Child Leukemia Management System
A Pilot EHR Application Based on the *open*EHR Architecture

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Introduction

- Collaboration with pediatric oncology department of the Karolinska University Hospital, Sweden
- Based on requirement for an integrated ICT support for child Leukemia treatment management
  - Auto-entered lab investigation results
  - On-going medications on oral chemotherapy
  - Observations on adverse-events
  - High-level overviews of records for given patient including all observations, adverse-events and medications
  - Clinical evaluation and adjustment of medications
  - Possibility for integrating decision support systems
- Testing two-level modelling and archetypes based EHR architecture

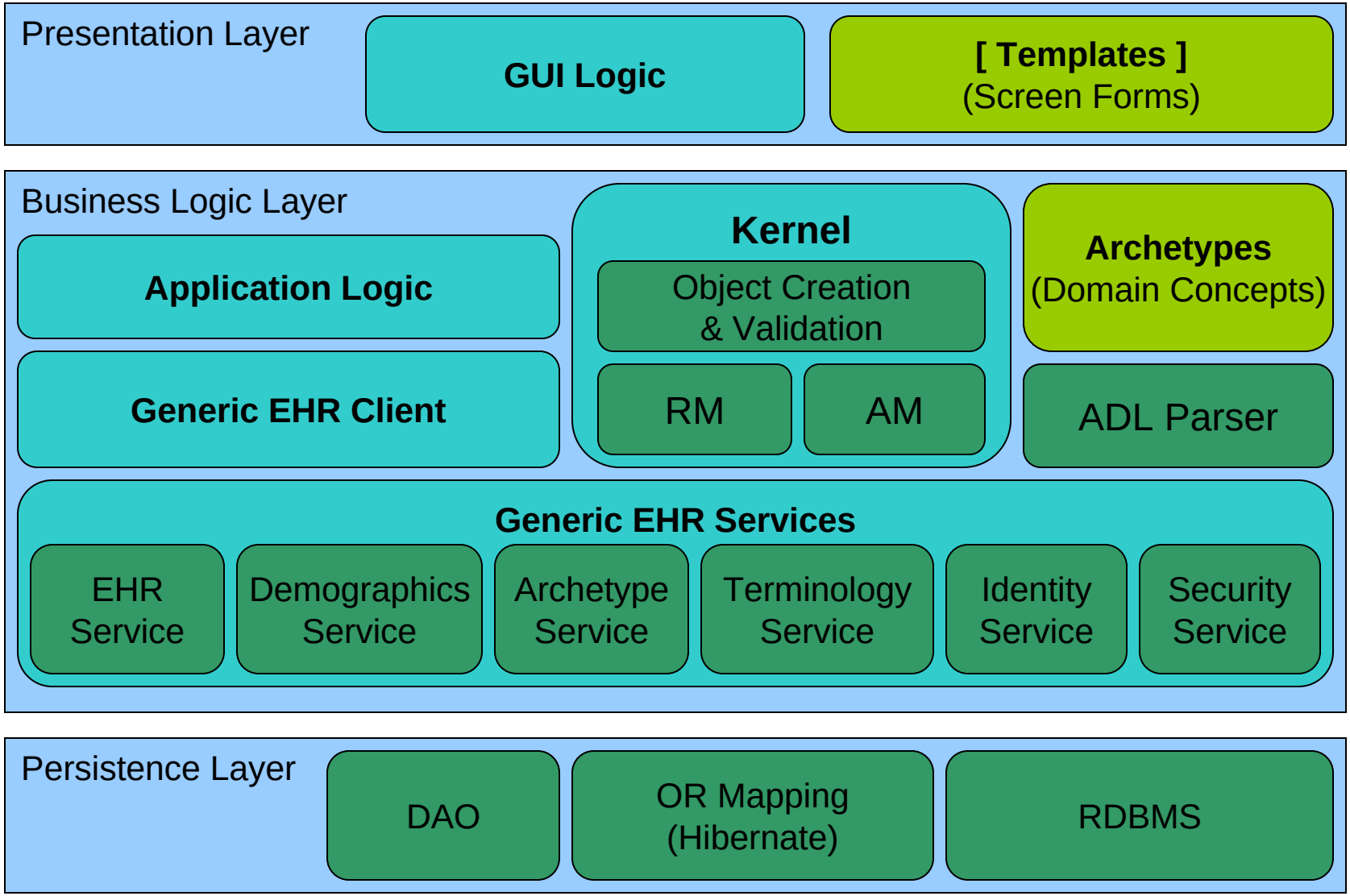
Methods

- Generic EHR system based on openEHR design specifications
  - Java implementation of the openEHR Reference Models and Archetype Model
  - Generic EHR Services
  - Application features: graphic or table overviews
- Clinical requirement modeled in archetypes
  - lab investigations
  - adverse-events
  - Overall evaluations
  - Medications: oral chemotherapy

