
Transforming Turkey's National Health Information System Messages to HL7 CDA R2 and CEN EN 13606

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Outline

■ Introduction

- Mapping the National Electronic Healthcare Records to International Standards - Case Study: Turkey
- Automatic Mapping of Local Coded Terms in EHR Documents to International Counterparts
- Mapping HL7 CDA R2 to CEN EN 13606
- Related Work
- Conclusion and Future Work

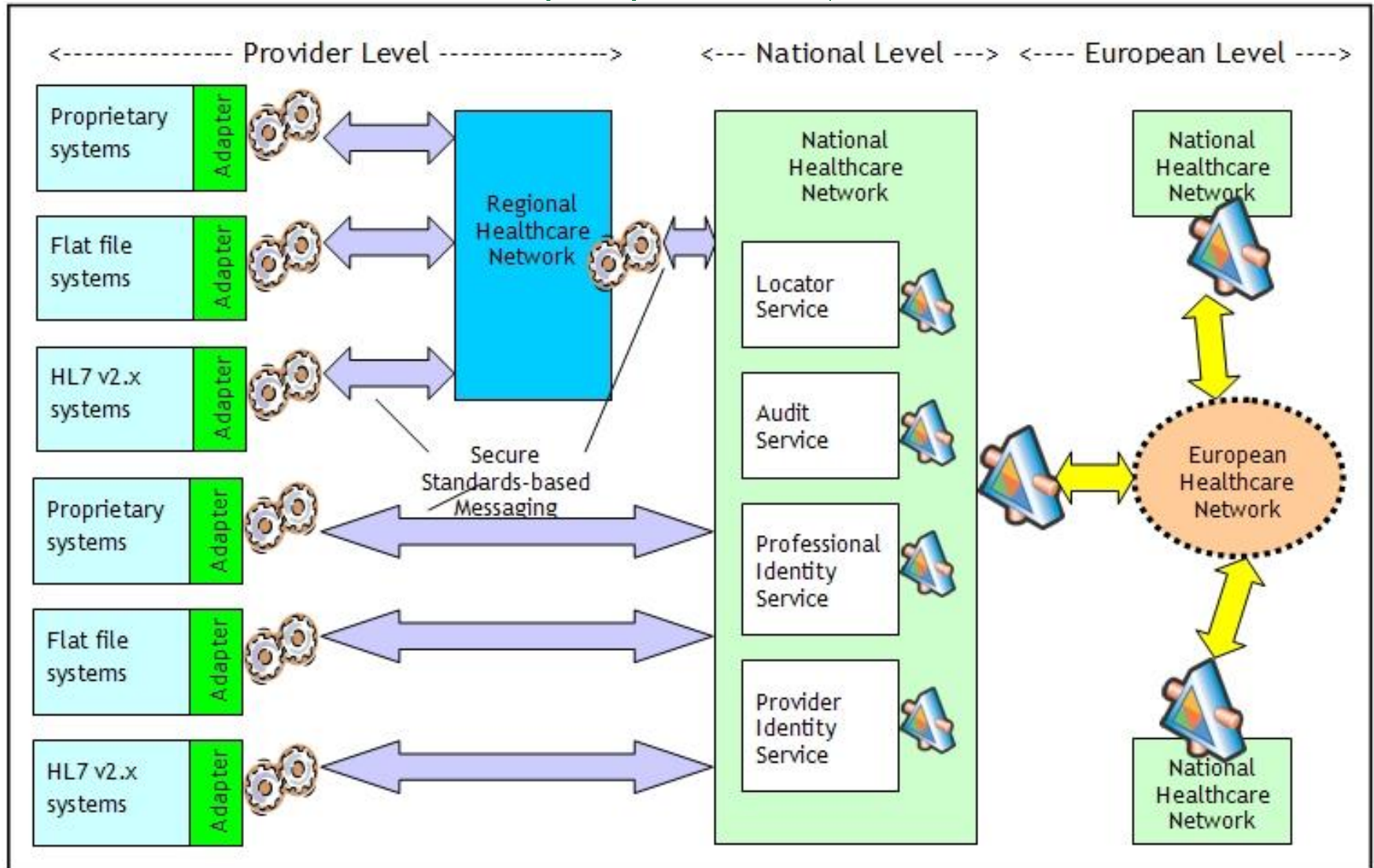
EHR interoperability

- National efforts:
 - Health Infoway in Canada, NHS in UK, DMP in France -> HL7 CDA
 - “Kind Messaging for the Electronic Healthcare Records” in Belgium

- Higher-level efforts:
 - The European Commission publishing recommendations for eHealth Interoperability
 - The new deadline for European Health Network: 2015
 - USA trying to share EHRs among the Regional Health Information Organizations through NHIN

