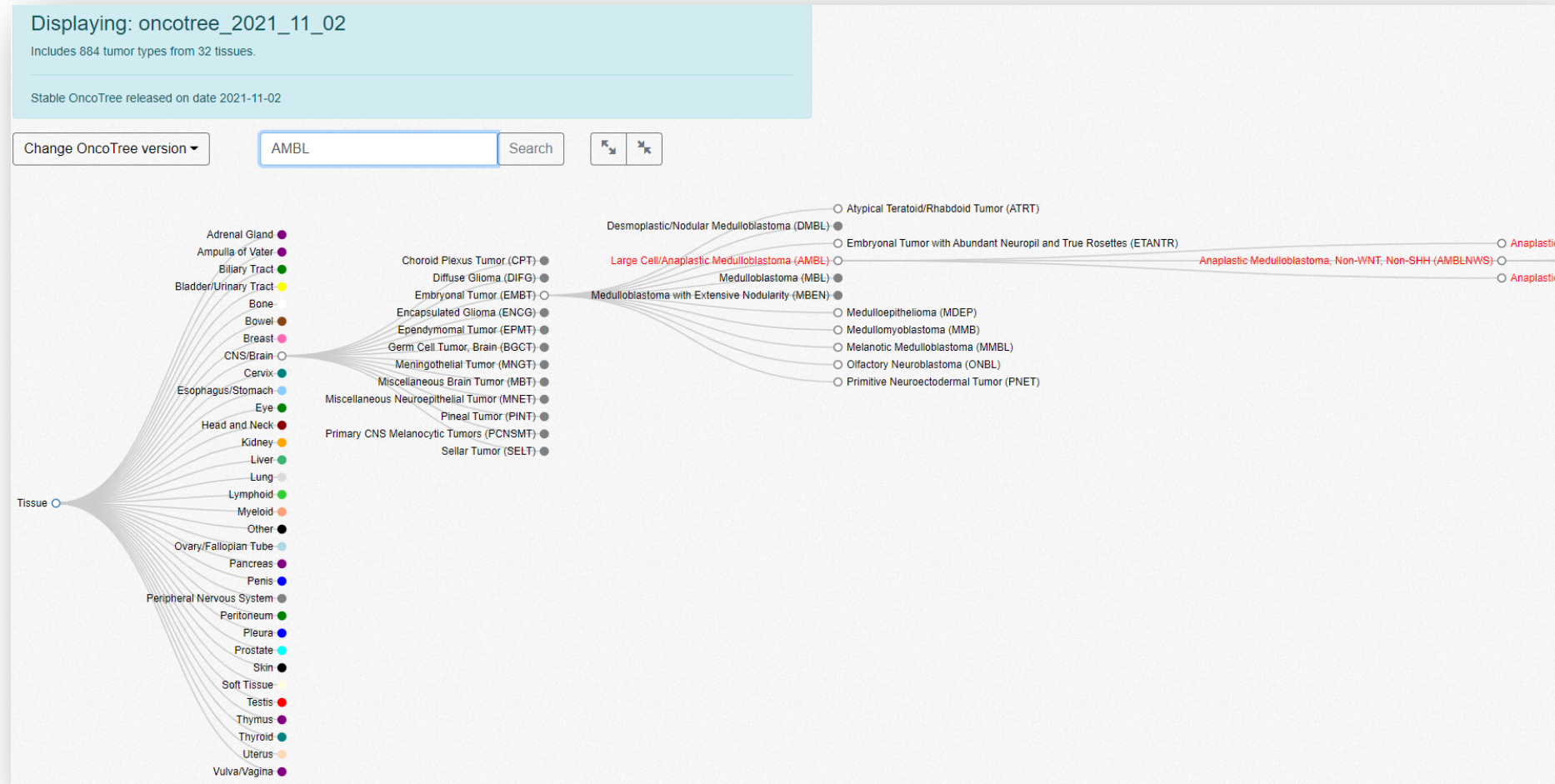
OncoTree

- Cancer classification System, maintained by MSKCC, NY, USA
- 2021-11-02: 884 tumor types, 32 tissues
- Not natively FHIR, but conversion easy



