IST-2103 STP Artemis: A Semantic Web Service-based P2P Infrastructure for the Interoperability of Medical Information systems

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Challenges of Healthcare Informatics

- The most common and prominent strategic aims in Europe are:
  - Improving access to clinical records
  - Enabling patient mobility and cross border access to healthcare
  - Reducing clinical errors and improving safety
  - Improving access to quality information
  - Improving efficiency of healthcare processes
  - (ref: CEN/ISSS Report Draft V4.1, 2004-08-16)

- All this implies the need for interoperability!
Challenges - why we do this project?

- Today no universally accepted standard for the digital representation of clinical data exists
- There is a multitude of medical information systems on the market, storing clinical information in all kinds of proprietary formats
- Most of the health information systems today are proprietary
- A patient's health information may be spread out over a number of different institutes which do not interoperate
- This makes it very difficult for clinicians to capture a complete clinical history of a patient
Functional and Semantic Interoperability

- **The Functional (syntactic) interoperability** is the ability of two or more systems to exchange information. This involves agreeing on:
  - The common network protocols such as Internet or Value Added Networks;
  - The common transport binding such as HTTP, FTP or SMTP and
  - The common message format like ASCII text, XML (Extensible Markup Language) or EDI (Electronic Data Interchange)

- **Semantic interoperability** is the ability for information shared by systems to be understood at the level of formally defined domain concepts so that the information is computer processable by the receiving system.
Artemis Objectives: Interoperability through Semantically Enriched Web services in the Healthcare Domain

- Achieving interoperability among Medical Information systems through:
  - Web service technology (Functional Interoperability), and
  - Semantic Mediation to provide semantic interoperability

- Furthermore to facilitate the discovery of Web services and for the scalability of the infrastructure, the use of Peer-to-peer networks
We will locate Semantically Enriched Web services through P2P
Basic Artemis Features

- Web services to wrap and expose existing healthcare applications
- Annotating Web services through Service Functionality Ontologies to describe what they are doing
- Annotating the Service Messages through Clinical Concept and Service Message Ontologies
- In Artemis, healthcare institutes are not expected to conform to a single common ontology
- The differences between disparate Service Functionality, Service Message and Clinical Concept Ontologies are mediated through Ontology Mapping
Healthcare Informatics

Semantics

- Semantics is domain knowledge!

- Medicine is one of the few domains to have extensive domain knowledge defined through standards

- These standards offer significant value in developing ontologies to express the semantics of Web services
What kind of Semantics?

- **Service Functionality Semantics:**
  - HL7 has categorized the events in healthcare domain by considering service functionality which reflects the business logic in this domain.
  - This classification can be used as a basis for defining the service action semantics through a Service Functionality Ontology.

- **Service Message Semantics:**
  - Electronic healthcare record (EHR) based standards like HL7 CDA (Clinical Document Architecture), GOM (GEHR Object Model), and CEN TC251's ENV 13606 define **meaningful components of EHR** so that when transferred, the receiving party can understand the record content better.
  - The **meaningful components** defined by these standards can be used in developing clinical concept ontologies (CCO).
  - The medical institutes can directly benefit from these CCOs or map their message ontologies to one of the CCO.
An Example Service Functionality Ontology

HealthCareServices

PatientAdministration
PatientCare
PatientReferral
Scheduling
ObservationReporting

PatientReferralRequest
PatientInfoRequest
CancelPatientReferral

InsuranceInformation
ClinicalInformation
DemographicData

GetClinicalInformation

serviceQuality
location

Properties of the Generic Service Class
An example Clinical Concept Ontology

DD02: Problem
DTC12: CarePlan
DF03: AllergyState
DTH03: Ongoing Problems
DTH08: Present Interpretations
DD01: Diagnosis
DTC08: Diagnostic Test Results
DS00: Patient
Ontology Network
Semantic Mediation

- Healthcare Institutes usually exchange XML or EDI messages

- In Artemis architecture, the healthcare institutes can develop their own ontologies, called message ontologies (automatically with the normalization tool provided)

- However these ontologies are proprietary

- The ontology mappings are achieved through semantic mediation
  - OWL2OWL mapping tool (OWLmt) developed
Semantic Mediation

- Artemis Mediator
  - Normalizes XML messages to OWL to create message Ontologies
  - Maps them to the target message ontology
    - This may involve mappings to and between CCO
  - De-normalizes them to XML or EDI
Message Schema Mapping