- The RIDE Project has proposed such an architecture:

Involvement of legacy systems in the European Healthcare Network proposed by RIDE



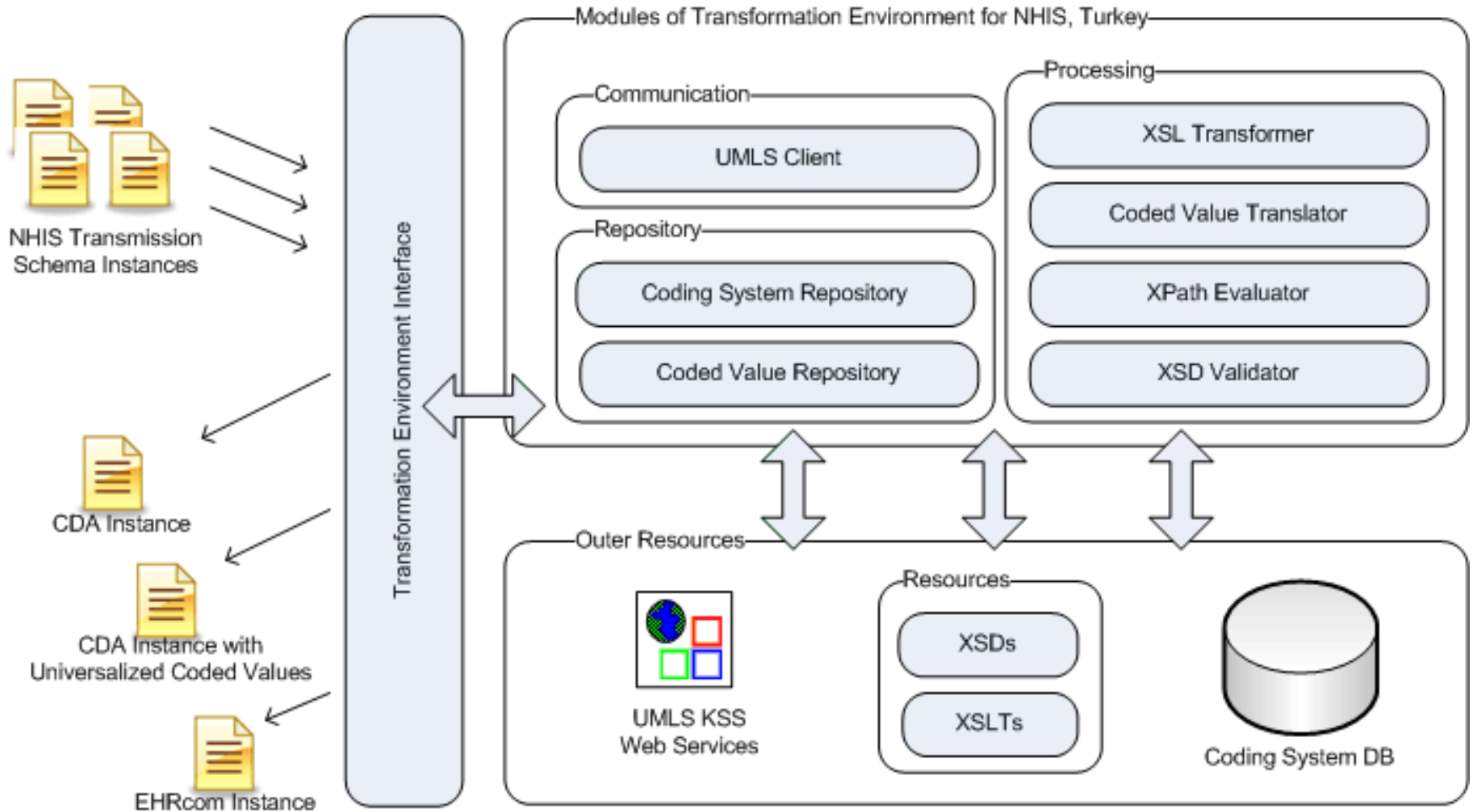
Requirements for such an architecture

1. Developing an Adaptor that will automatically transform the local EHR instances to the commonly agreed format(s) -> *structure level interoperability*
2. Locally developed coded terms that exist in the local EHRs shall be translated to a code system or language that the other participants in the network can understand -> *semantic interoperability*

The objectives of this work...

