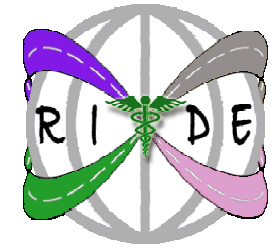


A survey on the Analysis of Electronic Healthcare Standards

Gokce B. Laleci, METU-SRDC

<http://www.srdc.metu.edu.tr/webpage/projects/ride/>

Based on...



- RIDE Publication

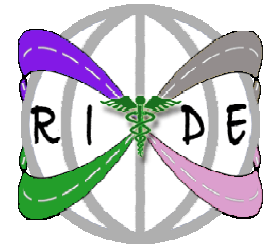
- Eichelberg M., Aden T., Riesmeier J., Dogac A., Laleci G. A Survey and Analysis of Electronic Healthcare Record Standards ACM Computing Surveys, Vol. 37, No:4, December 2005

- Analysis Section will be covered

- Full paper at:

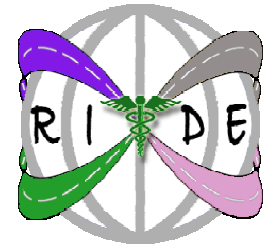
- <http://www/webpage/publications/2005/EichelbergAdenDogacLaleci.pdf>

Aim



- The level of interoperability support:
 - Does the EHR provide structured content suitable for automated processing? Does it specify content distribution rules?
- Functionality:
 - Does the standard allow for an explicit retrieval of records (or parts thereof) for a specific patient, based on an incoming request? Can it contain multimedia data? What kind of security mechanisms are supported for accessing healthcare records?

Aim



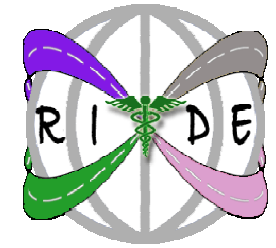
□ Complementarity:

- Since not all the standards provide all the necessary features, is it possible to combine them in a complementary way? Do the standard initiatives affect one another?

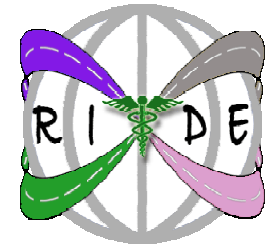
□ Market relevance:

- Is the standard accepted in the marketplace? Are there commercial implementations available or any signs of uptake by industry?

Analyzed



- The GEHR/OpenEHR Initiative
- CEN/TC 251 AND ENV/EN 13606 EHRCOM
- HL7
 - Messaging
 - Clinical Document Architecture
- DIGITAL IMAGING AND COMMUNICATIONS IN MEDICINE (DICOM)
 - Web Access to DICOM Persistent Objects (WADO)
 - DICOM Structured Reporting
- INTEGRATING THE HEALTHCARE ENTERPRISE (IHE)
 - Retrieve Information for Display (RID)
 - Cross-Enterprise Document Sharing (XDS)
- MEDICAL MARKUP LANGUAGE (MML)

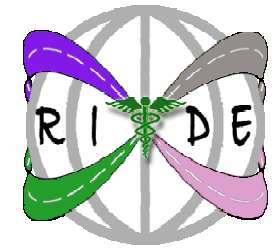


Scopes of EHR Standards

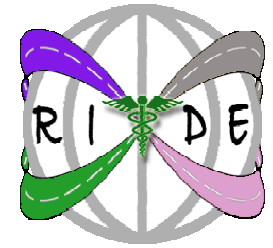
	CEN EHRcom	HL7 CDA	ISO WADO	DICOM SR	IHE RID	IHE XDS	MML
EHR Content Structure	Yes	Yes	No	Yes	No	No	Yes
EHR Access Services	Yes	No	Yes	Yes	Yes	Yes	No

- DICOM SR and EHRcom
- CDA and MML only specify a content format but
 - specify both content structure and access services
 - no communication protocol
 - the communication protocol for EHRcom (EN 13606-5)
- XDS and RID only specify communication protocols and are "content agnostic"
- WADO
 - somewhat of a special case because it only provides an alternative access protocol to DICOM images and reports
 - it uses DICOM SR as a format for structured EHR content

Content Structure



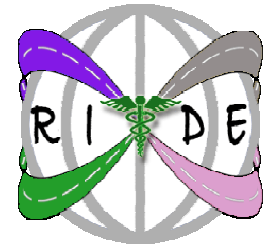
	CEN EHRcom	HL7 CDA	DICOM SR	MML
EHR contains persistent documents	Yes	Yes	Yes	Yes
EHR can contain multimedia data (images, signals, movies)	Yes	Yes	Yes	Yes
EHR document can contain references to multimedia data	Yes	Yes	Yes	Yes
EHR structured content suitable for processing	Yes	Yes	Yes	Yes
EHR supports archetypes / templates	Yes	Yes	Yes	Yes
EHR specifies library of archetypes / templates	Yes	Yes	Yes	Yes
EHR specifies distribution rules	Yes	No	No	Yes
EHR standard covers visualization	No	Yes	No	No
EHR supports digital signatures on persistent documents	No	No	Yes	No



Support for persistent documents

- ❑ medical information systems usually store medical information in a structured, normalized database in which each basic unit of information is kept separately
- ❑ medical information systems still allow to combine such entries into a classical document which might be exchanged in digital form between departments
- ❑ For **CDA, DICOM SR and MML**, the persistent document is the basic unit in which information is assembled, stored and communicated

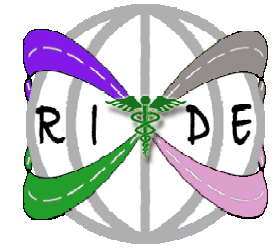
Support for persistent documents



□ In EHRcom

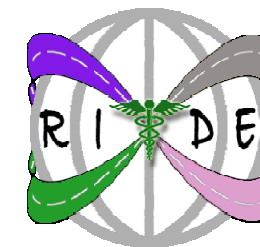
- communication is based on the “EHR extract”
 - more than a document because it contains one or more “compositions” plus structuring information such as folders
- content submission and audit trail are based on the composition:
 - persistent documents can be represented in EHRcom as well

Content Structure



	CEN EHRcom	HL7 CDA	DICOM SR	MML
EHR contains persistent documents	Yes	Yes	Yes	Yes
EHR can contain multimedia data (images, signals, movies)	Yes	Yes	Yes	Yes
EHR document can contain references to multimedia data	Yes	Yes	Yes	Yes
EHR structured content suitable for processing	Yes	Yes	Yes	Yes
EHR supports archetypes / templates	Yes	Yes	Yes	Yes
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EHR specifies distribution rules	Yes	No	No	Yes
EHR standard covers visualization	No	Yes	No	No
EHR supports digital signatures on persistent documents	No	No	Yes	No

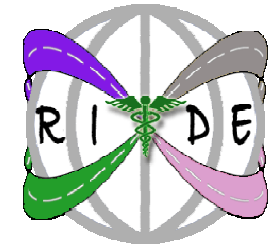
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EHR specifies distribution rules	Yes	No	No	Yes
EHR standard covers visualization	No	Yes	No	No
EHR supports digital signatures on persistent documents	No	No	Yes	No

Content modules
DTD based

archetypes templates templates



Content Structure

	CEN EHRcom	HL7 CDA	DICOM SR	MML
EHR contains persistent documents	Yes	Yes	Yes	Yes

