Standardized EHR Interoperability – Preliminary results of a German pilot project using the archetype methodology

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Neuherberg, 2012-06-05
The ByMedConnect Project

Goals:
- Providing an integration solution for EHR systems in the region of Ingolstadt
- Evaluating the ISO 13606 standard … and the CCR

Core partners:
HelmholtzZentrum münchen
German Research Center for Environmental Health

Sponsored by:
Heterogeneity

... content, technology

→ Paper based communication
→ Quality of care
→ Costs
Contents

- The information model (semantic interoperability)

- The technical solution (technical interoperability)

- Scientific challenges
Contents

- The information model (semantic interoperability)

- The technical solution (technical interoperability)

- Scientific challenges
Standards: ASTM CCR – Continuity of Care Record

1. CCR Identifying Information
   - Information “from/to” Practitioners
   - Dates
   - Purpose
   - Optional Extension

2. Patient Identifying Information
   - Optional Extension

3. Patient Insurance/Financial Info
   - Optional Extension

4. Advance Directives
   - Optional Extension

5. Patient’s Health Status
   - Condition, Diagnosis, or Problem
   - Family History
   - Social History & Health Risk Factors
   - Adverse Reactions/Allergies/etc.
   - Medications
   - Immunizations
   - Vital Signs/Physiological Measurements
   - Laboratory Results/Observations
   - Procedures/Imaging
   - Optional Extensions

6. Care Documentation
   - Care Plan Recommendation
   - Practitioners

Mandated Core Elements of the CCR
The EHR Extract comprises...

a hierarchy of Folders

Compositions contain...

Sections

(sections may be nested)

Entries with data as...

Elements

Clusters

Clusters may be nested & contain Elements

archetype (adl_version=1.4)

archetype_id

[specialise] archetype_id

concept

concept_id

language

dADL: language details

[description]

dADL: descriptive meta-data

[declarations]

FOPL: declaration statements

cADL: formal constraint definition

[invariant]

FOPL: assertion statements

ontology

dADL: terminology and language definitions

[revision_history]

dADL: history of change audits
ByMedConnect Data Set (1)
The ByMedConnect Data Set contains the exchange relevant data only
Contents

- The information model (semantic interoperability)

- The technical solution (technical interoperability)

- Scientific challenges
ByMedConnect Server (simplified)

**SERVER SIDE (ByMedConnect)**

- Enter data manually via web form
- View medical data via web form
- Upload/download data via web service
- Upload/download data via web form

**CLIENT SIDE**

- L2b*

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ByMedConnect Server (full description)
Contents

- The information model (semantic interoperability)

- The technical solution (technical interoperability)

- Scientific challenges
  - A) Automized validation
  - B) UML CD to XML Schema
  - C) Interoperability evaluation
B) Applying validation methods: Basic approach

Senders activities

1 (exporting)

EHR system

Data export file (XML)

Schema Transform. Script or Procedure

Senders

2 (using)

ISO 13606

Archetype (ADL)

Canonical Knowledge

3 (producing)

VALIDATION METHOD

Transformed export file (XML)

4 (validating)

Senders activities

5 (using)

Receivers activities

5 (using)

ISO 13606

Archetype (ADL)

6 (producing)

EHR system

Import ready file (XML)

Receivers

7 (importing)

Senders activities

EHR system

Data export file (XML)

Schema Transform. Script or Procedure

Senders

B) Applying validation methods: Basic approach

Senders activities

1 (exporting)

EHR system

Data export file (XML)

Schema Transform. Script or Procedure

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ISO 13606

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6 (producing)

EHR system

Import ready file (XML)

Receivers

7 (importing)

Senders activities

EHR system

Data export file (XML)

Schema Transform. Script or Procedure

Senders
B) Applying validation methods: The RM model

Senders activities

Senders
Schema Transform. Script or Procedure

Senders
EHR system

Data export file (XML)

Canonical Knowledge

ISO 13606
Archetype (ADL)

ISO 13606
Reference Model (UML)

VALIDATION METHOD

Transformed export file (XML)

1 (exporting)

2 (using)

3 (producing)

4 (validating)

5 (using)

Senders activities

B) Applying validation methods: The RM model

Senders

Schema Transform. Script or Procedure

Senders
EHR system

Data export file (XML)

Canonical Knowledge

ISO 13606
Archetype (ADL)

ISO 13606
Reference Model (UML)