- Development of an Adaptor for automatically transforming National Health Information System (NHIS) of Turkey Transmission Schema instances to HL7 CDA R2 conformant EHRs
- Development of a Terminology Server based architecture enabling automatic mapping of the local coded terms that appear in the NHIS Transmission Schema instances to international counterparts
- Development of an Adaptor for automatically transforming CDA conformant NHIS Transmission Schema instances to CEN EN 13606 conformant EHRs

The Architecture of the Transformation Environment for NHIS



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National Health Information System (NHIS) of Turkey

- The National Health Data Dictionary (NHDD) is developed to enable the parties to share the same meaning of data

- 46 Minimum Health Data Sets (MHDS) and 261 data elements

Some data elements

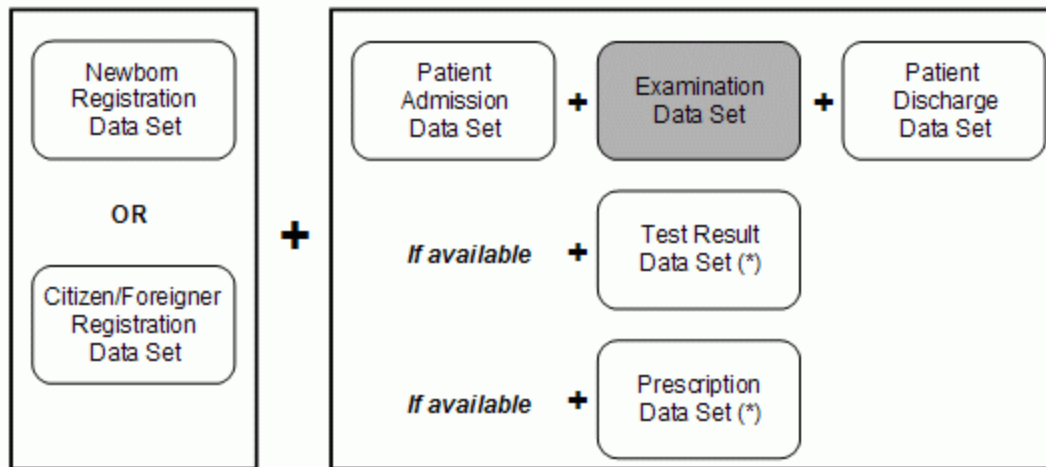
- Address
- Name
- Main Diagnosis
- Vaccination
- Treatment Method
- Diastolic Blood Pressure
- Healthcare Institution
- Marital Status

Some MHDSs

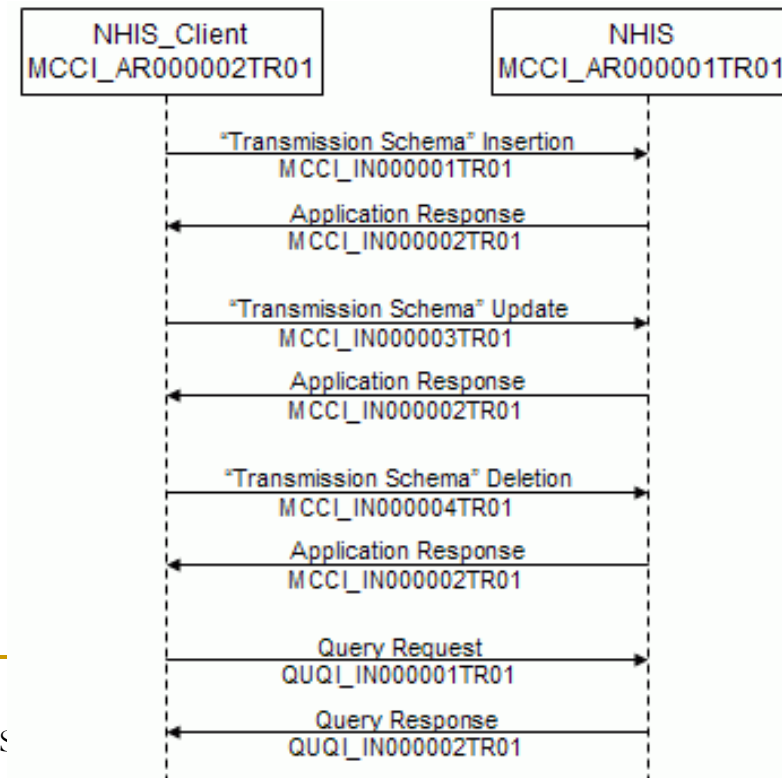
- Citizen/Foreigner Registration MHDS
- Medical Examination MHDS
- Prescription MHDS
- Pregnant Monitoring MHDS
- Cancer MHDS
- Inpatient MHDS

Data Collection and Sharing in the NHIS

- HL7 CDA is preferred as the EHR content format
- “Transmission Schemas” are mapped to CDA
- HL7 Version 3 is preferred for messaging
- HL7 Web Service Profile is used
 - 25 HL7 Web Services