- statements specifying under which circumstances the EHR content may be communicated
 - different concept from access control in that they are part of the EHR content, not part of an EHR access protocol
 - It is up to the implementation of an EHR system how the distribution rules are executed or mapped to an EHR access protocol

templates				
EHR specifies distribution rules	Yes	No	No	Yes
EHR standard covers visualization	No	Yes	No	No
EHR supports digital signatures on persistent documents	No	No	Yes	No

Content Structure

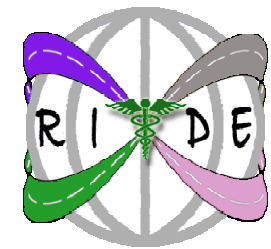


	CEN EHRcom	HL7 CDA	DICOM SR	MML
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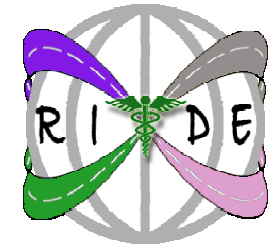
- most of them do not specify how EHR content should be visualized, because this touches safety issues
- CDA specification gives at least recommendations on how documents are to be structured and encoded in order to facilitate the visualization process
 - requires that all information needed for document presentation to a human reader must be present in the "narrative block" in each document section, enabling a simple and generic presentation of the document through style sheets

EHR specifies distribution rules	Yes	No	No	Yes
EHR standard covers visualization	No	Yes	No	No
EHR supports digital signatures on persistent documents	No	No	Yes	No

Content Structure



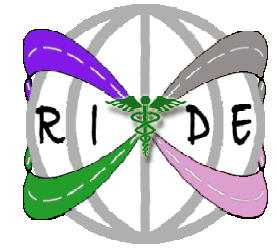
	CEN EHRcom	HL7 CDA	DICOM SR	MML
<ul style="list-style-type: none"> • DICOM SR is the only standard in which this is explicitly specified • EHRcom, CDA and MML can all be represented in XML <ul style="list-style-type: none"> • digital signatures could be handled through the XML-Signature standard • However, none of these standards explicitly states how signed documents would be handled by a document repository 				
EHR specifies library of archetypes / templates	Yes	Yes	Yes	Yes
EHR specifies distribution rules	Yes	No	No	Yes
EHR standard covers visualization	No	Yes	No	No
EHR supports digital signatures on persistent documents	No	No	Yes	No



EHR Access services

	CEN EHRcom	ISO WADO	DICOM SR	IHE RID	IHE XDS
Service for querying EHR content	Yes	No	Yes	Yes	Yes
Service for retrieving EHR content	Yes	Yes	Yes	Yes	Yes
Service for submitting EHR content	Yes	No	Yes	No	Yes
Document-centric storage / retrieval	No	Yes	Yes	Yes	Yes
Content format agnostic	No	No	No	Yes	Yes

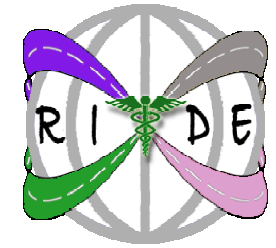
- ❑ CEN EHRcom refers to the EHRcom communication protocol to be published as EN 13606-5
- ❑ DICOM SR refers to the DICOM Storage and Query/Retrieve Services that are used for the transport of DICOM SR documents and images
- ❑ CDA and MML which do not currently define access services are not shown in the table



EHR Access services

	CEN EHRcom	ISO WADO	DICOM SR	IHE RID	IHE XDS
Service for querying EHR content	Yes	No	Yes	Yes	Yes
Service for retrieving EHR content	Yes	Yes	Yes	Yes	Yes
Service for submitting EHR content	Yes	No	Yes	No	Yes
Document-centric storage / retrieval	No	Yes	Yes	Yes	Yes
Content format agnostic	No	No	No	Yes	Yes

- WADO is a special case since it is the only protocol that does not allow to query for document content
 - requestor needs a-priori knowledge about the location and the document ID
 - WADO is not a comprehensive EHR protocol of its own, but only a supplementary service that needs to be combined with other services such as XDS for queries



EHR Access services

	CEN EHRcom	ISO WADO	DICOM SR	IHE RID	IHE XDS
Service for querying EHR content	Yes	No	Yes	Yes	Yes
Service for retrieving EHR content	Yes ✓	Yes ✓	Yes	Yes ✓	Yes ✓
Service for submitting EHR content	Yes	No	Yes	No	Yes
Document-centric storage / retrieval	No	Yes	Yes	Yes	Yes
Content format agnostic	No	No	No	Yes	Yes

- WADO and RID are "read only" services, that is, they do not support the submission of new documents to a repository



EHR Access services

	CEN EHRcom	ISO WADO	DICOM SR	IHE RID	IHE XDS
Service for querying EHR content	Yes	No	Yes	Yes	Yes
Service for retrieving EHR content	Yes	Yes	Yes	Yes	Yes
Service for submitting EHR content	Yes	No	Yes	No	Yes
Document-centric storage / retrieval	No	Yes	Yes	Yes	Yes
Content format agnostic	No	No	No	Yes	Yes

- In all standards, except EHRcom, the persistent document is the basic unit of information that is queried, retrieved or submitted to the EHR
- EHRcom instead uses the concept of an "EHR extract", which may contain several documents, for query and retrieval

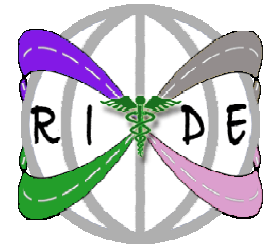
EHR Access services



	CEN EHRcom	ISO WADO	DICOM SR	IHE RID	IHE XDS
Service for querying EHR content	Yes	No	Yes	Yes	Yes
Service for retrieving EHR content	Yes	Yes	Yes	Yes	Yes
Service for submitting EHR content	Yes	No	Yes	No	Yes
Document-centric storage / retrieval	No	Yes	Yes	Yes	Yes
Content format agnostic	No	No	No	Yes	Yes

- IHE RID and IHE XDS are content format agnostic
 - they treat documents as opaque byte streams and only process the metadata accompanying the document

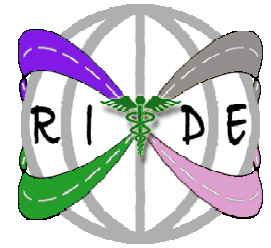
Content Agnostic



□ Advantages:

- easier to define and implement
- facilitates the inclusion of generic (non-medical) document formats such as PDF, RTF, JPEG or MPEG into the EHR
- general purpose document management systems (such as ebXML registry in the case of IHE XDS) can be used for content format agnostic EHR protocols, which may have a significant impact on the price of software solutions

Content Agnostic



□ Disadvantages:

- may contain "anything"
- the EHR does not contain any structure beyond the structure established through the metadata in the EHR registry
- not possible to support advanced services beyond document visualization such as document processing, mediation or automated translation services
- not guaranteed that references between documents in the EHR are possible due to the varying content formats
- not guaranteed that a recipient will even be able to correctly visualize a document retrieved from the EHR system due to an unknown format or encoding

IHE RID & XDS



- RID works around the disadvantages mentioned above
 - requires the document server to be able to convert each document into one of a few well-known formats (JPEG, CDA or PDF)
- XDS uses the concept of so-called XDS Document Content Profiles
 - restricts document formats and encoding options for specific clinical applications
 - An actor that claims conformance to a specific document content profile will be able to interoperate with other actors supporting the same profile

Security Features



	ISO WADO	DICOM SR	IHE RID	IHE XDS
Supports transport level encryption	Yes	Yes	Yes	Yes
Protocol allows to transmit user credentials	Yes	Yes	Yes	Yes
Protocol enforces access rules	No	No	No	Yes

