On the Evaluation of HL7 CDA R2 Documents Richness and Validation Reliability

IHIC 2017

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IHE-Europe
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Scope of the paper

IHIC 2015	IHIC 2016	IHIC 2017
➢Validation of Basic CDA requirements using Gazelle ObjectsChecker ➢Validation tools requirement coverage	➢Validation of Basic CDA requirements using Gazelle ObjectsChecker ➢Validation tools requirement coverage ➢Coupling Gazelle ObjectsChecker with Templates authoring tool : ART-DECOR, and automatic generation of constraints	➢Validation of Basic CDA requirements using Gazelle ObjectsChecker ➢Validation tools requirement coverage ➢Coupling Gazelle ObjectsChecker with Templates authoring tool : ART-DECOR, and automatic generation of constraints ➢Study about the richness of clinical information in tested CDA documents, and validation reliability

Outline

- Problematic
- State of the art
- CDA templates richness analysis
- Results
  - CDA specifications comparison
  - IHE Richness scoring of CDA documents
  - Combined richness and validation process
- Conclusion

Problematic (1)

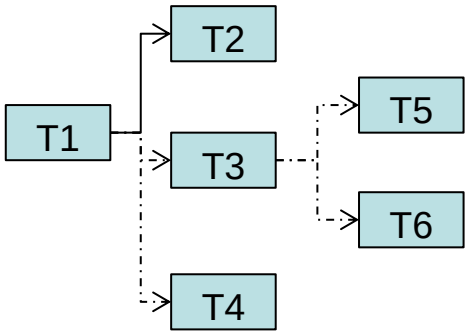
- Certification of CDA content creator tools

- => We SHALL clearly identify covered certified areas
  - *"provide an estimation of uncertainty of measurement"* (ISO 17025)
  - *"clearly identify the data that are not covered by the IHE-CAS accreditation"* (IHE Conformity assessment)

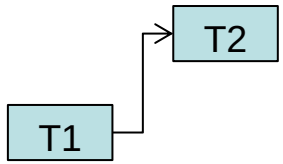
Problematic (2)

- Relevant VS minimal test data (eHDSI project)
- Testing process for CDA content creator tools
  - Most of CDA templates are optional
  - Most of CDA documents tested contains minimal test data

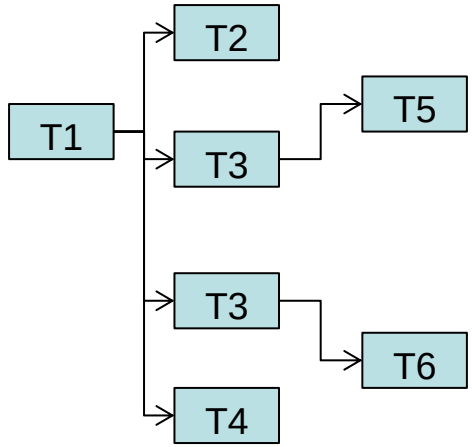
Specification



Minimal Test Data



Relevant Test Data



➢Aim: Avoid minimal test data and provide covered templates analysis

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State of the ART

- Richness of CDA documents
  - Definition: “how rich are the clinical information in the CDA document”
  - Few are the study on the subject
- Scoring of C-CDA documents
  - Introduced by Meaningful use
  - Provides a score based on specific component
  - Promotes best practice for C-CDA