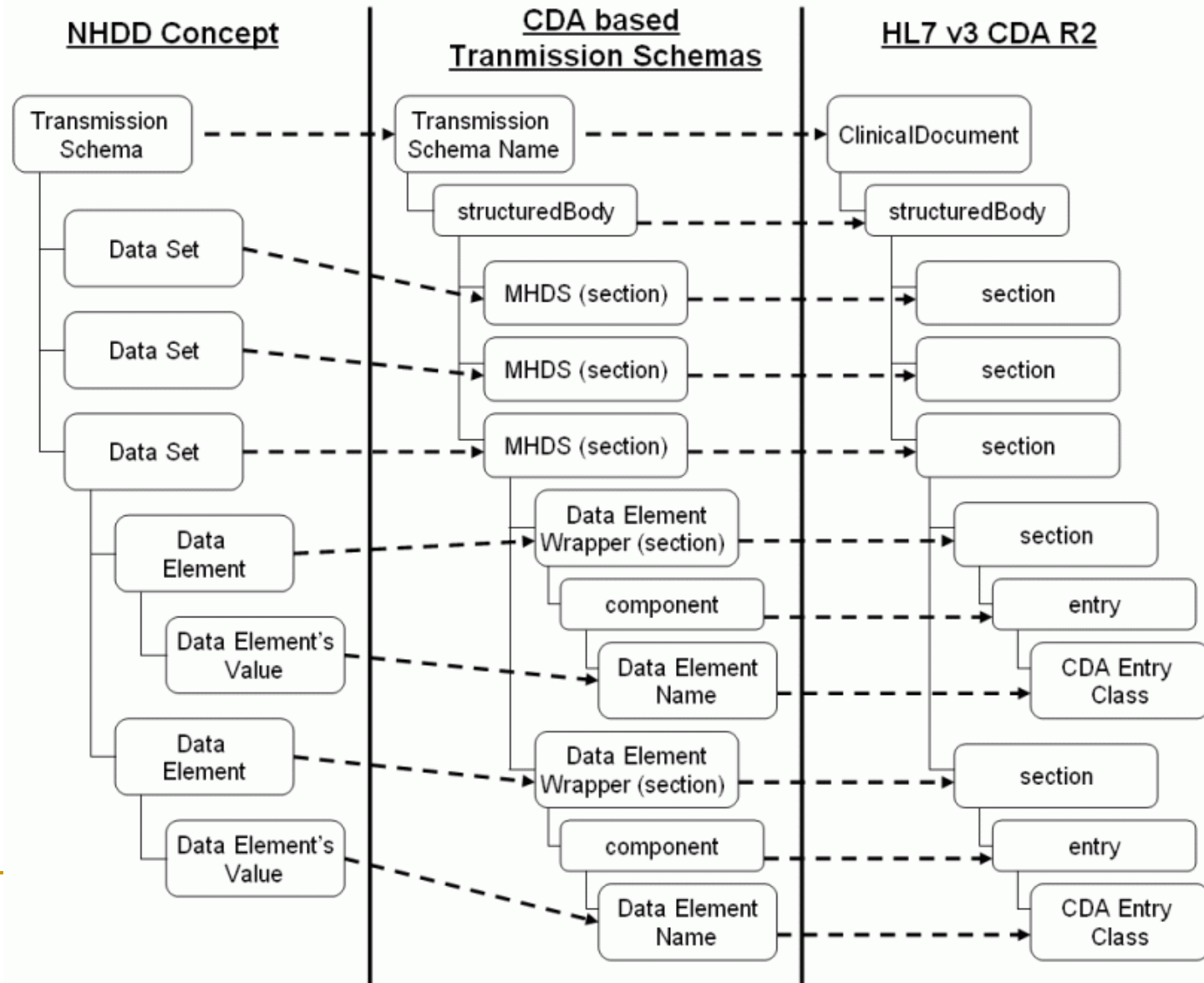


(*) Can be repeated in case of multiple instances



Incompatible changes done on the original CDA Schema

- 14 major categories of incompatible changes have been identified



Example transformations

```
<examination xmlns="urn:hl7-org:v3" classCode="DOCCLIN" moodCode="EVN">  
  <id root="2.16.840.1.113883.3.129.2.1.3" extension="11333439-08ab-42c5-ec2d-17064c153456" />  
  <ClinicalDocument xmlns="urn:hl7-org:v3" classCode="DOCCLIN" moodCode="EVN">  
    <typeId root="2.16.840.1.113883.1.3" extension="POCD_HD000040"/>  
    <id root="2.16.840.1.113883.3.129.2.1.3" extension="11333439-08ab-42c5-ec2d-17064c153456" />
```

```
<recordTarget typeCode="RCT" contextControlCode="OP">  
  <babyPatientRole classCode="PAT">  
    <recordTarget>  
      <patientRole>  
        <id root="2.16.840.1.113883.3.129.1.1.1" extension="12345678905.20080209.1"/>  
        <patient>  
          <administrativeGenderCode code="1" codeSystem="2.16.840.1.113883.3.129.1.2.21" codeSystemName="Cinsiyet"  
codeSystemVersion="1.0" displayName="Erkek"/>  
          <birthTime value="20080209"/>  
          <guardian classCode="GUARD">  
            <id root="2.16.840.1.113883.3.129.1.1.1" extension="16892264390"/>  
            <code code="MTH" codeSystem="2.16.840.1.113883.5.111" codeSystemName="RoleCode"  
codeSystemVersion="1.0" displayName="Mother"/>  
            <guardianPerson/>  
          </guardian>  
        </patient>  
      </patientRole>  
    </recordTarget>
```