- All of these protocols can certainly be extended with security features for encryption, user credentials and access control, **but such security concepts will only be interoperable among different implementations if standardized**
- Since the EHRcom protocol is not specified yet, its security properties are not known

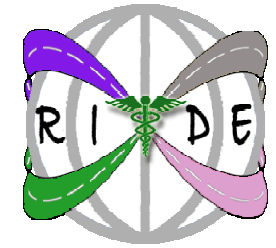
Security Features



	ISO WADO	DICOM SR	IHE RID	IHE XDS
Supports transport level encryption	Yes	Yes	Yes	Yes
Protocol allows to transmit user credentials	Yes	Yes	Yes	Yes
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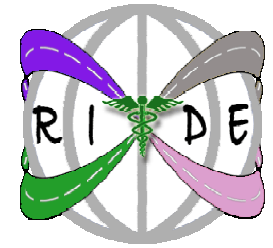
- All remaining four protocols support a transport level encryption, that is, an encryption of record content during transmission
- In all cases, this is implemented using the TLS

Security Features



	ISO WADO	DICOM SR	IHE RID	IHE XDS
Supports transport level encryption	Yes	Yes	Yes	Yes
Protocol allows to transmit user credentials	Yes	Yes	Yes	Yes
Protocol enforces access rules	No	No	No	Yes

- an important feature because it allows the EHR system to determine which user is requesting access and, based on this information, to implement user or role based access control
- WADO and RID
 - IHE Enterprise User Authentication (EUA) integration profile which is based on Kerberos and the transmission of Kerberos tickets through the HTTP protocol

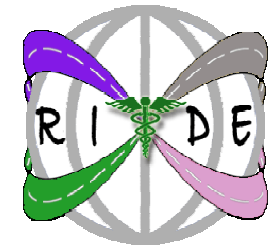


Security Features

	ISO WADO	DICOM SR	IHE RID	IHE XDS
Supports transport level encryption	Yes	Yes	Yes	Yes
Protocol allows to transmit user credentials	Yes	Yes	Yes	Yes
Protocol enforces access rules	No	No	No	Yes

- DICOM
 - allow for the use of IHE EUA in DICOM
- Cross-Enterprise User Authentication (XUA) that addresses the issue of user authentication for cross-enterprise communication, in particular for use with the RID and XDS integration profiles
- XUA is based on the OASIS Security Assertion Markup Language 2.0 (SAML)

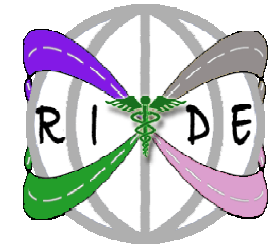
Combinations of EHR Content and Communication Protocol



Standards & EHR Standard Content Formats

Protocol/ Content	EHRcom EN 13606-5	WADO HTTP	DICOM SR DICOM Q/R	RID WSDL/HTTP	XDS ebXML/HTTP
EHRcom extract	Yes	No	No	Yes	Yes
CDA document	(Embedded)	No	No	Yes	Yes
SR document	(Embedded)	Yes	Yes	Yes	Yes
MML document	(Embedded)	No	No	Yes	Yes

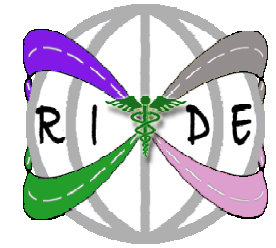
Combinations of EHR Content and Communication Protocol



Standards & General Purpose Content Formats

Protocol/ Content	EHRcom EN 13606-5	WADO HTTP	DICOM SR DICOM Q/R	RID WSDL/HTTP	XDS ebXML/HTTP
PDF	Embedded	Yes	Yes	Yes	Yes
HTML/ XHTML	Embedded	Yes	No	Yes	Yes
RTF	Embedded	Yes	No	Yes	Yes

Combinations of EHR Content and Communication Protocol

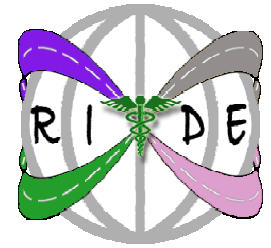


Standards & Multimedia Content

Formats for Images, Signals and Movies

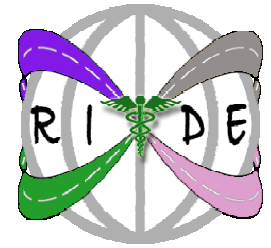
Protocol/ Content	EHRcom EN 13606-5	WADO HTTP	DICOM SR DICOM Q/R	RID WSDL/HTTP	XDS ebXML/HTTP
DICOM	Embedded	Yes	Yes	Yes	Yes
JPEG	Embedded	Yes	Embedded	Yes	Yes
TIFF, BMP, PNG	Embedded	No	No	Yes	Yes
MPEG	Embedded	No	Embedded	Yes	Yes
AVI	Embedded	No	No	Yes	Yes

EHR Standard Harmonization Efforts



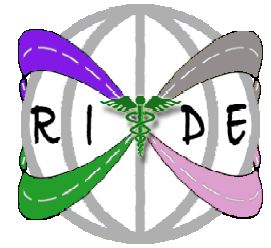
- The cooperation between CEN/TC 251 and HL7 is governed by a Memorandum of Understanding
 - both organizations agree, amongst others, to work towards a harmonization of the HL7 RIM with the CEN object oriented information models for the CEN message standards.
 - collaborate through joint task forces, in particular in the field of EHR standards, i. e. the revision of ENV 13606 and the work of the HL7 CDA group

EHR Standard Harmonization Efforts



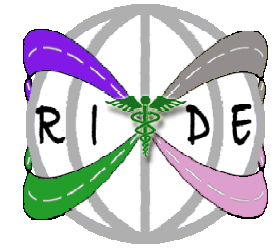
- The openEHR foundation has agreed on a Memorandum of Understanding with CEN/TC 251 to join the EHR-related efforts of both organizations
- The openEHR archetype concept will be included in the revised version of the European Pre-standard ENV 13606 which will be released as a European Standard

EHR Standard Harmonization Efforts



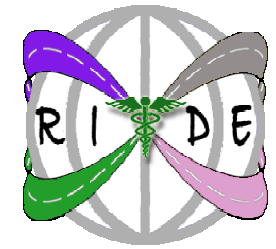
- a common reference model (classes and datatypes) based on the HL7 version 3 reference information model (RIM) will be developed, resulting in major changes in the openEHR architecture and EN 13606

EHR Standard Harmonization Efforts

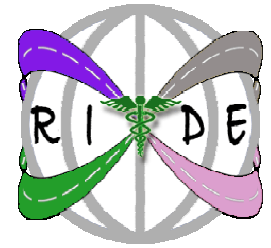


- The EHRcom reference model is based on the HL7 version 3 Reference Information Model (RIM) and can be expressed as an HL7 Domain Message Information Model (D-MIM), that is, as a specialization of the HL7 RIM
- The data types used in the EHRcom reference model are defined in CEN/TS 14796 and are a true subset of the HL7 version 3 data types

Analysis of Market Relevance of EHR Standards



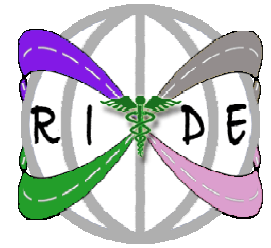
	CEN EHRcom	HL7 CDA R2	ISO WADO	DICOM SR	IHE RID	IHE XDS	MML
Final specification available	No	Yes	Yes	Yes	Yes	Yes	Yes
Implemented	No	Yes	Yes	Yes	Yes	Yes	Yes
Commercial products available	No	Yes	Yes	Yes	Yes	Yes	Yes
Intended for international market	Yes	Yes	Yes	Yes	Yes	Yes	No
Focussed on medical imaging sector	No	No	Yes	Yes	No	No	No



