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### An Infrastructure for the Interoperability of Medical Information Systems

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#### The Interoperability Challenge

Today's eHealth information systems are proprietary and often only serve one specific department within a healthcare facility. This means it is impossible to easily share data across one facility, never mind trying to share between different facilities, or even different countries. The European Commission-sponsored project Artemis (A Semantic Web Service-based P2P Infrastructure for the Interoperability of Medical Information Systems - IST-1-002103-STP, <http://www.srcd.metu.edu.tr/artemis/>) addresses this important interoperability problem.

The issue of healthcare IT interoperability can be investigated in the following ways: exchanged healthcare messages and Electronic Health Records (EHRs).

#### Achieving Interoperability

For the interoperability of exchanged healthcare messages, messaging interfaces or interface engines are used. Currently, the Health Level 7 (HL7) Version 2 Messaging Standard is the most widely implemented standard in healthcare. Unfortunately, HL7 V2 compliance does not imply direct interoperability between healthcare systems because V2 has no explicit information model. Instead, it has rather vague definitions for many data fields and contains many optional fields. It offers great flexibility but it also requires detailed bilateral agreements amongst the healthcare systems to achieve interoperability. HL7 Version 3 was therefore developed, based on an object-oriented data model called the Reference Information Model (RIM). However, a drawback is that HL7 V3 cannot communicate with HL7 V2. EHRs also suffer from similar problems. An EHR is healthcare information digitally stored throughout an individual's lifetime that supports continuity of care, education and research, while ensuring confidentiality at all times. A number of standardisation efforts are progressing to provide the interoperability of EHRs such as CEN/TC 251 EHRcom, openEHR and HL7 Clinical Document Architecture (CDA). However, an exchange of well-structured and machine processable electronic healthcare records has not been achieved in practice at this point in time.

#### How Artemis Addresses the Challenges

The Artemis project addresses these problems and provides an interoperability platform where organisations keep their proprietary systems, but expose their functionality through web services. Whilst these web services provide technical interoperability, they do not yet provide a mechanism for automatic processing of the message content received, unless the sent and received messages conform to the same interface standard. Since it is not realistic to expect a globally unique healthcare message standard, Artemis takes an alternative approach and semantically annotates both web service functionality and the messages web services exchange. An essential element in defining the semantics of web services is domain knowledge. Medical informatics is one of the few domains to have considerable knowledge developed through standards. For example, HL7 standards categorise events and define messages in healthcare based on-service functionality, which reflects business logic. Artemis uses HL7 as a basis for defining both the service action semantics and the message semantics.

The Artemis message exchange framework provides the exchange of meaningful clinical information among healthcare institutes through semantic mediation. An ontology mapping tool is developed for mapping different healthcare ontologies into one another and then using the mapping definition produced for automatically translating message instances. The framework proposed is generic enough to mediate between any incompatible healthcare standards currently in use.

For the interoperability of EHRs, Artemis uses "archetypes". Archetype-based interoperability discovers existing archetypes based on their

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semantics. It then annotates archetypes with ontologies, composes templates from archetypes and retrieves corresponding data from the underlying medical information systems. Artemis also uses electronic business XML (ebXML) Registry semantic constructs to annotate, store, discover and retrieve archetypes.

When it comes to the discovery of Web services, currently the most prominent Web service registries are Universal Description, Discovery & Integration (UDDI) and electronic business XML (ebXML). There are also very recent efforts to use peer-to-peer (P2P) networks based on Web services. However, today's service registries and P2P architectures do not provide semantically enriched search capabilities. In the ARTEMIS project, extensions are provided to these architectures to enable the discovery web services based on their semantic descriptions.

#### **Locating and Accessing Clinical Records for Continuity of Care**

Another crucial aspect of ARTEMIS is the ability to find and retrieve clinical information about a particular patient from different healthcare organisations where concrete sources are unknown. In most countries there are no unique personal identifiers that would be valid for the whole lifetime of an individual, and would be used by all parties in healthcare and for all episodes of care. On the contrary, in many cases several identifiers for a patient exist - even within a single organisation. Consequently, a protocol is needed that allows for the identification of patients by means of non-unique patient-related attributes. Artemis developed a "Patient Identification Process Protocol" (PIP). PIP provides a solution for a common problem in the healthcare sector that is likely to become very important with the increasing mobility of the workforce in Europe; locating and accessing prior clinical records for the continuity of care.

Healthcare information systems operate within a strict regulatory framework that ensures the protection of personal data and outlines the conditions where processing is allowed. The Artemis project responded to these conditions by providing comprehensive security and privacy protection mechanisms.

Currently, an Integrating the Healthcare Enterprise (IHE) initiative proposes the Retrieve Information for Display (RID) integration profile to allow users to retrieve and display patient-related documents on systems other than those storing documents. Although the RID profile is well suited for use in a single hospital or within a trust of hospitals belonging to a single Patient Identifier Domain, it is not designed for cross-boundary access to information stored in different hospitals. Artemis developed a middleware infrastructure that extends the IHE RID protocol for cross-enterprise search and access to patient-related clinical information, even if no Master Patient Index is available, and without modifications to existing Information Source actors. Applied to the ARTEMIS infrastructure, the RID Information Source and Display actors may be located in different institutions using different Patient ID domains and different sets of demographic data. Within the ARTEMIS network, clinical records can be located using the "Patient Identification Protocol" (PID Protocol) which can also be combined with the IHE Crossenterprise Document Sharing (XDS) Integration Profile.

#### **The Artemis Prototype**

The ARTEMIS Project has a prototype that realises a scenario where, after an accident, a patient is admitted to the most appropriate hospital from the ambulance. The patient is admitted before the ambulance arrives at the hospital, via a mobile device. The hospital admissions service then automatically seeks out any relevant healthcare records of the patient in the ARTEMIS P2P network, and presents them to the doctor, even though the hospitals discovered may not be using interoperable standards with each other. In the prototype, the mediation between HL7 Version 2 and HL7 Version 3 messages is also demonstrated. This is a considerable improvement over current systems.

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