Example transformations

```
<examination classCode="DOCCLIN" moodCode="EVN">
[CDA Header]
<ClinicalDocument classCode="DOCCLIN" moodCode="EVN">
[CDA Header]
<component typeCode="COMP" contextConductionInd="true">
<structuredBody classCode="DOCBODY" moodCode="EVN">
<component typeCode="COMP" contextConductionInd="true">
<section classCode="DOCSECT" moodCode="EVN">
...
</section>
</component>
<component typeCode="COMP" contextConductionInd="true">
<section classCode="DOCSECT" moodCode="EVN">
...
</section>
</component>
<component typeCode="COMP" contextConductionInd="true">
<section classCode="DOCSECT" moodCode="EVN">
...
</section>
</component>
...
</structuredBody>
</component>
</examination>
```

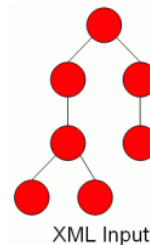
Example transformations

```
<dischargeDiagnosisSection classCode="DOCSECT" moodCode="EVN">
  <id root="2.16.840.1.113883.3.129.2.1.5" extension="b66aa560-8b8e-4078-8236-d7edcdf5ce3a"/>
  <section classCode="DOCSECT" moodCode="EVN">
    <id root="2.16.840.1.113883.3.129.2.1.5" extension="b66aa560-8b8e-4078-8236-d7edcdf5ce3a"/>
    <code code="TANI" codeSystem="2.16.840.1.113883.3.129.2.2.3" codeSystemName="Veri Kısmı"
codeSystemVersion="1.0" displayName="Tanı Verisinin Olduğu Bölüm"/>
    <text mediaType="text/x-hl7-text+xml">Sevk Tanısı: Mide ülseri</text>
    <entry typeCode="COMP" contextConductionInd="true">
      <observation classCode="OBS" moodCode="EVN">
        <code code="SEVKTANISI" codeSystem="2.16.840.1.113883.3.129.2.2.6" codeSystemName="Tanı Tipi"
di codeSystemVersion="1.0" displayName="Sevk Tanısı"/>
        <value xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:type="CV" code="K25"
codeSystem="2.16.840.1.113883.6.3" codeSystemName="ICD-10" codeSystemVersion="1.0" displayName="Mide
ülseri"/>
      </observation>
    </entry>
  </section>
```

An example XSL Transformation Rule

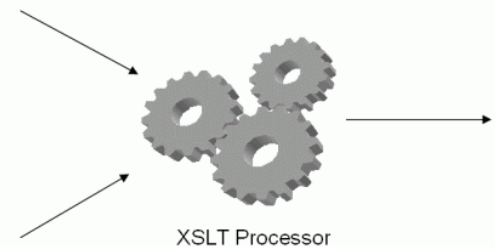
```
<xsl:template name="dischargeDataset-component1">
  <xsl:element name="component">
    <xsl:copy-of select="@*" copy-namespaces="no"/>
    <xsl:element name="section">
      ...
      <xsl:for-each select="hl7:dischargeDiagnosisSection/hl7:component">
        <xsl:call-template name="dischargeDataset-component1-component"/>
      </xsl:for-each>
    </xsl:element>
  </xsl:element>
</xsl:template>

<xsl:template name="dischargeDataset-component1-component">
  <xsl:element name="entry">
    <xsl:copy-of select="@*" copy-namespaces="no"/>
    <xsl:element name="observation">
      <xsl:attribute name="classCode">OBS</xsl:attribute>
      <xsl:attribute name="moodCode">EVN</xsl:attribute>
      <xsl:copy-of select="hl7:dischargeDiagnosis/hl7:code"
        copy-namespaces="no"/>
      <xsl:element name="value">
        <xsl:attribute name="xsi:type">CV</xsl:attribute>
        <xsl:copy-of select="hl7:dischargeDiagnosis/hl7:value/@*"
          copy-namespaces="no"/>
      </xsl:element>
    </xsl:element>
  </xsl:element>
</xsl:template>
```



```
<xsl:template
name="idCodeText">
<xsl:copy-of
select=".hl7.id"
copy-namespaces="no"/>
<xsl:copy-of
select=".hl7.code"
copy-namespaces="no"/>
<xsl:copy-of
select=".hl7.text"
copy-namespaces="no"/>
</xsl:template>
```