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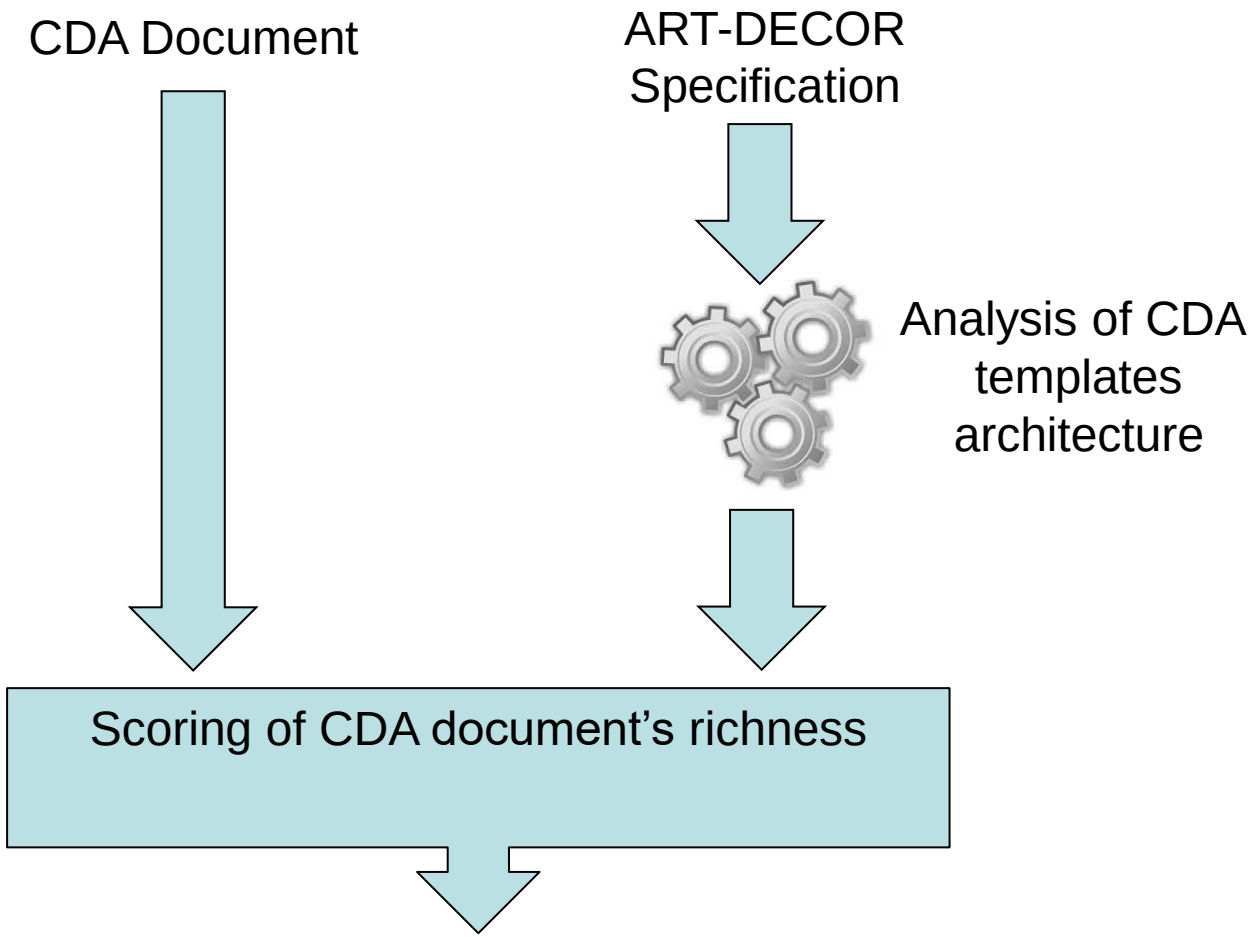
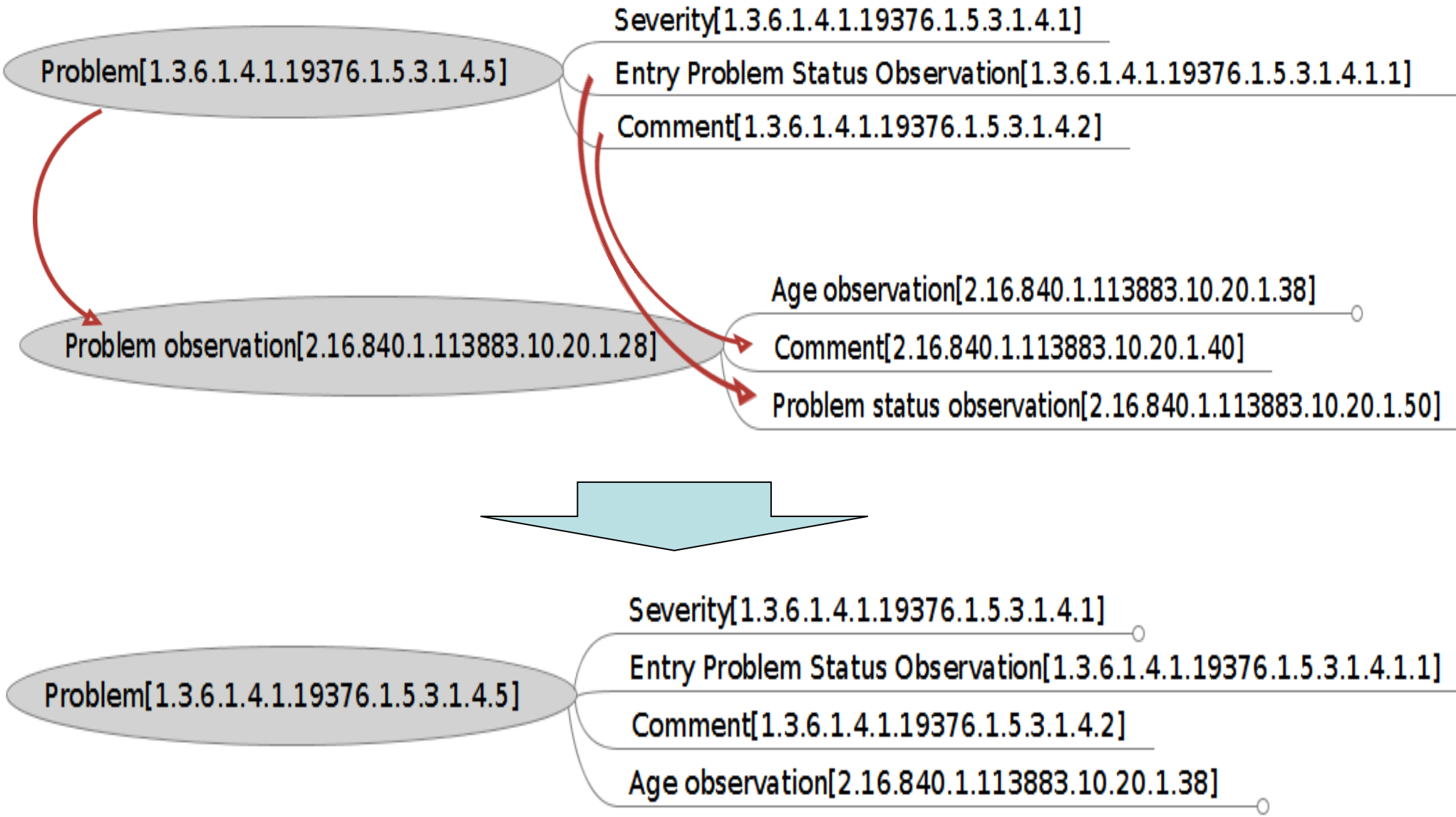
Methodology