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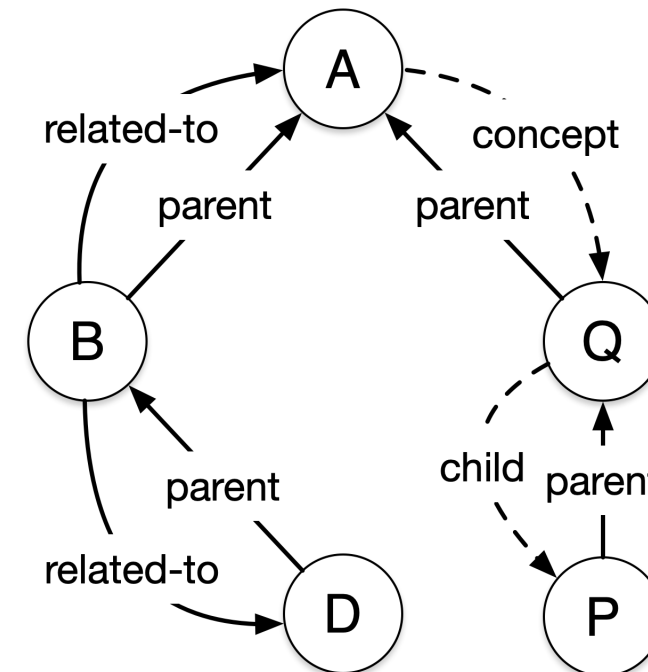
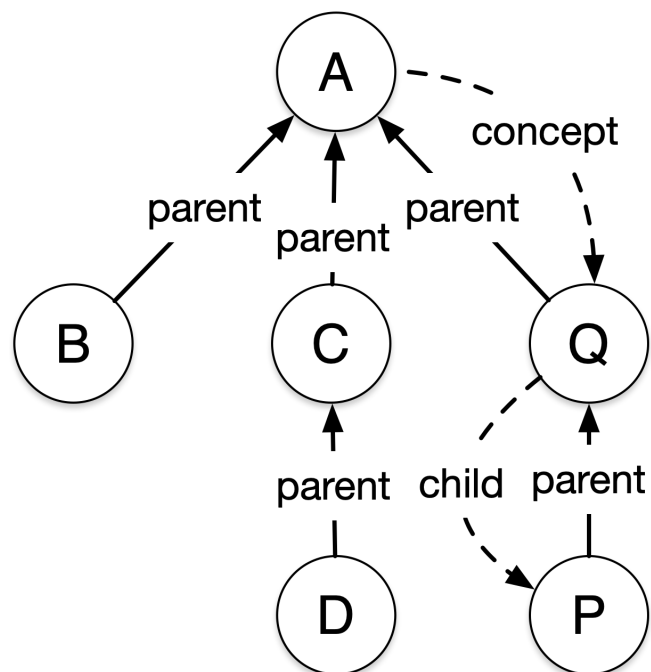
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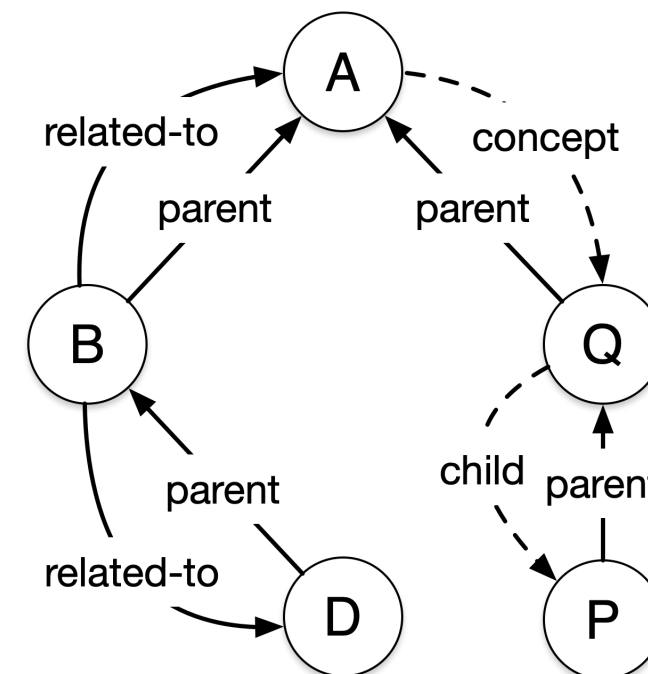
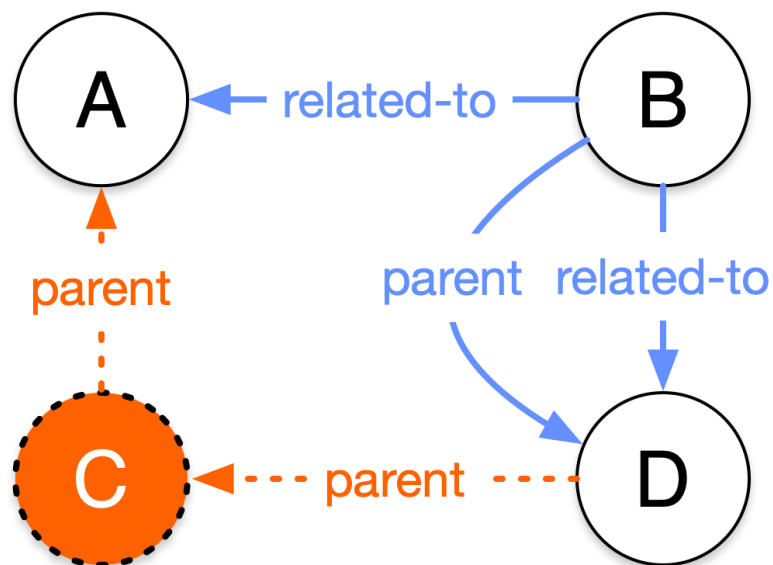
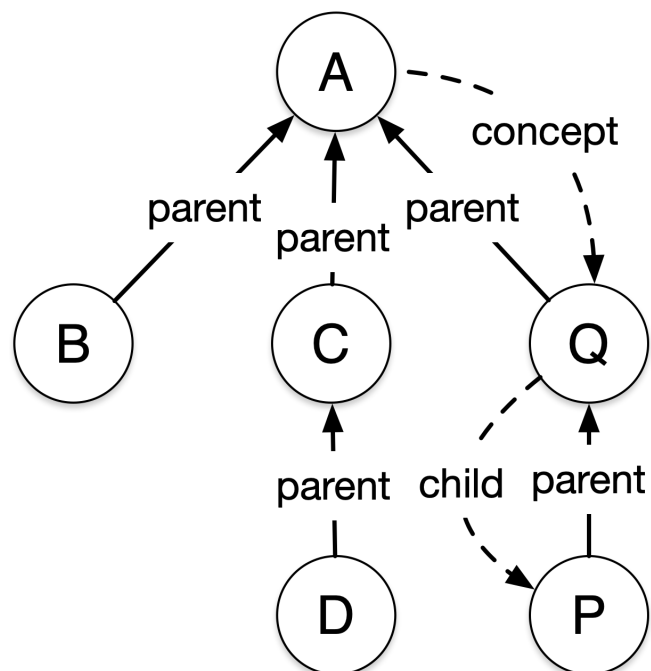
November 2, 2021