Conclusions

- no clear “winner”
- content format standards are surprisingly similar in concept and capabilities
 - Using a two-level modeling approach with a simple reference model
 - constraint rules (archetypes, templates) for mapping clinical data onto the model
- differ in the progress achieved in the standardization process
 - DICOM SR already has a large library of standard templates encapsulating domain knowledge

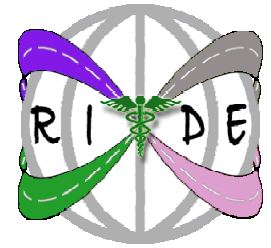
Conclusions



□ Market relevance

- DICOM SR is clearly the most advanced EHR standard at the time being in terms of content structure, template library and access services
- But, focus of DICOM is the medical imaging sector
 - the acceptance outside the medical imaging domain is rather limited because vendors have no experience with the complex protocol and binary encoding rules used by the DICOM standard
- MML is purely for Japan market
 - is likely that MML will be completely merged with the CDA specification once it supports templates

Conclusions



□ Access services

- DICOM is the specification that has been stable for the longest time
- EHRcom are currently under development
- for CDA it is not even clear if there will be standardized access services at all
- IHE: Retrieve Information for Display (RID)
 - inter-departmental
 - can easily be used in a cross-enterprise setting using the same approach that is also used in XDS

Conclusions

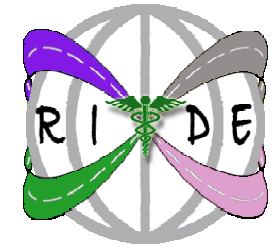


□ Access services

■ The XDS integration profile

- defines all access services needed for an EHR and has been designed for cross-enterprise use
- still a number of open issues such as access control and document content profiles for non-imaging domains
- there seems to be significant interest in XDS, both from the commercial side and from national EHR projects
 - Canada Health Infoway
 - a successful market uptake is likely

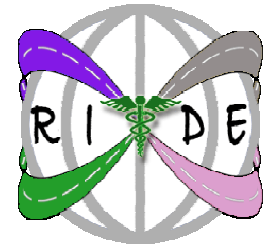
Conclusions



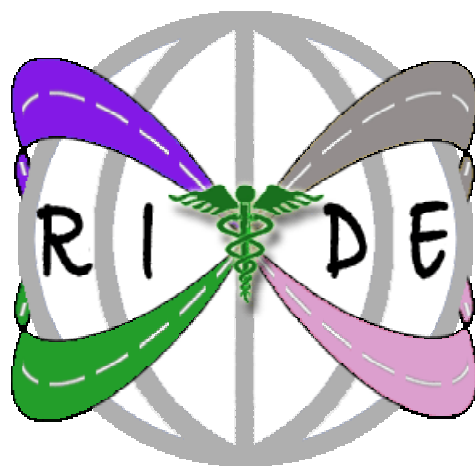
□ candidates

- XDS with structured content in CDA or EHRcom format and image access through WADO (XDS-I)
- EHRcom as a comprehensive EHR solution
 - The convergence of EHRcom, openEHR and HL7 makes the success of the new standard certainly more likely
- CDA as a comprehensive EHR solution
 - HL7 V3 Medical Records messages (DSTU)

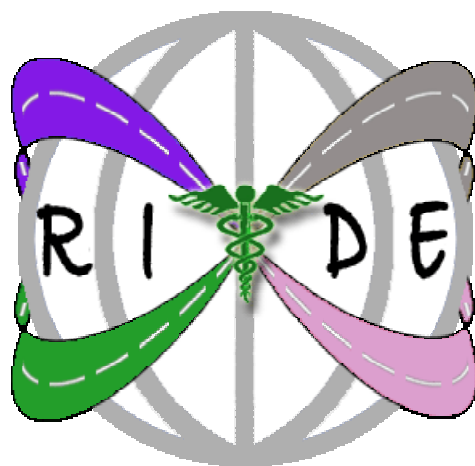
Finally...



- given the large number of EHR standards, conformance to one of these standards or implementing a combination of them will not solve the interoperability problem
 - there will always be some health-care institutes using a different, incompatible EHR standard
 - true interoperability of EHRs will only be possible by providing semantic interoperability

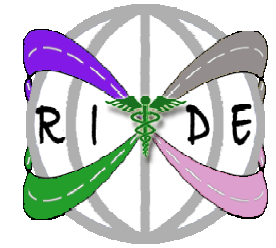


Thank you



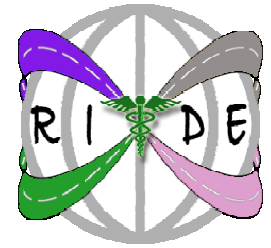
Extra Slides

GEHR/OPENEHR



- Started in 1992m as an EU project
 - Good European Health Record
 - Good Electronic Health Record
 - OpenEHR
- Archetypes
 - a two level methodology to model the HER structure
 - A generic reference model
 - Role, act, entity
 - Healthcare and application specific concepts such as *blood pressure* is defined as archetypes
 - Similar to
 - HL7 CDA and DICOM Structured Reporting

Archetypes

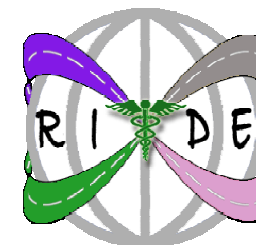


- Descriptive data
 - Id, code for clinical concept modeled by the archetype, author, version, purpose...
- Constraint rules
 - Define restrictions on the valid structure, cardinality, and content
- Ontological references
 - Controlled vocabulary
 - Language translations
 - Bindings from local code values to external vocabularies such as SNOMED