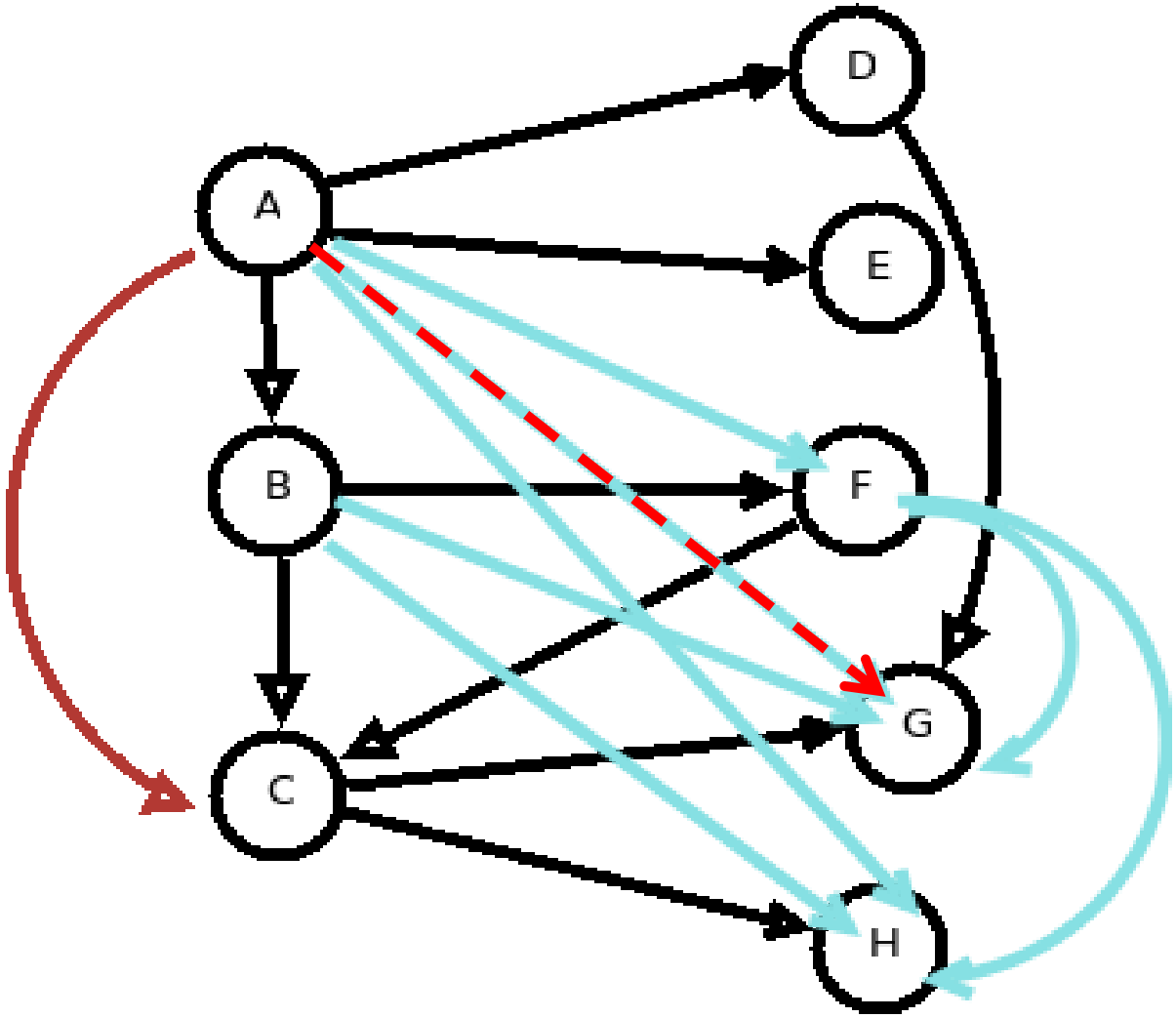
Analysis of CDA templates architecture

Real templates analysis