- **New Stable Release** OncoTree version `oncotree_2021_11_02` is now the latest stable release. The previous stable version is still accessible as version `oncotree_2020_10_01`.
- **New nodes added:**
 - Desmoplastic/Nodular Medulloblastoma, NOS (DMBLNOS)
 - Desmoplastic/Nodular Medulloblastoma, SHH Subtype (DMBLSHH)
 - Anaplastic Medulloblastoma, NOS (AMBLNOS)
 - Anaplastic Medulloblastoma, Non-WNT, Non-SHH (AMBLNWS)
 - Anaplastic Medulloblastoma, Group 3 (AMBLNWSG3)
 - Anaplastic Medulloblastoma, Group 4 (AMBLNWSG4)
 - Anaplastic Medulloblastoma, SHH Subtype (AMBLSHH)
 - Medulloblastoma, NOS (MBLNOS)
 - Medulloblastoma, Non-WNT, Non-SHH (MBLNWS)
 - Medulloblastoma, Group 3 (MBLG3)
 - Medulloblastoma, Group 4 (MBLG4)
 - Medulloblastoma, SHH Subtype (MBLSHH)
 - Medulloblastoma, WNT Subtype (MBLWNT)
 - Medulloblastoma with Extensive Nodularity, NOS (MBENNOS)
 - Medulloblastoma with Extensive Nodularity, SHH Subtype (MBENSHH)
 - Pancreatic Neuroendocrine Carcinoma (PANEC) *in the original version of this news release this node was accidentally omitted*
- **Nodes reclassified**
 - The following list of oncotree codes had the mainType shortened to drop the suffix "NOS": ADRENAL_GLAND, AMPULLA_OF_VATER, BILIARY_TRACT, BLADDER, BONE, BOWEL, BRAIN, BREAST, CERVIX, EYE, HEAD_NECK, KIDNEY, LIVER, LUNG, LYMPH, MYELOID, OTHER, OVARY, PANCREAS, PENIS, PERITONEUM, PLEURA, PNS, PROSTATE, SKIN, SOFT_TISSUE, STOMACH, TESTIS, THYMUS, THYROID, UTERUS, VULVA
 - Cholangiocarcinoma (CHOL) now has direct parent Intraductal Papillary Neoplasm of the Bile Duct (IPN) [previously: Biliary Tract (BILIARY_TRACT)]
 - Gallbladder Cancer (GBC) now has direct parent Intracholecystic Papillary Neoplasm (ICPN) [previously: Biliary Tract (BILIARY_TRACT)]