XSLT Code (XSL)



Result Document
(XML, HTML, text)

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Semantic Interoperability

- The previous objective accomplished structural interoperability, which is crucial

- However, more is needed in order to enable semantic interoperability
 - Mapping of coded terms from locally developed coding systems to international counterparts to the extend possible

- Our solution: Terminology Server based modular architecture for automatic mapping of the local coded terms
 - Unified Medical Language System (UMLS) Knowledge Source Server (KSS) as the Terminology Server
 - CDA conformant EHRs from NHIS of Turkey as the subject

UMLS KS Web Services

- Secure Web Services providing 49 operations such as “Get Concept Properties”, “Find Lexical Unique Identifier”
- findLUI operation with search string “asthma”:

Code System	Code	Display Name
CCPSS	1017373	ASTHMA
COSTAR	80	ASTHMA
CST	ASTHMA	ASTHMA
DXP	U000273	ASTHMA
OMIM	605010.0004	ASTHMA
SNMI	D2-51000	ASTHMA
WHO	1367	ASTHMA
CCS	128	Asthma
CCS	8.3	Asthma
ICD10	J45	Asthma
ICD10AM	J45	Asthma
ICD9CM	493	Asthma
ICPC	R96	Asthma
ICPC2EENG	R96	Asthma
ICPC2P	R96001	Asthma
LCH	U000405	Asthma
LOINC	MTHU020815	Asthma
MDR	10003553	Asthma

MEDLINEPLUS	T2	Asthma
MSH	D001249	Asthma
MTH	NOCODE	Asthma
NCI	C28397	Asthma
NDFRT	C1098	Asthma
OMIM	MTHU003537	Asthma
PSY	4190	Asthma
RCD	H33..	Asthma
SNM	D-4790	Asthma
SNOMEDCT	195967001	Asthma
MDR	10003560	Asthma NOS
SNOMEDCT	266365004	Asthma NOS
SNMI	D2-51000	Asthma, NOS
MSH	D001249	Asthmas
AOD	5951	asthma
BI	BI00009	asthma
CSP	1525-2157	asthma
ICPC2ICD10ENG	MTHU008836	asthma
ICPC2P	R96001	asthma

Developments

■ Locating the Coded Values

□ XPath:

```
//hl7:confidentialityCode|//hl7:administrativeGenderCode|//hl7:raceCode|//hl7:code|//hl7:value[@xsi:type='CV']
```

■ Building the Local Database

- 173 nationally developed coding systems in the Health Coding Reference Server
- A local DB is maintained for the mapping environment

“Diagnosis Type” Code System

“CodedValue” Instances for “Diagnosis Type” Code System

code	trDisplayName	enDisplayName	prefCodeSystemName	variant
ANATANI	Ana Tanı	Main diagnosis	<i>NULL</i>	{1, 2}
EKTANI	Ek Tanı	Secondary diagnosis	LOINC	{3, 4, 5, 6}
SEVKTANISI	Sevk Tanısı	Referral diagnosis	SNOMEDCT	{7}
CIKISTANISI	Çıkış Tanısı	Discharge diagnosis	<i>NULL</i>	{8}
KOMPLIKASYONTANISI	Komplikasyon Tanısı	Complication diagnosis	<i>NULL</i>	<i>NULL</i>

Universal Variants for the “Diagnosis Type” Code System

id	codeSystemName	code	displayName
1	SNMI	G-1007	Main diagnosis
2	SNOMEDCT	8319008	Main diagnosis
3	LOINC	MTHU021495	Secondary diagnosis
4	MTH	U000281	Secondary diagnosis
5	SNMI	G-1008	Secondary diagnosis
6	SNOMEDCT	85097005	Secondary diagnosis
7	SNOMEDCT	406523004	Referral diagnosis
8	HL7V3.0	DISDX	discharge diagnosis