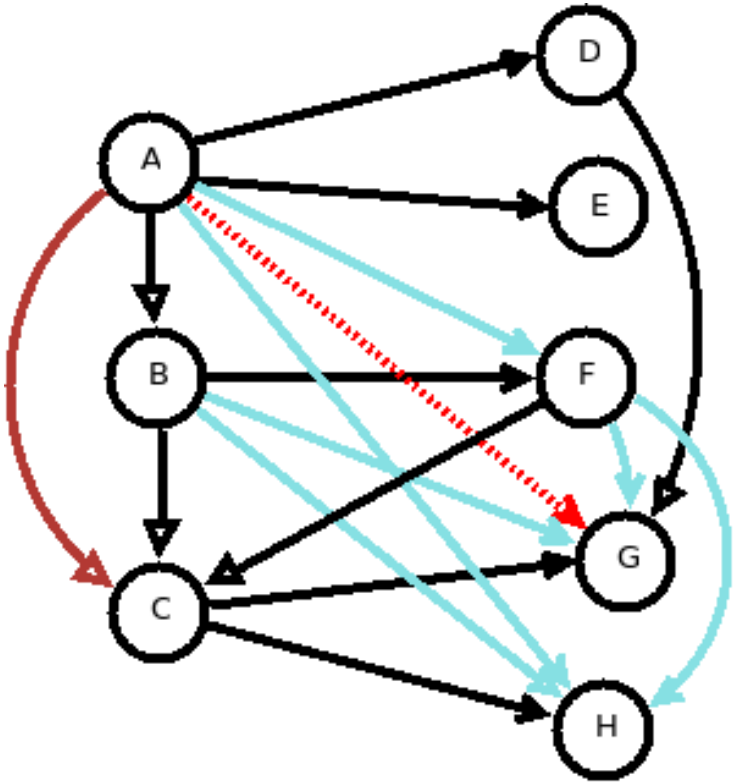
Analysis of CDA templates architecture

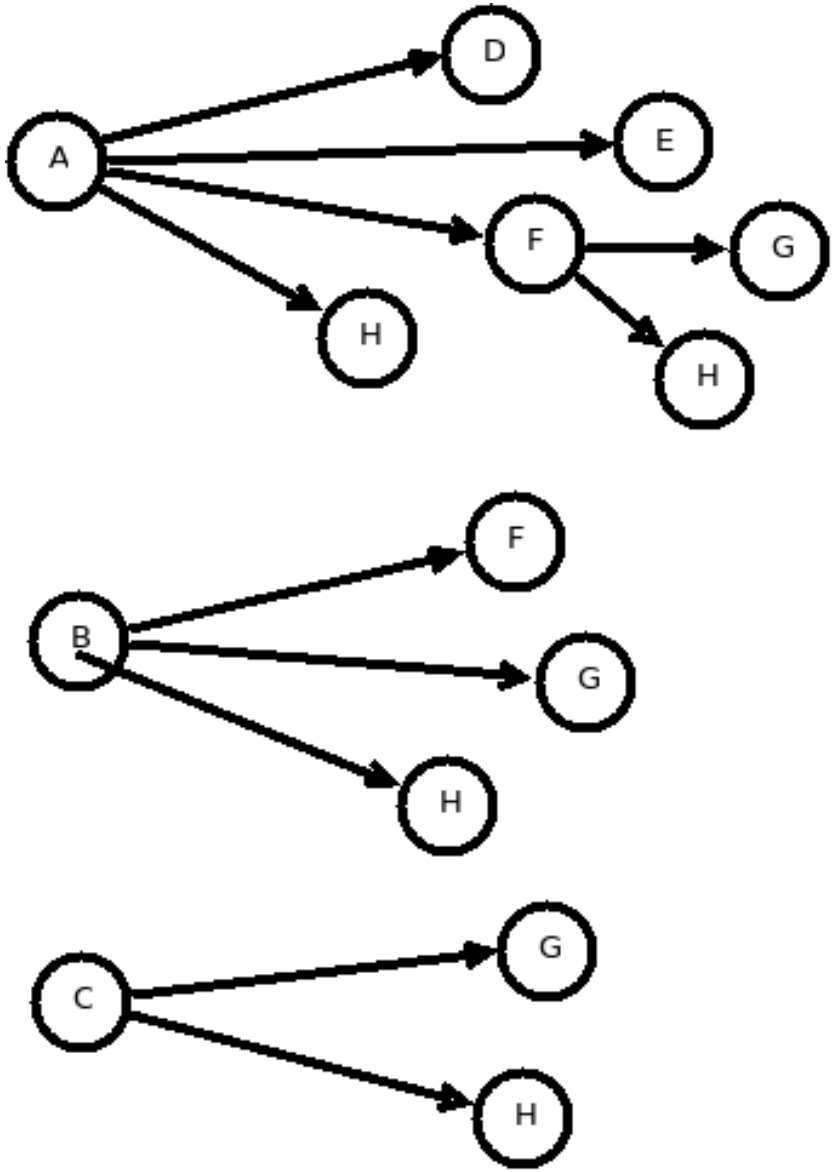
Problem abstraction (1)