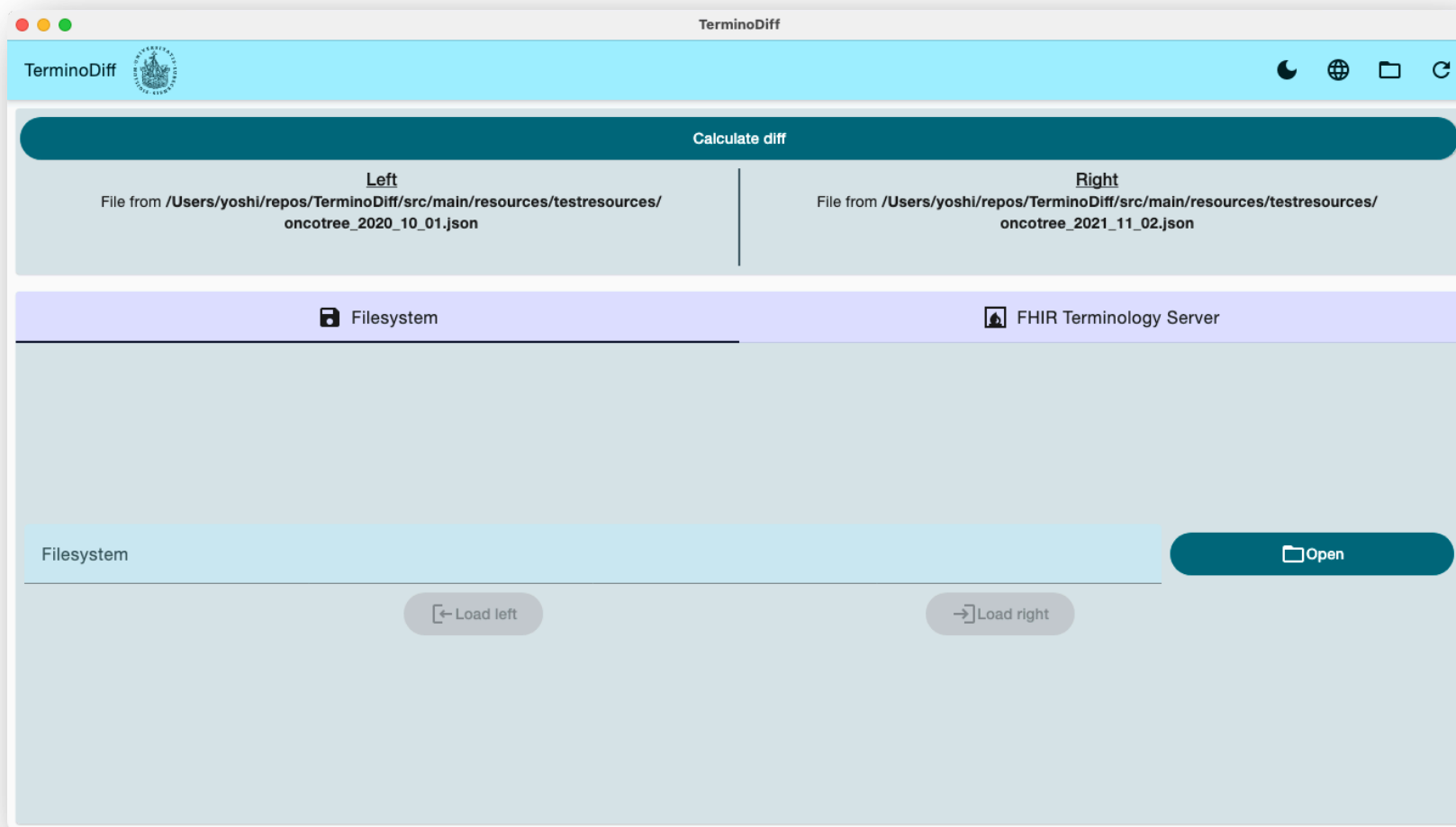
Difference Graphs



Difference Graphs



TerminoDiff



- GPLv3
- Kotlin + Jetpack Compose for cross-platform
- Support for local and remote CodeSystems
- Metadata and concept differences shown

TerminoDiff

The screenshot shows the TerminoDiff web application interface. At the top, there is a 'Calculate diff' button. Below it, two panels are shown: 'Left' and 'Right'. The 'Left' panel shows a file from '/Users/yoshi/repos/TerminoDiff/src/main/resources/testresources/oncotree_2020_10_01.json'. The 'Right' panel shows a file from '/Users/yoshi/repos/TerminoDiff/src/main/resources/testresources/oncotree_2021_11_02.json'. Below these panels, there are tabs for 'Filesystem' and 'FHIR Terminology Server'. The 'FHIR Terminology Server' tab is active, showing a server URL 'https://r4.ontoserver.csiro.au/fhir'. Below the server information, there are buttons for 'Load left', 'VRead', and 'Load right'. A table below shows the results of the diff calculation, with 1530 elements. The table has columns for 'Select', 'Canonical URL', 'Version', 'Name', 'Title', and 'Meta Version'. The selected row is highlighted in blue.

| Select | Canonical URL | Version | Name | Title | Meta Version |
|----------------------------------|--|------------|-----------------------------|--|--------------|
| <input type="radio"/> | https://terminology.hl7.org/CodeSystem/v3-RoleClass-test2 | 2018-08-12 | v3.RoleClass | v3 Code System RoleClass | 1 |
| <input type="radio"/> | https://test.terminologi.ehelse.no/fhir/CodeSystem/NCxP | 0.1 | NCxP | NCMP-NCSP-NCRP - Norsk klinisk prosedyrekodeverk | 1 |
| <input type="radio"/> | http://ontoserver.csiro.au/example/italian-diseases/fixe- | 1.1.2 | Italian_diseases_fixed_file | Italian diseases fixed file | 1 |
| <input type="radio"/> | https://www.test.com | null | Test | test | 1 |
| <input checked="" type="radio"/> | https://www.samisaude.com.br/fhir/r4/CodeSystem/encounter- | 1.0 | Encounter_admission | Tipo de admisão no atendimento | 3 |

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TerminoDiff

The screenshot shows the TerminoDiff web application interface. At the top, there are navigation buttons: "Left graph", "Difference Graph" (selected), "ConceptMap", and "Right graph". Below this is a "Concept Diff" section with filters: "All (885)", "Only identical (861)", "Only different (24)", "Only concept differences (8)", "Only left (0)", and "Only right (16)". The main content is a table titled "24 concepts" with columns: Code, Graph, Display, Definition, Properties / Designations, and Overall. Below this is a "Metadata Diff" section titled "24 elements" with columns: Property, Comparison, Left value, and Right value.

| Code | Graph | Display | Definition | Properties / Designations | Overall |
|-----------|-------|-----------------------------------|------------|---------------------------|--------------|
| AMBLNOS | | Anaplastic Medulloblastoma, NOS | null | 3 P / 0 D | → Only right |
| AMBLNWS | | Anaplastic Medulloblastoma, Non- | null | 3 P / 0 D | → Only right |
| AMBLNWSG3 | | Anaplastic Medulloblastoma, Group | null | 3 P / 0 D | → Only right |

| Property | Comparison | Left value | Right value |
|---------------|------------|---|--------------------------------|
| Date | Different | Thu Oct 01 00:00:00 CEST 2020 | Tue Nov 02 00:00:00 CET 2021 |
| ID | Different | CodeSystem/oncotree-2020-10-01 | CodeSystem/oncotree-2021-11-02 |
| Version | Different | 20201001 | 20211102 |
| Canonical URL | Identical | http://oncotree.mskcc.org/fhir/CodeSystem | |

