Model Driven Development of Clinical Information Systems using openEHR

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Study Context

• Maintaining software in healthcare is **hard**!
  – Real world experience: endoscopy reporting application
  – Almost entirely driven by MST – standard domain terminology
    (Minimal Standard Terminology for Digestive Endoscopy – version 2)

• Essence of problem:
  – Biomedical ‘**stuff**’ is volatile
  – hardcoding domain knowledge into software (code + DB)

• New Model Driven Development – using openEHR
  – Archetype modelling + Defined GUI directives
  – Extended openEHR.NET library (Ocean Informatics)
  – Formal comparative evaluation of the ‘old’ and ‘new’ system
    [http://openehr.codeplex.com](http://openehr.codeplex.com)
Research Questions

• Is openEHR implementable at all? Feasible? (for our specific requirements)
• How to create usable GUI?
• Is it bad to hardcode domain knowledge into software (code + DB)
• Can software evolve without (significant) techy intervention? To what extent?
• Any other challenges?
• Model driven? (development/architecture/approach)
• By OMG around 2001
• Separate business and application logic from its underlying execution platform technology so that:
  – changes in the underlying platform do not affect existing applications
  – business logic can evolve independently from the underlying technology
• Model – using a Domain Specific Language
• Tackle complexity, volatility & improve efficiency
Background - *openEHR*

TWO-LEVEL MODELLING APPROACH

- **TEMPLATES**
- **ARCHETYPES**
- **TERMINOLOGY**
  - ICD10 AM, LOINC, SNOMED, Etc.
- **REFERENCE MODEL**

Level-1 (UML)

Level-2 (ADL)
## MST Structure

### MST Findings for Duodenum

<table>
<thead>
<tr>
<th>HEADINGS</th>
<th>TERMS</th>
<th>ATTRIBUTES</th>
<th>ATTRIBUTE VALUES</th>
<th>SITES</th>
</tr>
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<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td></td>
<td>Site(s)</td>
<td></td>
</tr>
<tr>
<td>Lumen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenosis</td>
<td>Appearance</td>
<td>Extrinsic</td>
<td>Site(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Benign intrinsic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Malignant intrinsic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traversed</td>
<td>Yes</td>
<td></td>
<td>Site(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deformity</td>
<td>Appearance</td>
<td>Extrinsic</td>
<td>Site(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-ulcer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evidence of previous surgery</td>
<td>Specify</td>
<td></td>
<td>Site(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suture Material Visible</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contents</td>
<td>Blood</td>
<td>Kind of blood</td>
<td>Red</td>
<td>Site(s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clot</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Hematin (altered blood)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parasites</td>
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<td></td>
<td>Site(s)</td>
<td></td>
</tr>
<tr>
<td>Foreign Body</td>
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<td></td>
<td>Site(s)</td>
<td></td>
</tr>
<tr>
<td>Stent</td>
<td>Type</td>
<td>Specify</td>
<td>Site(s)</td>
<td></td>
</tr>
</tbody>
</table>

### MST Hierarchy

- **Endoscopic Observation / Procedure**
  - **Heading**
  - **Term**
    - **Site**
    - **Attribute**
      - **Value**
Content Model Coverage

Examination Characteristics (35)

Upper and Lower GIS Endoscopy
  - Examination information
  - Reasons for Endoscopy
  - Complications
  - ERCP

Endoscopic Findings (658)

Upper GIS Endoscopy
  - Findings for Esophagus
  - Findings for Stomach
  - Findings for Duodenum

Lower GIS Endoscopy
  - Findings for Colon
  - ERCP
  - Findings for Duodenum
    - Findings for Papilla Major
    - Findings for Papilla Minor
    - Findings for Pancreas
    - Findings for Biliary System

Interventions (101)

Diagnostic Therapeutic

GastrOS GUI (856)
(SDE=812 | Wrapper=44)

Diagnosis (18)

Upper GIS Endoscopy
  - Esophagus
  - Stomach
  - Duodenum

Lower GIS Endoscopy
  - Colon
  - Jejunum

Wrapper (44)

Reporting
  - Print Preview
  - Sign-off (5)
  - Patient/Visit View (39)
GUI Directives

• Archetypes & Templates only to do with structure + semantics of health information
• Need to define presentation aspects
• Majority thinks a separate model for that
• We don’t:
  – hard to separate at times
  – Archetypes expected to change rapidly so maintaining a separate model might be hard
  – Perhaps with good tooling might work
• We exploited Template Annotations
Implementation Methodology

• GastrOS: Windows forms app using .Net/C#
• A basic ‘Wrapper’ + SDE component
• openEHR.Net: Release 1.0.1 RM & AOM
• Templates with GUI Directives operational templates (XML)
• Creates GUI automatically, validates and persists user entered data
• Also extended model beyond MST to include vitals & adverse reactions – hard stuff!
Conclusions

• Is openEHR implementable at all? Feasible? (for our specific requirements) ➔ YES
• How to create usable GUI? ➔ Described
• Is it bad to hardcode domain knowledge into software (code + DB) ➔ DEFINITELY
• Can software evolve without (significant) techy intervention? To what extent? ➔ Cautious Yes
• Any other challenges? ➔ need more time!!!
QUESTIONS?

http://gastros.codeplex.com

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