Analysis of CDA templates architecture

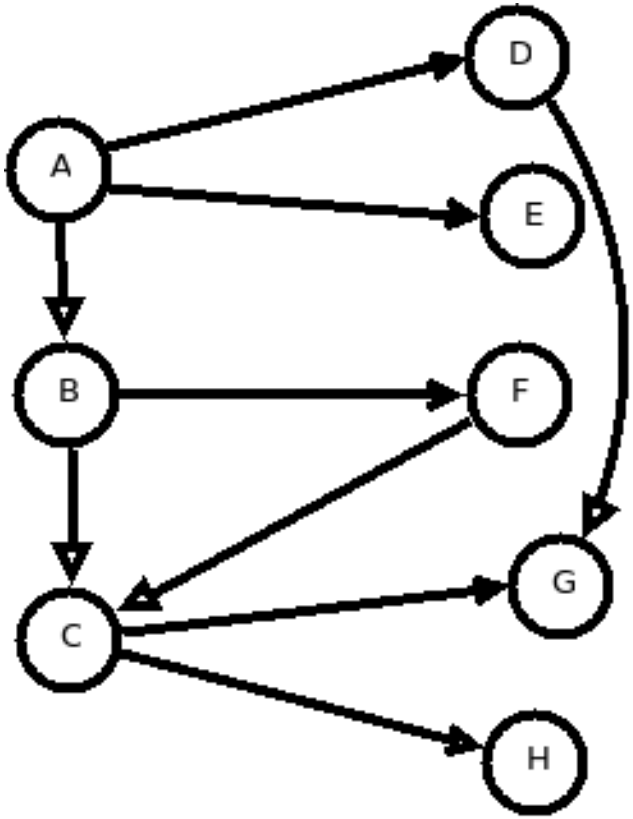
Problem abstraction (2)





Analysis of CDA templates architecture

Mathematical analysis (1)

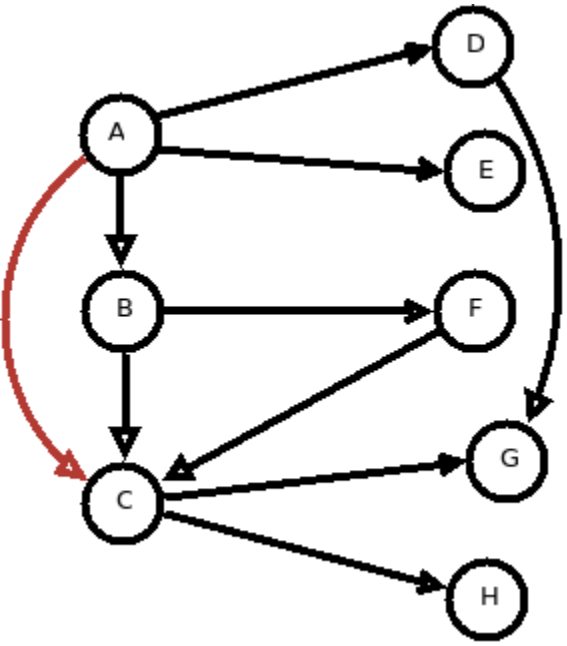


$$A = \begin{pmatrix} 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$B = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Analysis of CDA templates architecture

Mathematical analysis (2)

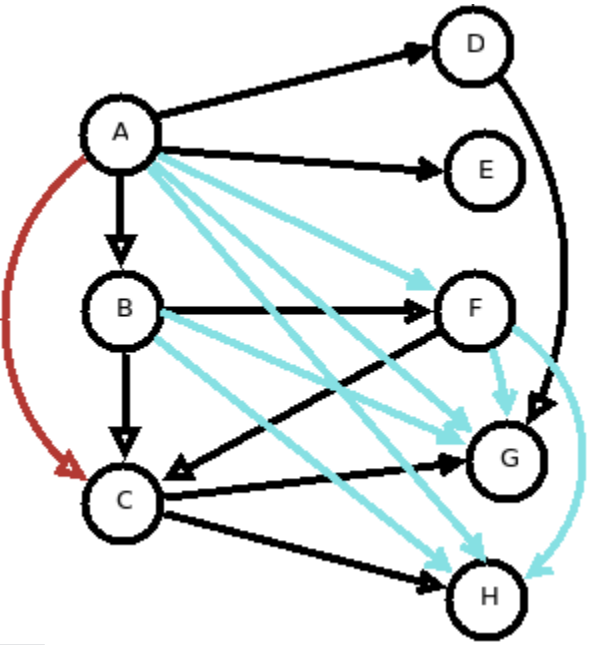


$$A = \begin{pmatrix} 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad B = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$BxB = \begin{pmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Analysis of CDA templates architecture

Mathematical analysis (3)