Software methods

- Presentation layer
  - Web-based front-end using model-view-controller framework Maverick
  - Auto generated screen forms using XSLT transformation
- Business logic layer
  - Generic EHR services wired up using Spring Framework
  - Deployed in JBoss Application server
  - JAXB for XML data binding
  - JavaCC for producing Archetype Definition Language (ADL) parser
- Persistence layer
  - Hibernate for Object-relational mapping
  - MySQL as DBMS

System Architecture of the pilot EHR application



The main EHR archetype

-EHR-COMPOSITION.leukemia_treatment.v3.adl - Eclipse SDK

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InspectorTest.java | Inspector.java | Occurrence.java | InspectionResult.... | TestClass.java | ArchetypeID.java | openEHR-demograph... | ope

```
22    rights = <copyright to ice medical informatics, all rights reserved>
23
24 definition
25     COMPOSITION[at0000] matches {
26         content cardinality matches {*; ordered} matches {
27             SECTION[at0001] occurrences matches {0..1} matches {       -- observations
28                 items cardinality matches {*; ordered} matches {
29                     OBSERVATION[at4000] occurrences matches {0..1} matches {       -- observation for length and weight
30                         data matches {
31                             SINGLE_EVENT[at4001] matches {
32                                 origin matches {yyyy-mm-dd hh:mm:ss}
33                                 item matches {
34                                     ITEM_LIST[at4002] matches {
35                                         representation matches {
36                                             Cluster[at4003] matches {
37                                                 items cardinality matches {*; ordered} matches {
38                                                     ELEMENT[at4004] occurrences matches {0..1} matches {    -- weight
39                                                         value matches {
40                                                             DV_QUANTITY matches {
41                                                                 magnitude matches {|>0.0|}
42                                                                 units matches {"Kg"}
43                                                             }
44                                                         }
45                                                     }
46                                                     ELEMENT[at4005] occurrences matches {0..1} matches {    -- length
47                                                         value matches {
48                                                             DV_QUANTITY matches {
49                                                                 magnitude matches {|>0.0|}
50                                                                 units matches {"M"}
51                                                             }
```

The table overview

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Address http://192.168.100.2:8080/openpatient.do?index=0

S□□k / skapa patientmapp | Hantera patientmapp | Medicinska inst□□llningar | Systeminst□□llningar

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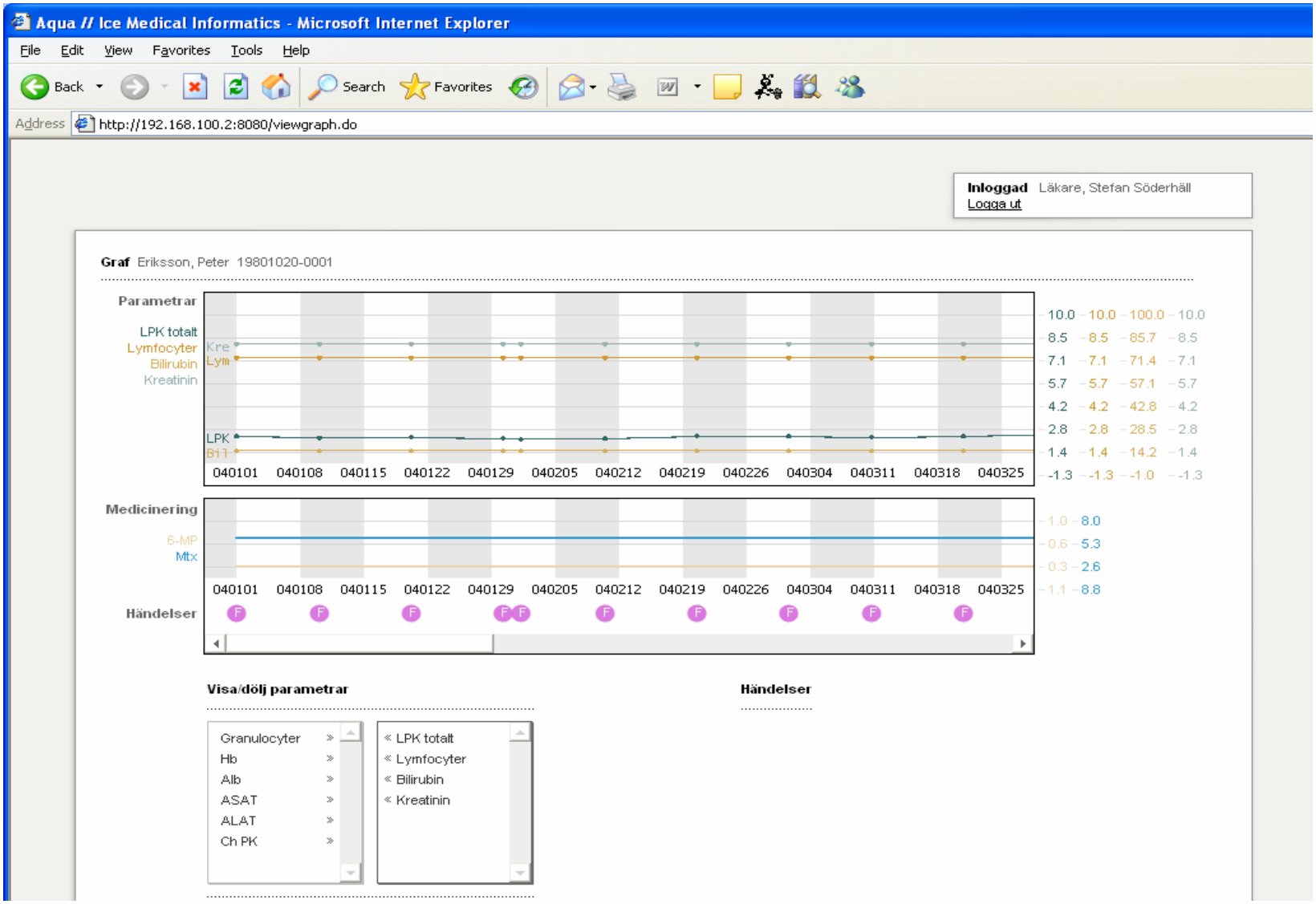
□□versiktstabell Eriksson, Peter 19801020-0001