Example mappings

```
<code code="MUAYENE-YENIDOGAN" codeSystem="2.16.840.1.113883.3.129.2.2.1" codeSystemName="Döküman Tipi" displayName="Muayene MSVS (Yenidoğan)">
```

```
<code code="302199004" codeSystem="2.16.840.1.113883.6.96" codeSystemName="SNOMEDCT" displayName="Examination"/>
```

```
<administrativeGenderCode code="1" codeSystem="2.16.840.1.113883.3.129.1.2.21" codeSystemName="Cinsiyet" displayName="Erkek">
```

```
<administrativeGenderCode code="M" codeSystem="2.16.840.1.113883.5.1" codeSystemName="AdministrativeGender" displayName="Male"/>
```

```
<code code="TETKIKSONUCU" codeSystem="2.16.840.1.113883.3.129.2.2.2" codeSystemName="Veriseti" displayName="Tetik Sonucu Veriseti">
```

```
<code code="TETKIKSONUCU" codeSystem="2.16.840.1.113883.3.129.2.2.2" codeSystemName="Data Set" codeSystemVersion="1.0" displayName="Test result data set"/>
```

```
<code code="CIKIS" codeSystem="2.16.840.1.113883.3.129.2.2.2" codeSystemName="Veriseti" displayName="Çıkış Veriseti">
```

```
<code code="18842-5" codeSystem="2.16.840.1.113883.6.1" codeSystemName="LOINC" displayName="Discharge Summarization Note"/>
```

Example mappings

```
<code code="RAPOR" codeSystem="2.16.840.1.113883.3.129.2.2.3" codeSystemName="Veri Kısmı"  
displayName="Rapor Verisinin Olduğu Bölüm">
```

```
<code code="RAPOR" codeSystem="2.16.840.1.113883.3.129.2.2.3" codeSystemName="Data Section"  
codeSystemVersion="1.0" displayName="Report data section"/>
```

```
<code code="ANATANI" codeSystem="2.16.840.1.113883.3.129.2.2.6" codeSystemName="Tanı Tipi" displayName="Ana  
Tanı">
```

```
<code code="8319008" codeSystem="2.16.840.1.113883.6.96" codeSystemName="SNOMEDCT" displayName="Main  
diagnosis"/>
```

```
<code code="ILAC" codeSystem="2.16.840.1.113883.3.129.2.2.3" codeSystemName="Veri Kısmı" displayName="İlaç  
Verisinin Olduğu Bölüm">
```

```
<code code="10160-0" codeSystem="2.16.840.1.113883.6.1" codeSystemName="LOINC" displayName="Medications"/>
```

```
<confidentialityCode code="1" codeSystem="2.16.840.1.113883.3.129.1.2.77" codeSystemName="Gizlilik"  
displayName="Normal">
```

```
<confidentialityCode code="N" codeSystem="2.16.840.1.113883.5.25" codeSystemName="Confidentiality"  
displayName="Normal"/>
```

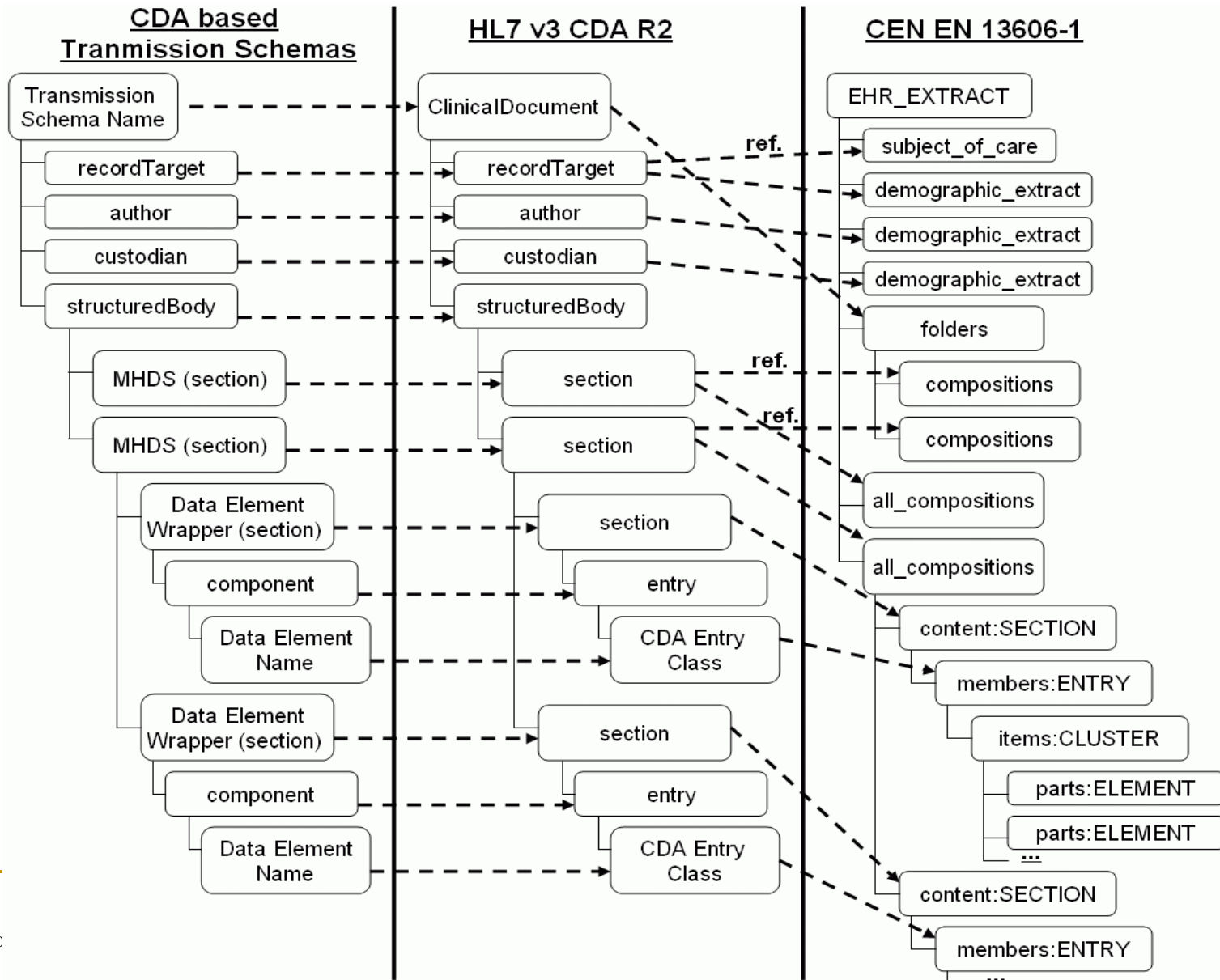
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CEN EN 13606