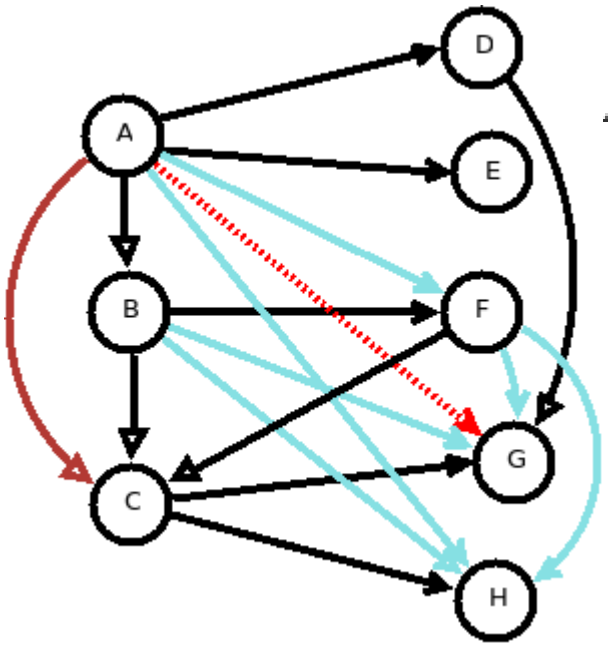


$$A = \begin{pmatrix} 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad C = B + B^2 = \begin{pmatrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$CxA = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Analysis of CDA templates architecture

Mathematical analysis (4)



$$A = \begin{pmatrix} 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad C = B + B^2 = \begin{pmatrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$AxC = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \begin{matrix} 1 \\ 1 \\ 1 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{matrix}$$

Analysis of CDA templates architecture

Mathematical analysis (4)

- Formula :

$$\Phi = (CA + A) \,\&\, \overline{\mathrm{AC}} = \left(\sum_{n=0}^{\infty} B^n A \right) \,\&\, \overline{\sum_{n=1}^{\infty} AB^n} \qquad (1)$$

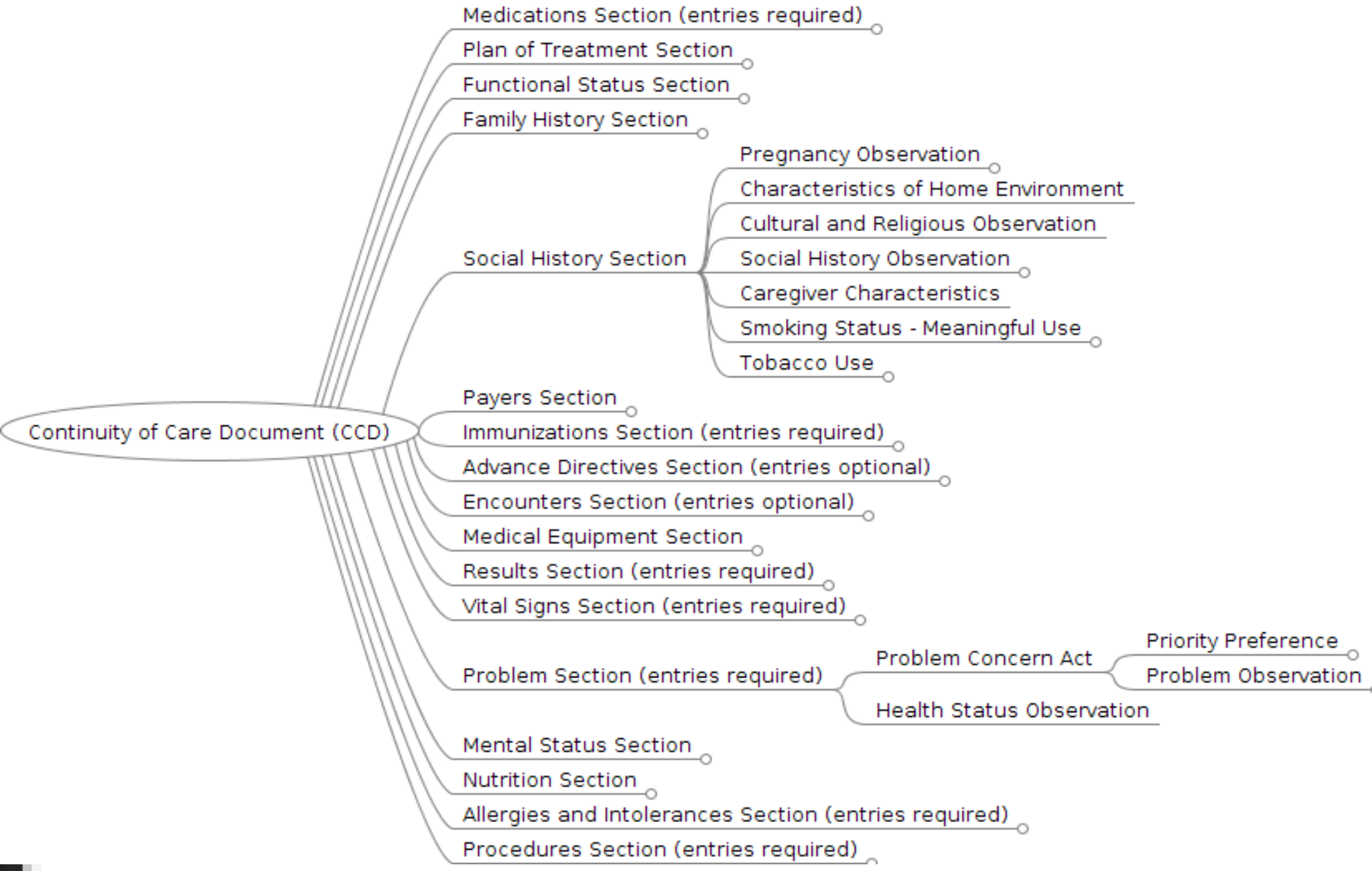
- Where :