	040610	040620	040701	040710	040720	040730	040801	040810	040820	040901	040910	040920
LPK totalt	3.7	3.9	3.4	3.1	3.2	3.0	2.8	2.9	3.5	3.4	3.2	3.4
Granulocyter	28.0	29.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0
Lymfocyter	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Hb	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0
Alb	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Bilirubin	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
ASAT	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27
ALAT	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
Ch PK	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Kreatinin	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6
weight	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0
length	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
name												
strength	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
form	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dose	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
duration	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dose	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
duration	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dose												

The graph overview



Auto-generated screen form based on demographics archetype

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Skapa patientmapp

child patient		**parent one contact**		**parent two contact**	
first name		first name		first name	
last name		last name		last name	
person number		home phone		home phone	
phone number		work phone		work phone	
Skapa patientmapp		mobile phone		mobile phone	

Spara patientdata

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Discussion

- Two-level model and archetype based EHR Architecture – a paradigm shift for building EHR applications
- More adaptive EHR Systems
  - Detailed clinical requirement modeled as archetypes unforeseeable by EHR developers
  - Generic EHR systems driven by archetypes authored by clinical professionals
  - Challenges
    - auto-generated screen forms based on archetype
    - Scalable persistence layer for fine-grained objects
    - integration between archetypes-driven part and non-archetypes-driven part of the system
- Improved EHR Interoperability
  - EHR models based on standards
  - Machine interpretable archetypes
  - Towards semantic interoperability by sharing meaning of expressions and terms thru bindings between EHR nodes and terminologies
  - Challenges
    - archetype governance
    - term bindings between EHR nodes and terminologies
    - effective EHR query based on archetypes

Conclusion

- Two-level modelling and archetypes based EHR architecture seems to be useful
- EHR independent EHR representation improves EHR interoperability
- Possible to build EHR applications for specific need based on generic EHR architecture

References

1. Beale T, Heard S, Kalra D, Lloyd D. Architecture Overview, http://svn.openehr.org/specification/TAGS/Release-1.0.1/publishing/architecture/overview.pdf, last accessed on 2007/05/30
2. Beale T. Archetypes: Constraint-based domain models for future-proof information systems. In: Eleventh OOPSLA Workshop on Behavioral Semantics
3. The openEHR Java Reference Implementation project, http://svn.openehr.org/ref_impl_java/TRUNK/project_page.htm, last accessed on 2007//5/30
4. Chen R. openEHR Reference Model Java ITS, http://svn.openehr.org/specification/TAGS/Release-1.0.1/publishing/its/Java/openEHR-JavaITS.pdf, last accessed on 2007/05/30
5. Chen R, Klein G. The openEHR Java Reference Implementation Project, Medinfo Proceedings
6. Garde S, Hullin CM, Chen R, Leslie H, Heard S, Schuler H, Gränz J, Knaup P, Hovenga E. Towards Sustainability of Health Information Systems: How Can We Define, Measure and Achieve It. Medinfo 2007 Proceedings
7. Garde S, Knaup P, Hovenga E, Heard S. Towards Semantic Interoperability for Electronic Health Records: Domain Knowledge Governance for openEHR Archetypes. Accepted for Methods of Information in Medicine 2007
8. Sundvall E, Qamar R, Nyström M, Forss M, Petersson H, Åhlfeldt H, A Rector. Integration of Tools for Binding Archetypes to SNOMED CT. Proceedings of SMCS2006; 1-3 Oct, Copenhagen, Denmark, p 64-68
9. Schuler T, Garde S, Heard S, Beale T. Towards automatically generating graphical user interfaces from openEHR archetypes, Stud Health Technol Inform. 2006; 124:221-6.
10. H van der Linden, Schuler T, Chen R, Talmon J. Generic screen representations for future proof systems, is it possible? Medinfo 2007 Proceedings

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