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| Property | Comparison | Left value | Right value |
|-----------------|------------|---|--------------------------------|
| Date | Different | Thu Oct 01 00:00:00 CEST 2020 | Tue Nov 02 00:00:00 CET 2021 |
| ID | Different | CodeSystem/oncotree-2020-10-01 | CodeSystem/oncotree-2021-11-02 |
| Version | Different | 20201001 | 20211102 |
| Canonical URL | Identical | http://oncotree.mskcc.org/fhir/CodeSystem | |
| Case-Sensitive? | Identical | FALSE | |
| Compositional? | Identical | FALSE | |
| Contact | Identical | 0 items | |
| Content | Identical | Complete | |

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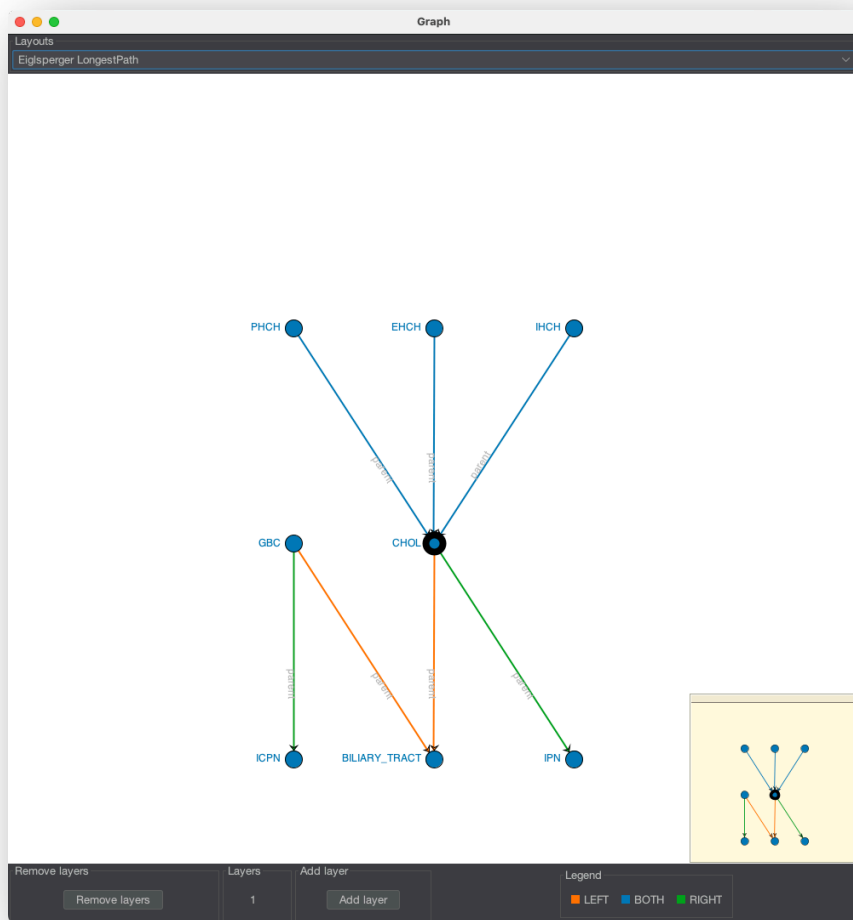
The screenshot displays the TerminoDiff web application interface. At the top, there are navigation buttons for 'Left graph', 'Difference Graph', 'ConceptMap', and 'Right graph'. Below this, the 'Concept Diff' section shows a summary of 24 concepts with filters for 'All (885)', 'Only identical (861)', 'Only different (24)', 'Only concept differences (8)', 'Only left (0)', and 'Only right (16)'. A table lists the concepts with columns for Code, Graph, Display, Definition, Properties / Designations, and Overall. The 'Overall' column uses color-coded buttons to indicate the status of each concept: orange for 'Only right' (PANEC) and yellow for 'Different' (CHOL, EHCH, GBAD, GBASC, GBC). Below the Concept Diff is the 'Metadata Diff' section, which shows 24 elements. A table displays a comparison of the 'Date' property, showing a 'Different' status with a yellow button, comparing 'Thu Oct 01 00:00:00 CEST 2020' on the left and 'Tue Nov 02 00:00:00 CET 2021' on the right.

| Code | Graph | Display | Definition | Properties / Designations | Overall |
|-------|-------|--|----------------|---------------------------|--------------|
| PANEC | ✳ | Pancreatic Neuroendocrine | null | 3 P / 0 D | → Only right |
| CHOL | ✳ | Identical Cholangiocarcinoma | Identical null | 5 Δ2 P / 0 D | Different |
| EHCH | ✳ | Identical Extrahepatic Cholangiocarcinoma | Identical null | 3 Δ1 P / 0 D | Different |
| GBAD | ✳ | Identical Gallbladder Adenocarcinoma, NOS | Identical null | 3 Δ1 P / 0 D | Different |
| GBASC | ✳ | Identical Adenosquamous Carcinoma of the Gallbladder | Identical null | 3 Δ1 P / 0 D | Different |
| GBC | ✳ | Identical Gallbladder Cancer | Identical null | 5 Δ2 P / 0 D | Different |