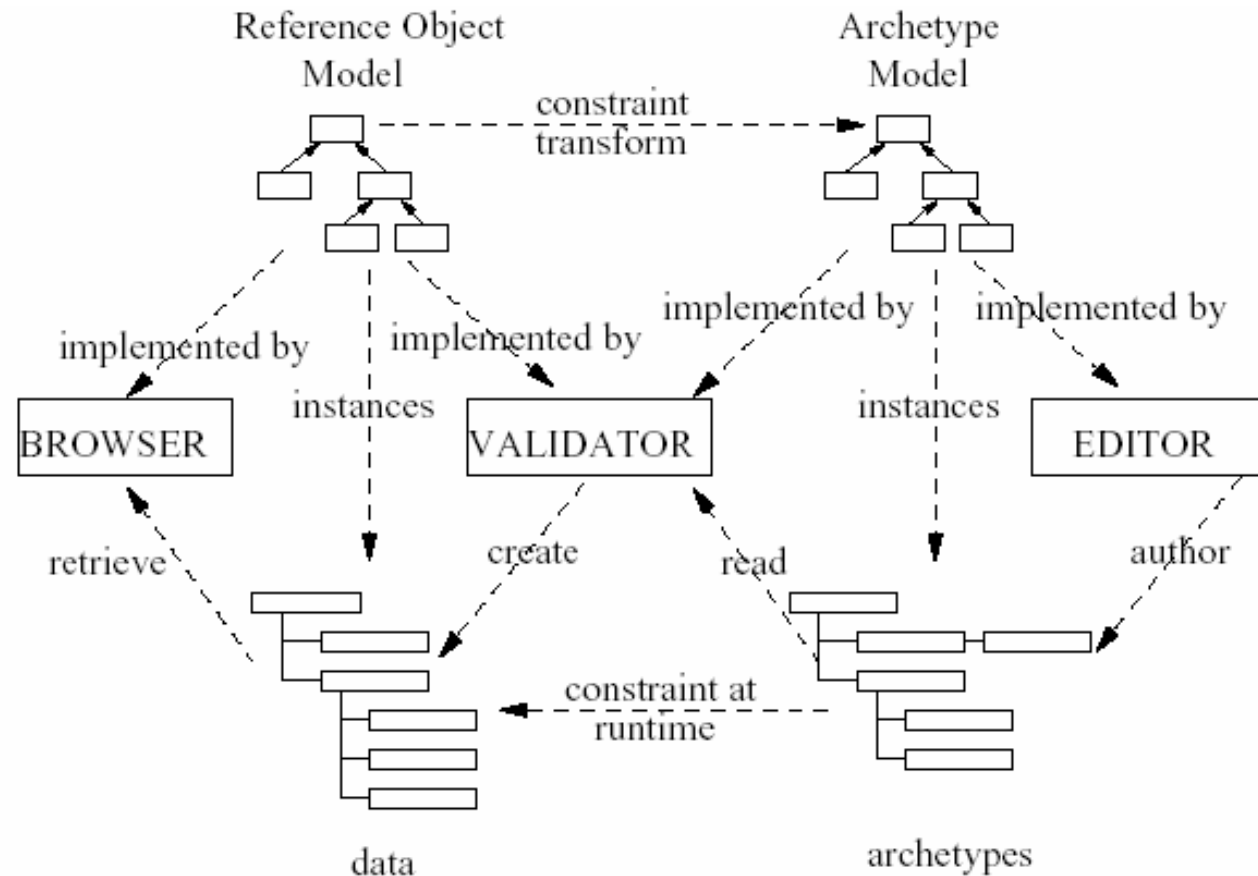
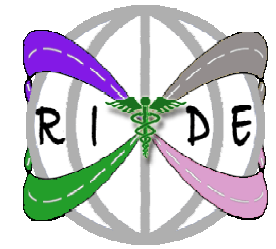
```

OBSERVATION[at1000.1] matches {-- complete blood picture
  name matches {
    CODED_TEXT matches {
      code matches {[ac0001]} -- complete blood count}}
  data matches {
    LIST_S[at1001] matches {-- battery
      items cardinality matches {0..*} \epsilon {
        ELEMENT[at1002.1] matches {-- haemaglobin
          name matches {
            CODED_TEXT matches {
              code matches {[ac0003]} -- haemaglobin}}
          value matches {
            QUANTITY matches {
              value matches {0..1000}
              units matches {^g/l|g/dl|.+^}}}}
        ELEMENT[at1002.2] occurrences matches {0..1} matches
        {-- haematocrit
          name matches {
            CODED_TEXT matches {
              code matches {[ac0004]}-- haematocrit}}
          value matches {
            QUANTITY matches {
              value matches {0..100}
              units matches {"%"}}}}}
        ELEMENT[at1002.3] occurrences matches {0..1} matches
        {-- platelet count
          name matches {
            CODED_TEXT matches {
              code matches {[ac0005]} -- platelet count}}
          value matches {
            QUANTITY matches {
              value matches {0..100000}
              units matches {"/cm^3"}
            }}}}}}}

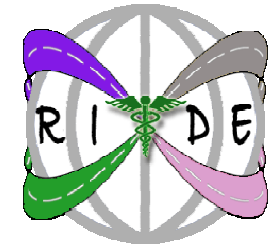
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Archetypes

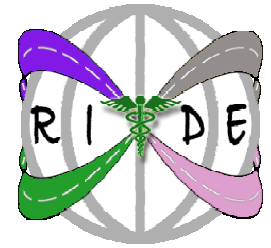


OpenEHR Framework



- A reference information model
- ADL language to express archetypes
- An archetype library
- A collection of open source implementations of the openEHR specifications

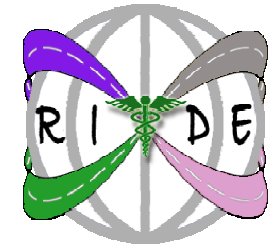
CEN/TC 251 and ENV/EN 13606 EHRCOM



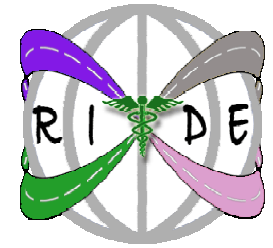
□ CEN ENV 13606 2000

- a message-based standard for the exchange of electronic healthcare records
 - an EHR information model
 - a list of machine-readable domain terms
 - a method of specifying “distribution rules”
 - request and response messages that allow systems to exchange subsets of an HER
- does not attempt to specify a complete HER system
 - focuses on the interfaces relevant for a communication between EHR systems

CEN ENV 13606 2000

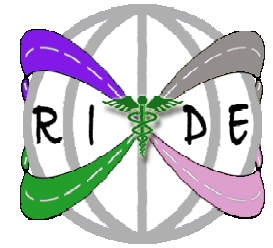


- was intended to be the first fully implementable EHR standard
 - subsets of it were implemented in a number of EHR projects
 - UK, Denmark, the Netherlands, Sweden, and Norway
 - none of these projects used the complete ENV 13606 specification
 - single-level modeling approach made the information model extremely complex
 - lots of optionality and a level of abstraction that made the model quite difficult to comprehend and implement



EN 13606 EHRcom

- In 2001, CEN/TC 251 decided to revise ENV 13606 into a full European Standard
 - adopt the openEHR archetype methodology
- (1) The Reference Model
- (2) Archetype Interchange Specification
- (3) Reference Archetypes and Term Lists
- (4) Security Features
- (5) Exchange Models
- only the reference model (EN 13606-1) is stable, whereas parts 2 through 5 are still working drafts
 - Our study focuses on the reference model as defined in [CEN prEN 13606-1 2004]

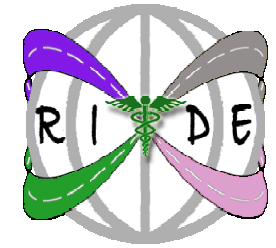


EHRcom reference model

- consists of four packages
 - Extract
 - defines the root class of the reference model
 - the data structures for EHR content
 - Demographics
 - a minimal data set to define the various persons, software agents, devices and organizations that are referenced within the EHR extract
 - Access Control
 - under development as EN 13606-4, will define a representation for EHR access policies
 - Message
 - under development as EN 13606-5, will define the attributes required to communicate the EHR extract to a requesting process via a message or other serialized form
 - Will allow to define HL7 version 3 messages to be used for communication of EHR extracts

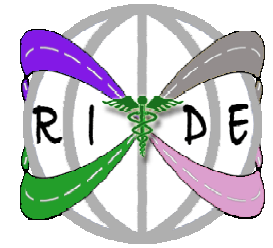
Logical Building Blocks of EHRcom

[Kalra 2004]



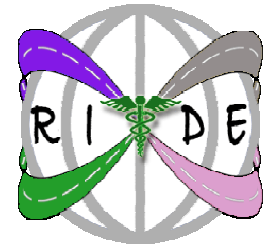
EHR	The electronic healthcare record for one person
Folders	High-level organization of the EHR e.g. per episode, per clinical speciality
Compositions	A clinical care session, encounter or document e.g. test result, letter
Sections	Clinical headings reflecting the workflow and consultation process
Entries	Clinical "statement" about Observations, Evaluations, and Instructions
Clusters	Nested multi-part data structures (tables and interval time series) e.g. audiogram
Elements	Leaf nodes with single data values e.g. reason for encounter, body weight
Data Values	Data types for instance values e.g. coded terms, measurements with units

EHRCom & Archetypes



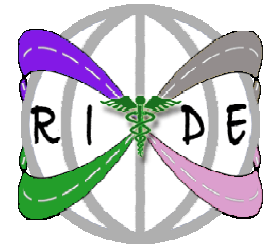
- EN 13606-2 will define an archetype description language (ADL), that is, a formal language that is related to the EHRcom reference model
- Archetypes expressed in this language will be convertible to HL7 Refined Message Information Models (R-MIMs) and Common Message Element Types (CMETs)
- It is intended to harmonize the EHRcom archetype concept with the HL7 Clinical Document Architecture (CDA) and HL7 Templates

HL7 message Protocols



- trigger event
 - causes the exchange of messages between a pair of applications
 - an HL7 message is prepared by collecting the necessary data from the underlying application systems and it is passed to the requestor, usually as an EDI (Electronic Data Interchange) message
- HL7: Version 2 and Version 3, the first parts of which were approved in 2004 by the American National Standards Institute [ANSI]
- HL7 Version 2 Messaging Standard is the most widely implemented standard for healthcare information in the world today
 - being HL7 Version 2 compliant does not imply direct interoperability between healthcare systems
 - no precisely defined underlying information model; the definitions for many data fields are rather vague and there is a multitude of optional data fields
 - provides great flexibility, but necessitates detailed bilateral agreements

HL7 CDA



- previously called Patient Record Architecture (PRA)
 - defines structure and semantics of medical documents for the purpose of exchange
 - derive their meaning from the HL7 Reference Information Model (RIM) and use the HL7 Version 3 Data Types



Table I. Hierarchy of CDA “Levels” in Release One and Release Two

<i>CDA Release One</i>	<i>CDA Release Two</i>
CDA Level One	The unconstrained CDA specification
CDA Level Two	The CDA specification with section-level templates applied
CDA Level Three	The CDA specification with entry-level templates applied

□ Level One:

- The CDA header is derived from RIM and unambiguously defines the semantics of each entry in the document
- CDA Body contains the clinical document content, can be unstructured or can be comprised of nested containers
- such as sections, paragraphs, lists, and tables through structured markup

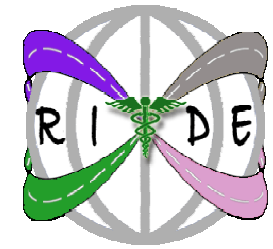
□ Level Two CDA

- it is possible to constrain both structure and content of a document by means of a template and thereby increase interoperability since the receiver knows what to expect

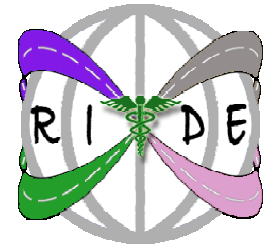
```