VALIDATION METHOD

Transformed export file (XML)

1 (exporting)

2 (using)

3 (producing)

4 (validating)

5 (using)
B) Validation methods: Rinner/Duftschmid, 2010

Senders activities

Senders
Schema Trasform. Script or Procedure

ISO 13606
Archetype (ADL) D

Senders
EHR system

Data export file (XML)

Transformed export file (XML)

1 (exporting)

2 (using)

3 (producing)

Developed by MU Wien

Derived by the en13606 Assoc.
Canonical Knowledge

ISO 13606 Reference Model (XSD) S

Uses the RM XML Schema that was derived by UPV in order to use the RM-elements as building blocks when generating an archetype-specific XML Schema by a self-developed Java-Tool.

Cons-
- Method is tool reliant
- The tool itself uses an ADL parser of its choice.
- Generator procedure can't be standardized.

Representing an archetype in XML Schema was considered by Bird et. al. (2003) concluding that the dual model approach doesn't satisfy the "unique particle attribution" of XML Schema. That's why ADL (Archetype Definition Language) was invented.

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B) Validation methods: Maldonado, 2009

Senders activities

ISO 13606 Archetype (ADL) \( D \)
ISO 13606 Reference Model (XSD) \( S \)

Canonical Knowledge

XML Query (XQuery) \( D \)
LinkEHR EXE \( S \)

Data export file Schema (XSD)

Data export file (XML)

Transformed export file (XML)

Developed by UPV

1 (exporting)

Senders
EHR system

Validation methods: Maldonado, 2009

Developed by UPV

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B) Validation methods: ByMedConnect approach

- Senders activities
- Senders Schema Transform. Script or Procedure
- Data export file (XML)
- Senders EHR system
- Derived by applying a systematic approach
- ISO 13606 Reference Model (XSD) S
- ISO 13606 Archetype (XML) D
- Archetype Transf. Script (XSLT) S
- Transformed export file (XML)
- Developed by HMGU

Similar to Duftschmid et. al. uses XML Stylesheet transformation to generate an XML Schema. Archetype schema generation method can be standardized.

- ISO 13606 Reference Model (UML)
- ISO 13606 Archetype (XML) D
- ISO 13606 Reference Model (XSD) S

Derived by applying a systematic approach

Developed by HMGU

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German Research Center for Environmental Health
B) Solution: fully XML centric validation capabilities

Senders activities
- 1 (exporting)
  - Senders
    - EHR system
- 2 (using)
  - Senda Schema Transform. Script or Procedure
- 3 (producing)
  - Data export file (XML)

Senders
- Schema Transform. Script or Procedure
- Data export file (XML)

Canonical Knowledge

ISO 13606
- Archetype (ADL)

Receivers activities
- 6 (producing)
  - Import ready file (XML)
- 5 (using)
  - Rebec Schema Transform. Script or Procedure

Receivers
- Schema Transform. Script or Procedure
- Import ready file (XML)

ISO 13606
- Archetype Schema (XSD) D

Transformed export file (XML)

Senders activities
- Senders
  - EHR system

Receivers activities
- Receivers
  - EHR system

The generated schema acts as a substitute for the archetype ➔ sender/recipient can check validity on their own using generic tools.
C) ISO 13606 and model transformation

- **XML Schema** is suitable for validation but less powerful than UML CD

**A) Forward than reverse approach**

**B) Intersect approach**

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- **UML CD**
  - Element U1
  - Element U2
  - Element U3
  - Element U4
  - Element U5
  - Element U6
  - …
  - Element U19
  - …

- **XML Schema**
  - Element X1
  - Element X2
  - Element X3
  - Element X4
  - Element X5
  - …

1. UML CD to XML Schema
2. XML Schema to UML CD

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How to derive a **good** XML Schema out of an UML CD?
### ByMedConnect Server (accessibility evaluation)

<table>
<thead>
<tr>
<th>Degree of requirements fulfillment (levels of interoperability)</th>
<th>Requirements</th>
<th>Can export data</th>
<th>Can transform data</th>
<th>Is web service ready</th>
</tr>
</thead>
<tbody>
<tr>
<td>No conventional participation possible</td>
<td>L0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation is possible</td>
<td>L1</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirements are partially fulfilled</td>
<td>L2a</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Requirements are fully fulfilled</td>
<td>L2b</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>All requirements are fulfilled</td>
<td>L3</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
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Thank you for your attention!

Q&A