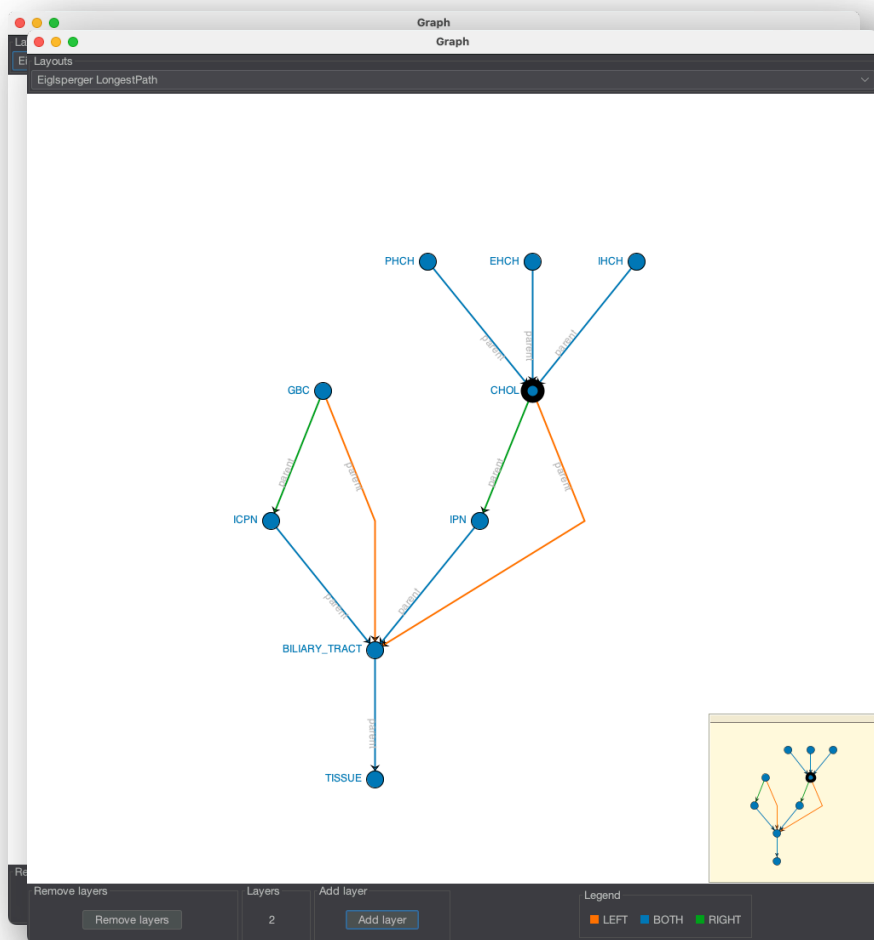
| Property | Comparison | Left value | Right value |
|----------|------------|-------------------------------|------------------------------|
| Date | Different | Thu Oct 01 00:00:00 CEST 2020 | Tue Nov 02 00:00:00 CET 2021 |

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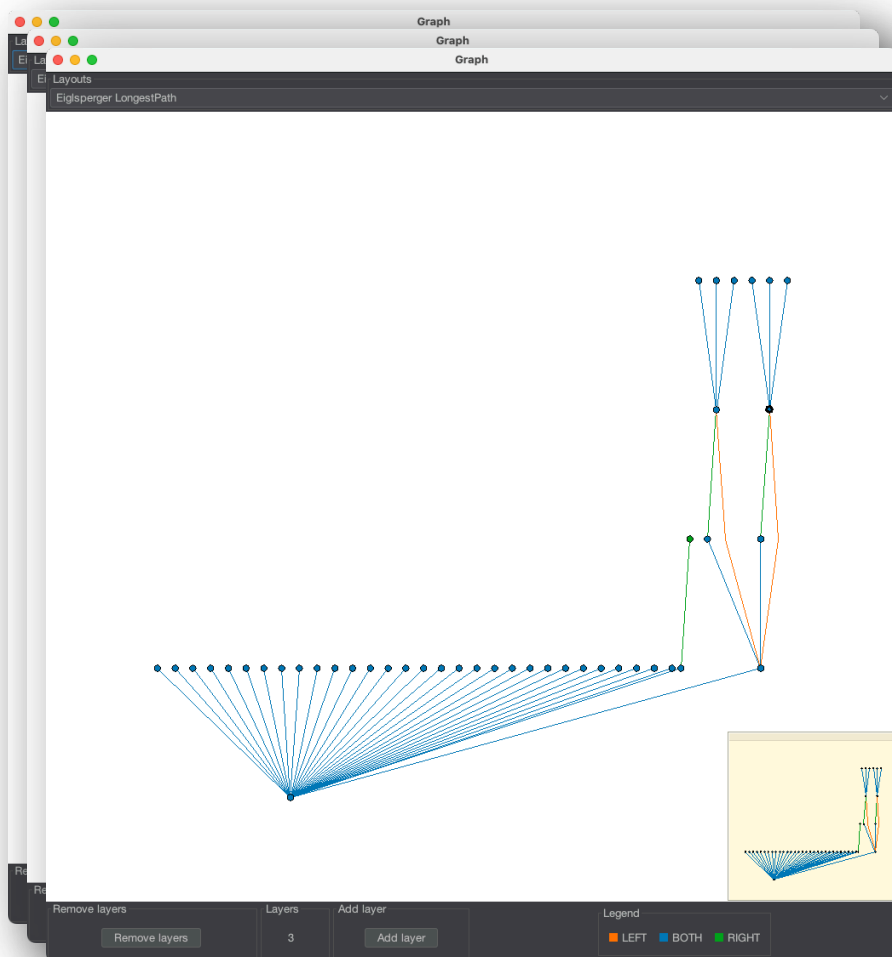
Graph View