Healthcare Institute A

HL7 v2.3 Message Schema

C-Normalization Engine

OWL Wrapper

Normalization Map

XSD → RDF → OWL

Ontology Mapper

HL7 v2.3 Ontology

Mapping Definition

OWL Wrapper

C-Normalization Engine

Healthcare Institute B

HL7 v3 Message Schema

C-Normalization Engine

OWL Wrapper

Normalization Map

XSD → RDF → OWL

Ontology Mapper

HL7 v3 Ontology
Message Instance Transformation

Healthcare Institute A

EDI2XML Converter

HL7 v2.3 Message

EDI XML

D-Normalization Engine

XML

OWL Wrapper

OWL

Mapping Engine

HL7 v2.3 Instance

HL7 v3 Instance

Mapping Definition

Normalization Map

Healthcare Institute B

D-Normalization Engine

HL7 v3 Message

XML

OWL Wrapper

OWL

Normalization Map
Additional Tools Used for creating HL7 v3 Message Schemas

- **HL7 RoseTree Tool** is used to create HL7 v3 messages

- RoseTree allows the user to graphically build a HMD (Hierarchical Message Definition) from the HL7 v3 Reference Information Model

- In order to translate the HMD to XSD, **HL7 v3 Schema Generator Tool** is used

- **Conceptual Normalization Engine** of the Harmonize project is used for XSD to OWL (and vice versa) mappings
Additional Tools Used for Instance Transformation

- **EDI to XML Conversion in HL7**: HL7 Application Programming Interface (HAPI) Assembler/Disassembler Tool is used to transform the HL7 v2 EDI messages into their XML representations.

- **Data Normalization Engine of the Harmonize project**: is used to transform XML Message instances to OWL instances.
Semantically Enriched Discovery Mechanism

- **Artemis Ontology**: All of the Artemis entities are represented in an Ontology called *Artemis Ontology*.
System Architecture

An instance of the related Artemis Ontology class is created and sent to the mediator through the secure Artemis P2P messaging system. It is stored to the Ontology Server, and Web service registries when necessary. Indices are created, sent to other mediators.

An API is provided for querying Artemis Entities, which in turn creates the necessary SE-RQL queries. Queries are routed to other necessary mediators and results are sent back to the peer.

User is provided with a graphical discovery interface. Queries are routed to other necessary mediators and results are sent back to the peer.

User provides inputs to the Web service using its own Message structure (XML/EDI). Parameters are normalized to OWL. Necessary mappings to the message structure of the provider are performed by the semantic processor, by the Mediator. Web service is invoked, and the results are propagated to the peer in the same manner.

Message structure of the organization is specified, message ontologies created, clinical concept ontologies conformed are selected.
Patient Identification and IHE RID

- A patient Identification protocol to locate hospitals that have information about a patient in Artemis P2P network
  - With comprehensive measures for security and privacy
  - Using cryptographic techniques
- Semantically enriched IHE RID implementation for retrieving medical documents
End result of the Artemis Project

- A middleware providing the interoperability of Medical Information Systems
- The project has been developing:
  1. Semantic mediation infrastructure for healthcare Web services
  2. Tools for semantically annotating and creating healthcare Web services
  3. Web service composition tool based on BPEL4WS
  4. Web service registries (UDDI and ebXML) enriched with healthcare semantics, Integrating Web services and Web services registries with P2P networks
  5. Secure, Semantic P2P discovery mechanism
  7. A distributed patient identification protocol with comprehensive security and privacy policies
  8. Artemis compliant IHE RID implementation
Market

- Artemis project will be one of the first initiatives to use Web services in the healthcare domain
- We plan to produce an early prototype to demonstrate system capabilities to the widest possible audience
- The market size will depend upon the system capabilities and how wide we can disseminate the results
Artemis Project: References

- [http://www.srdc.metu.edu.tr/artemis/](http://www.srdc.metu.edu.tr/artemis/)

- Marco Eichelberg, Thomas Aden, Wilfried Thoben, "A Distributed Patient Identification Protocol based on Control Numbers with Semantic Annotation", Submitted for Publication to IJSWIS.
Artemis Demonstration

- Artemis Project is being demonstrated at MedETel Exhibition Hall
  - We are looking forward to hosting you in our stand
    - To present you detailed Artemis functionalities
Thank you for your attention!