$$C = \sum_{n=1}^{\infty} \mathrm{B}^n$$

  - The complete matrix of inheritence

Analysis of CDA templates architecture

Outcome sample



Basic richness scoring (1)

- Basic Richness scoring

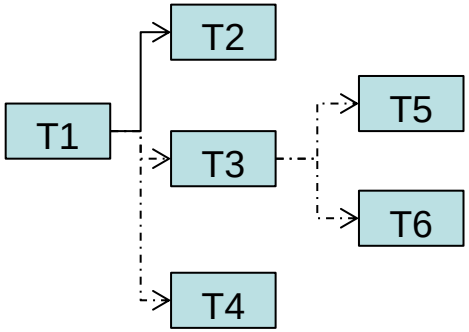
$$R_s = \frac{D_i}{T_i} = \frac{Number\ present\ templates}{Number\ possible\ templates} \qquad (3)$$

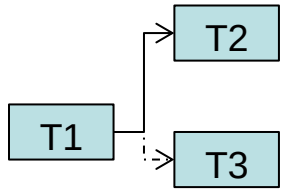
- Where

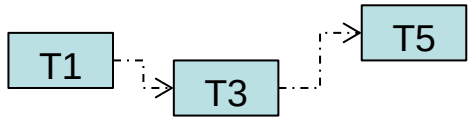
$$T_i = \sum_{l=0}^{\infty} sum_t\,(l) \qquad (4)$$

$$D_i = \sum_{l=0}^{\infty} sum_d\,(l) \qquad (5)$$

Basic richness scoring (2)







- $T_i = 6$
- $D_i = 3$
- $R_s = 3/6 = 0.5$
- => not sufficient to describe the level of containment

Weighted richness scoring (1)

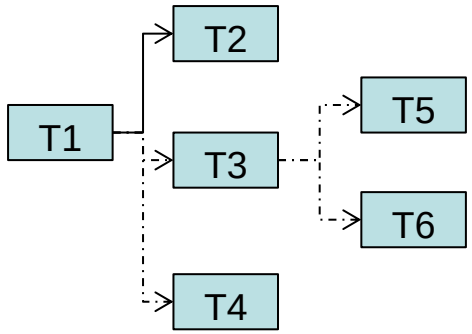
- Weighted Richness scoring $R_{ws} = \frac{D_{wi}}{T_{wi}}$
- Where

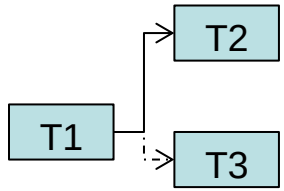
$$T_{wi} = \sum_{l=0}^{\infty} \frac{sum_t(l)}{f(l)}$$

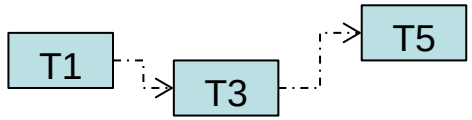
$$D_{wi} = \sum_{l=0}^{\infty} \frac{sum_d(l)}{f(l)}$$

  - f(l) = l
  - f(l) = l^2
  - f(l) = l!

Weighted richness scoring (2)







- f(I) = I!
- Example 1 :
  - T_{wi} = 1 + 3/2 + 2/6 = 2.83
  - D_{wi} = 1 + 2/2 = 2
  - R_{ws} = 2/2.83 = 0.70
- Example 2 :
  - T_{wi} = 1 + 3/2 + 2/6 = 2.83
  - D_{wi} = 1 + 1/2 + 1/6 = 1.83
  - R_{ws} = 1.83/2.83 = 0.64

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CDA specifications comparison