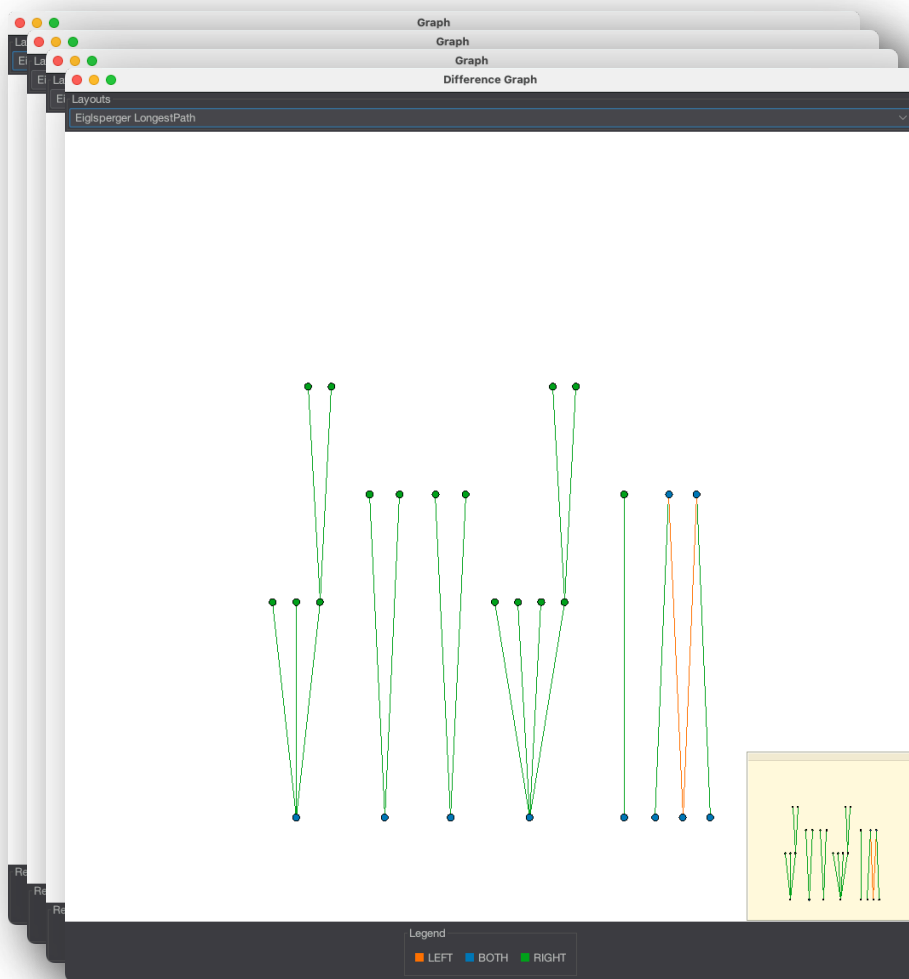
Graph View



Graph View



Graph View



- Localized graph view
 - Zoom out for changes in context
 - Changes connected to shown concepts are followed transitively
- Global difference graph view

Discussion & Outlook

- Still interesting opportunities for further development
 - Support for HL7 FHIR ValueSets and ConceptMaps
 - SNOMED CT, LOINC support
 - Algorithmic release note generation
- Comparison to approaches from Semantic Web / Ontology research
- Tooling support for FHIR terminology subject of ongoing development



Contact

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- www.linkedin.com/in/jpwiedekopf



Levels of Difference

| Level | Aspect | Example | Resolution strategy |
|-------|---------------------------|---|---|
| 1 | Metadata-level | | Presentation as a table in the GUI |
| 1.1 | Simple differences | title, name, version | String comparisons |
| 1.2 | Differences within lists | identifier, language | (keyed) difference lists, e.g., by language.code |
| 2 | Concept-level | | Presentation as a table in the GUI |
| 2.1 | Simple differences | display, definition | String comparisons |
| 2.2 | Differences within lists | property, designation | (keyed) difference lists, e.g., by property.code |
| 2.3 | Unilaterality of concepts | Deletions and additions of codes / concepts across versions | Surfacing in the table with dedicated filter and highlighting |
| 3 | Edge differences | Changes to properties linking concepts, i.e., parent | Creation and visualization of a difference graph |

ConceptMap creation support

ConceptMap

26 mappable; 20 automatically mapped; 0 accepted [Accept all](#)

26 elements

| Code | Display | Actions | Equivalence | Target | Comments | Status |
|-----------|--|---------|-------------|--------|----------|--------|
| AMBL | Large Cell/Anaplastic Medulloblastoma | ✱+ | | | | |
| AMBLNOS | Anaplastic Medulloblastoma, NOS | ✱+ | Narrower | AMBL | | ✱+ |
| AMBLNWS | Anaplastic Medulloblastoma, Non-WNT, Non-SHH | ✱+ | Narrower | AMBL | | ✱+ |
| AMBLNWSG3 | Anaplastic Medulloblastoma, Group 3 | ✱+ | Narrower | AMBL | | ✱+ |

- Algorithmic FHIR ConceptMap support
 - User must verify mappings
 - Only verified mappings included in output