<section>
  <code code="8709-8" codeSystem="2.16.840.1.113883.6.1" codeSystemName="LOINC"/>
  <title>Skin Exam</title>
  <text>Erythematous rash, palmar surface, left index finger.
    <renderMultiMedia referencedObject="MM2"/>
  </text>
  <entry>
    <Observation>
      <code code="106076001" codeSystem="2.16.840.1.113883.6.96"
        codeSystemName="SNOMED CT" displayName="Skin finding"/>
      <value xsi:type="CD" code="271807003"
        codeSystem="2.16.840.1.113883.6.96"
        codeSystemName="SNOMED CT" displayName="Rash"/>
      <targetSiteCode code="48856004"
        codeSystem="2.16.840.1.113883.6.96" codeSystemName="SNOMED CT"
        displayName="Skin of palmer surface of index finger">
        <qualifier>
          <name code="78615007" codeSystem="2.16.840.1.113883.6.96"
            codeSystemName="SNOMED CT" displayName="with laterality"/>
          <value code="7771000" codeSystem="2.16.840.1.113883.6.96"
            codeSystemName="SNOMED CT" displayName="left"/>
        </qualifier>
      </targetSiteCode>
      <entryRelationship typeCode="SPRT">
        <RegionOfInterest MMID="MM2">
          <id root="10.23.4567.4489"/>
          <code code="ELLIPSE"/> <value>3 1 3 7 2 4 4 4</value>
          <entryRelationship typeCode="SUBJ">
            <ObservationMedia> <id root="10.23.4567.345"/>
              <value xsi:type="ED" mediaType="image/jpeg">
                <reference value="lefthand.jpeg"/> </value>
            </ObservationMedia>
          </entryRelationship>
        </RegionOfInterest>
      </entryRelationship>
    </Observation>
  </entry>
</section>

```

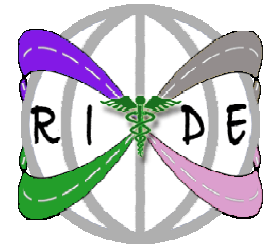


HL7 CDA



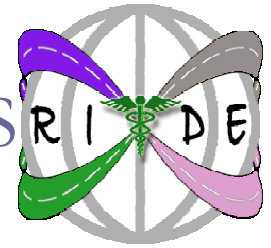
- does not specify services or protocols that are used to exchange a document
- From the perspective of HL7 messages
 - a CDA document is just a multimedia object than can be exchanged as a MIME (Multipurpose Internet Mail Extensions) package
- Many national and international pilot projects use HL7 CDA Release One as a format for clinical documents
- Vendors already have experience with HL7 and are likely to be aware of the opportunities offered by CDA
 - Opens the way to wide adoptance

HL7 CDA



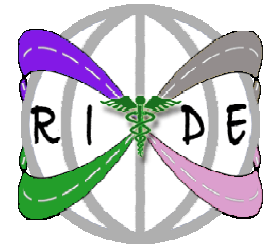
- ❑ The HL7 Clinical Document Architecture (CDA) is not an EHR standard since it only defines parts of an EHR architecture
- ❑ is currently being harmonized with the equivalent structures in EN 13606 and openEHR
- ❑ CDA is a subset of the EN 13606 Reference Model
- ❑ EN 13606 will most likely be compliant with CDA Release Two

DIGITAL IMAGING AND COMMUNICATIONS IN MEDICINE (DICOM)



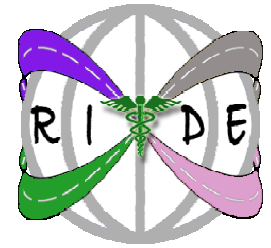
- the de-facto standard for medical image communication
- defines data structures and services for the vendor independent exchange of medical images and related information
- Developed by
 - National Electrical Manufacturers Association
- Unlike most other EHR standards
 - uses a binary encoding with hierarchical lists of data elements identified by numerical tags
 - a complex DICOM-specific application level network protocol

Web Access to DICOM Persistent Objects (WADO)



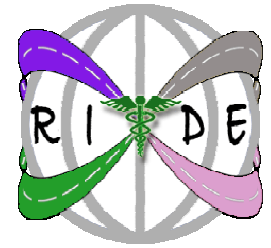
- ❑ a joint effort of DICOM and ISO
- ❑ defines a Web-based service that can be used to retrieve DICOM objects (images, waveforms and reports) via HTTP or HTTPS from a Web server
- ❑ query mechanism is not supported
- ❑ The Web client has to specify the DICOM object to be retrieved by its unique identifiers for the study
 - Options such as to anonymize DICOM object
 - The client can also request the server to convert the DICOM object to a different, presentation-ready format, for example, JPEG for images and HTML for reports

DICOM Structured Reporting



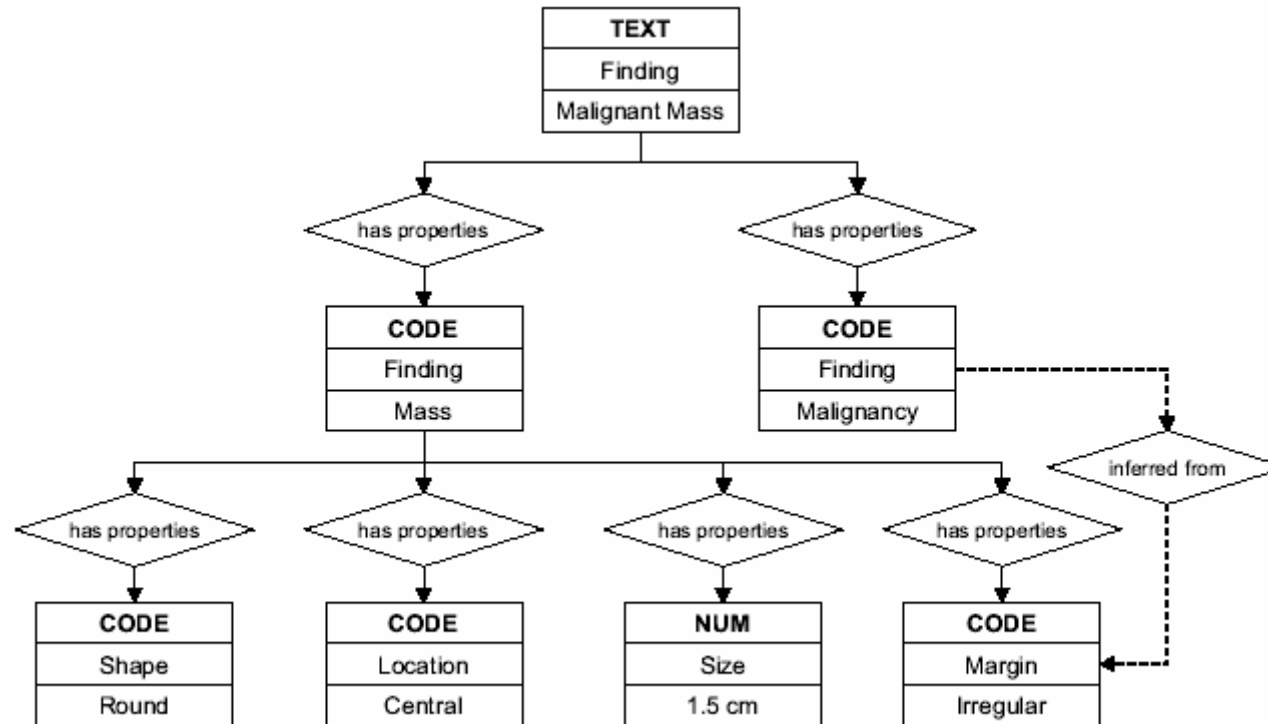
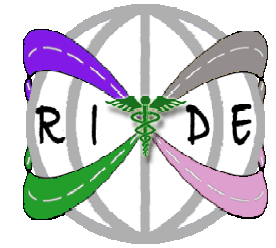