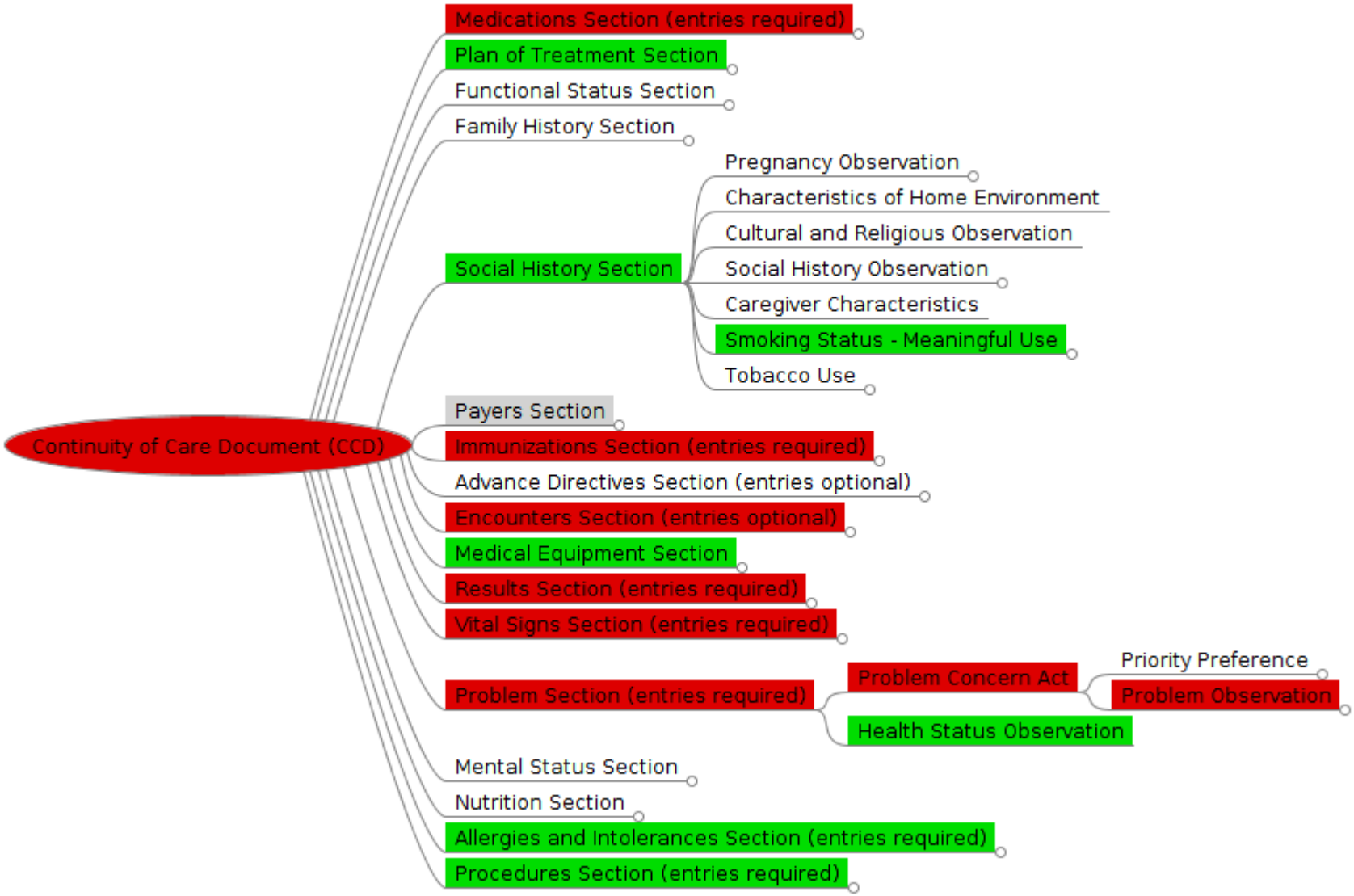
Standard	Basic Richness Template Indicator	Weighted Richness Template Indicator	Number Kind Templates referenced	Depth
IHE Discharge Summary Specification	1271	52.91	63	10
IHE Immunization Content Specification	796	40.15	68	10
IHE PHR Extract Specification	926	60.86	84	10
IHE Referral Summary Document	862	45.60	66	10
epSOS-Patient Summary	1161	59.67	65	10
C-CDA 2.1 CCD	705	73.77	104	9
C-CDA 2.1 Discharge Summary	645	75.20	101	9
C-CDA 2.1 Diagnostic Imaging Report	42	17.03	17	6

IHE Richness scoring of CDA documents

Standards	Average Weighted Richness Scoring	Number documents tested
ePSOS ePrescription	0,22	2447
ePSOS eDispensation	0,20	1322
ePSOS ePatient Summary	0,17	11530
IHE Immunization Content	0,22	276
IHE Referral Summary	0,24	1049
IHE Discharge Summary	0,31	526
IHE PHR Extract	0,13	827
C-CDA Referal Note	0,28	129
C-CDA CCD	0,20	1908

=> The tested CDA documents have low richness, far from relevant test datas

Combined richness and validation process



Validation Reliability = f(Validation result, Requirements Coverage, Documents richness)

Conclusion

- Outcome:
  - A methodology to:
    - Analyze the CDA specifications templates architecture
    - Score validated CDA documents
  - Possibility to compare CDA specifications macroscopically
  - Combination with Gazelle ObjectsChecker => Visual components validation result
- Perspectives
  - Applications: Certification/accreditation/audit process (CAS, Sequoia, eHDSI, …)
  - Improvement of CDA specifications architecture (templates circularity analysis)
  - Application of richness concept on other fields (FHIR, HL7V2, etc)

Any question ?

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