ConceptMap creation support

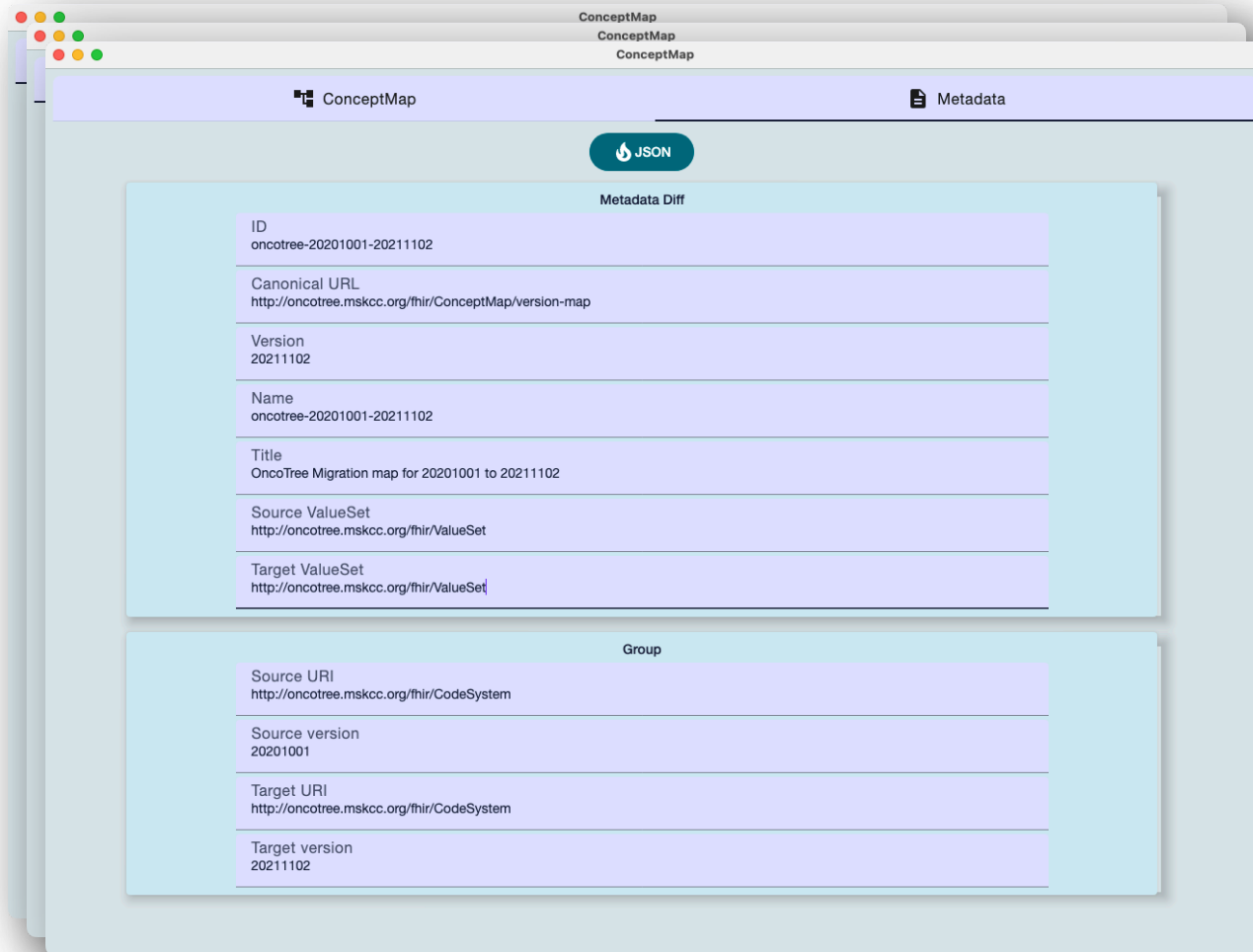
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26 elements

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|-----------|--|---------|-------------|--------|----------|--------|
| AMBL | Large Cell/Anaplastic Medulloblastoma | ✳️+ | | | | |
| AMBLNOS | Anaplastic Medulloblastoma, NOS | ✳️+ | Narrower | AMBL | | ✳️ |
| AMBLNWS | Anaplastic Medulloblastoma, Non-WNT, Non-SHH | ✳️+ | Wider | AMBL | | ✳️ |
| AMBLNWSG3 | Anaplastic Medulloblastoma, Group 3 | ✳️+ | Narrower | AMBL | | ✳️ |

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ConceptMap creation support



The screenshot shows a web application interface for creating a ConceptMap. The main content area is divided into two sections: "Metadata Diff" and "Group".

Metadata Diff

| | |
|-----------------|---|
| ID | oncotree-20201001-20211102 |
| Canonical URL | http://oncotree.mskcc.org/fhir/ConceptMap/version-map |
| Version | 20211102 |
| Name | oncotree-20201001-20211102 |
| Title | OncoTree Migration map for 20201001 to 20211102 |
| Source ValueSet | http://oncotree.mskcc.org/fhir/ValueSet |
| Target ValueSet | http://oncotree.mskcc.org/fhir/ValueSet |

Group

| | |
|----------------|---|
| Source URI | http://oncotree.mskcc.org/fhir/CodeSystem |
| Source version | 20201001 |
| Target URI | http://oncotree.mskcc.org/fhir/CodeSystem |
| Target version | 20211102 |

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 - User must verify mappings
 - Only verified mappings included in output