- an extension to the DICOM standard
 - that covers medical reports and other clinical data
 - a general model for encoding medical reports in a structured manner in DICOM's tag-based format
 - Allows the existing DICOM infrastructure network services like storage or query/retrieve, to be used to archive and to communicate, to encrypt and to digitally sign structured reports with only relatively small changes to existing systems

DICOM Structured Reporting

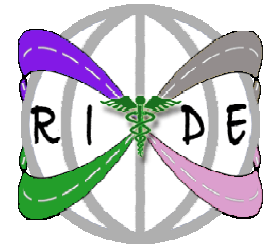


- In addition to the header information that is also used for DICOM images, the actual content of a structured report is represented by a document tree
- The semantics of most content items in the SR document tree is described by a machine-readable code and, therefore, enables computer-supported automatic evaluation and processing

Excerpt from a DICOM SR Document Tree

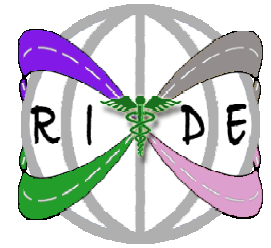


DICOM Structured Reporting



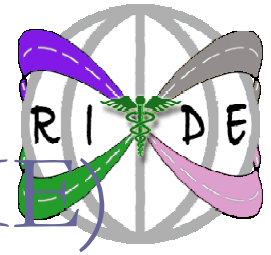
- In order to enhance interoperability in practice, the DICOM standard specifies document classes and other types of constraints for different medical applications
- This collection of standard templates, context groups and codes is called DICOM Content Mapping Resource (DCMR)

DICOM Structured Reporting



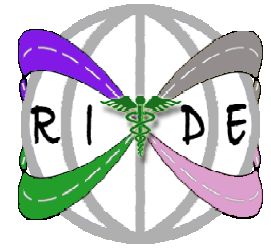
- Current products focus on medical fields that are already well-covered by the DICOM standard and where standard document templates exist,
 - Radiology and cardiology
- Outside of the “imaging world” DICOM is not that common and, therefore, it is rather unlikely that Structured Reporting will become accepted in the near future as an EHR standard

INTEGRATING THE HEALTHCARE ENTERPRISE (IHE)



- was founded in 1998 in the USA by the Radiological Society of North America (RSNA) [RSNA] and the Healthcare Information and Management Systems Society (HIMSS)
- does not develop standards as such, it selects and recommends appropriate standards for specific use cases and also develops restrictions
 - application profiles for these standards that allow for a simplified system integration

IHE Profiles



- integration profiles
 - Radiology, Cardiology, Laboratory as well as "IT Infrastructure"(IT-I)
 - IT-I covers use cases for inter-departmental or inter-institutional system integration
 - Retrieve Information for Display (RID)
 - Enterprise User Authentication (EUA)
 - Patient Identifier Cross-referencing (PIX)
 - Patient Synchronized Applications (PSA)
 - Consistent Time (CT)
 - Audit Trail and Node Authentication (ATNA)
 - Cross-Enterprise Document Sharing (XDS)
 - Patient Demographics Query (PDQ)
 - Personnel White Pages (PWP)
 - Patient Administration Management (PAM)
 - Document Digital Signature Content (DSG)
 - Notification of Document Availability (NAV)
 - Cross-Enterprise User Authentication (XUA)

IHE Retrieve Information for Display (RID)



□ **Two Web services :**

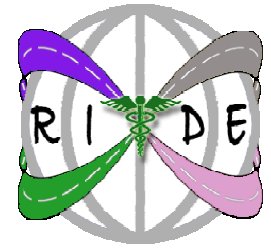
■ **Retrieve Specific Information:**

- Patient centric: patient ID
- Type of Request
- Date, Time, nMostRecent

■ **Retrieve a Document**

- Object Unique Instance Identifier (OID)
- Type of Request
- Content Type Expected

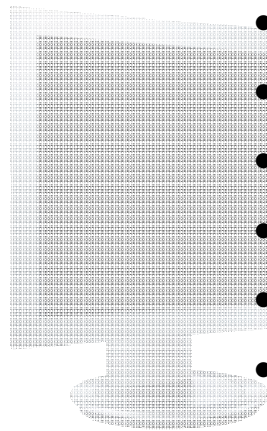
IHE Retrieve Information for



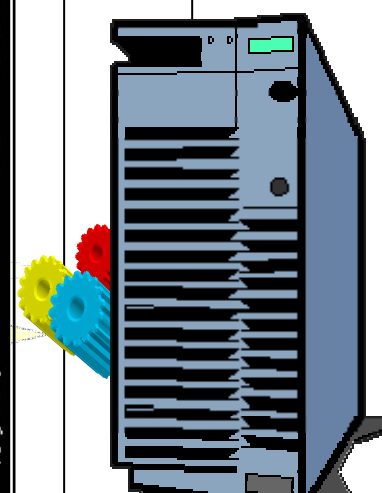
Display

Persistent Document

- Types of
- Summary
 - Summary
 - Summary
 - Summary
 - Summary
 - Summary
 - Summary
 - List of
 - List of



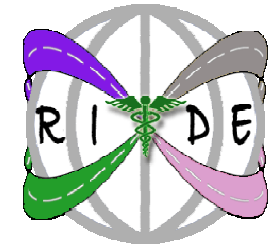
18529	[H]	RENAL MRA
12.09.1977		16.09.2002
F		3231
4-131		271084
		TR 5.5 ms
		...
[R]		[L]
SP: -2.5mm		
ST: 2.8mm		
512x512		
C21		Nanticoke Memorial Ho...
W42		GENESIS_SIGNA
	[F]	30 GAD
	[H]	RENAL MRA
18529		16.09.2002
12.09.1977		3231
F		
1-1		
[R]		
SP: -40.0mm		
ST: 10.0mm		
256x256		
C215		
W431		



```

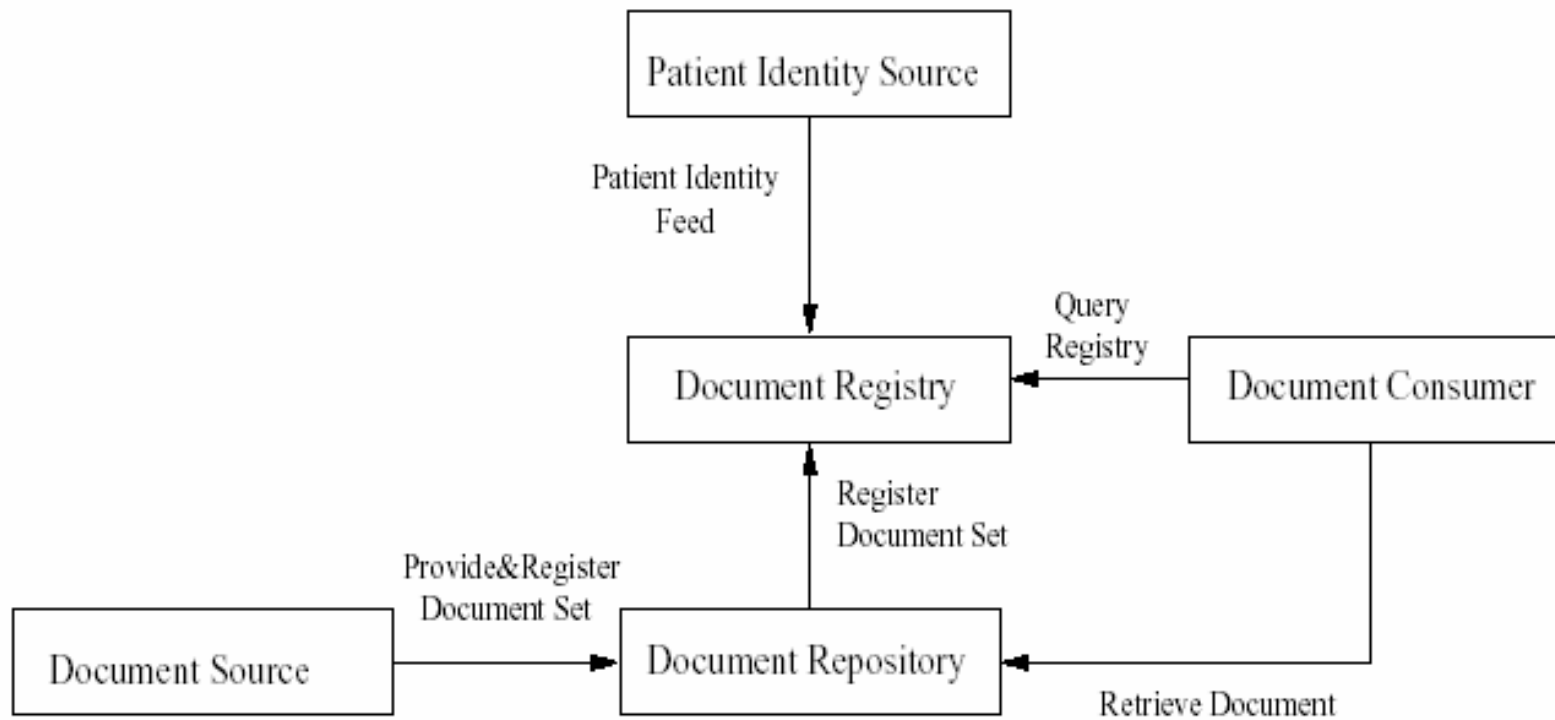
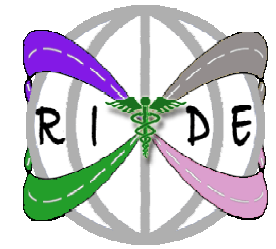
IHE-RID WSDL
<?xml version="1.0" encoding="utf8"?>
<definitions xmlns:http="http://schemas.xmlsoap.org/wsdl/http/"
xmlns:s="http://www.w3.org/2001/XMLSchema"
xmlns:s0="http://rsna.org/ihe/IHERetrieveForDisplay"
targetNamespace="http://rsna.org/ihe/IHERetrieveForDisplay"
xmlns="http://schemas.xmlsoap.org/wsdl/">
<types> <s:schema elementFormDefault="qualified"
targetNamespace="http://rsna.org/ihe/IHERetrieveForDisplay">
<s:simpleType name="summaryRequestType">
<s:restriction base="s:string">
<s:enumeration value="SUMMARY" />
<s:enumeration value="SUMMARY-RADIOLOGY" />
.....
    
```

IHE XDS

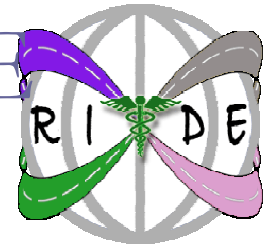


- to store healthcare documents in an ebXML registry/repository to facilitate their sharing
- a group of healthcare enterprises that agree to work together for clinical document sharing is called the “Clinical Affinity Domain”
 - Such institutes agree on a common set of policies such as how the patients are identified, the access is controlled, and the common set of coding terms to represent the metadata of the documents
 - to ensure the interoperability between the document sources and the document consumers, the clinical affinity domains also agree on the document format

IHE XDS

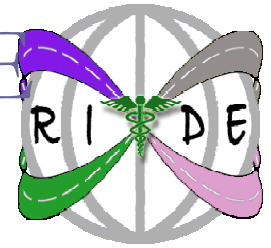


MEDICAL MARKUP LANGUAGE (MML)



- developed since the mid 1990s by the Electronic Health Record Research Group of the Japanese Ministry of Health and Welfare
 - to provide a standardized way to exchange medical documents and other clinical data
 - Based on XML (Extensible Markup Language) was chosen
 - The current version 3.0 uses the XML-based HL7 CDA One format

MEDICAL MARKUP LANGUAGE (MML)



- Can be exchanged via HL7 messages or by any other means of electronic communication
- The local header contains many fields that are also stored in the CDA header but in a different format
- So currently, HL7 CDA is merely used as a standardized container that carries MML information
- Compared to CDA Release One, MML specifies more restrictions on the structure and the content of a document
- Never really used outside Japan but actively used in Japan and there are commercial products on the market that support MML