- CEN EN 13606 Electronic Health Record Communication (EHRcom) is the European Standard for EHRs
- Consists of five parts, the first one being the Reference Model
- It lacks an Implementation Technology Specification, it provides UML class diagrams
 - First define the XML Schema Definition (XSD)
- In order to enrich the interoperability support of our work, we have developed another “Adaptor” for automatically creating CEN EN 13606 conformant EHR instances from HL7 CDA R2 conformant EHRs

Mapping CDA (generated from Transmission Schemas) to EN 13606-1



Example

```
<recordTarget contextContr
<patientRole classCode="I
<id extension="12345678
<patient classCode="PSN
  <name>
    <family>Yüksel</family
    <given>Mustafa</give
  </name>
  <administrativeGenderC
codeSystemName="Adminis
  <birthTime value="1984
  <raceCode code="TR" c
codeSystemVersion="1.0" d
  </patient>
</patientRole>
</recordTarget>
```

```
<demographic_extract xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:type="SUBJECT_OF_CARE_PERSON_IDENTIFICATION">
  <extract_id>
    <extension>12345678905</extension>
    <assigningAuthorityName>NVI, Turkey</assigningAuthorityName>
    <validTime/>
  </root>
  <oid>2.16.840.1.113883.3.129.1.1.1</oid>
</root>
</extract_id>
<name>
  <use>
    <codeValue>Patient Name</codeValue>
  </use>
  <validTime/>
  <namePart>
    <entityPartName>Yüksel</entityPartName>
    <namePartType>
      <codeValue>FAM</codeValue>
    </namePartType>
    <namePartQualifier>
      <codeValue>CL</codeValue>
    </namePartQualifier>
  </namePart>
  <namePart><!-- Mustafa similar to above --></namePart>
</name>
<administrativeGenderCode>
  <codingScheme>
    <oid>2.16.840.1.113883.5.1</oid>
  </codingScheme>
  <codingSchemeName>AdministrativeGender</codingSchemeName>
  <codingSchemeVersion/>
  <codeValue>M</codeValue>
</administrativeGenderCode>
<birthTime><time>19840101</time></birthTime></demographic_extract>
```

Example

```
<code code="8319008" cod  
diagnosis"/>
```

```
<parts xsi:type="ELEMENT">  
  <rc_id>  
    <extension>NA</extension>  
    <assigningAuthorityName>NHIS, Turkey</assigningAuthorityName>  
    <validTime/>  
    <root>  
      <oid>NA</oid>  
    </root>  
  </rc_id>  
  <name><originalText>Act code</originalText></name>  
  <meaning>  
    <codingScheme>  
      <oid>987654321.1</oid>  
    </codingScheme>  
    <codingSchemeName>CEN/TC251/EN13606-  
3:RECORD_COMPONENT_MEANING</codingSchemeName>  
    <codingSchemeVersion>1.0</codingSchemeVersion>  
    <codeValue>HL7-04</codeValue>  
    <displayName>Act_code</displayName></meaning>  
    <synthesised>>false</synthesised>  
    <item_category>  
      <codingScheme>  
        <oid>987654321.3</oid>  
      </codingScheme>  
      <codingSchemeName>CEN/TC251/EN13606-  
3:ITEM_CATEGORY</codingSchemeName>  
      <codingSchemeVersion>1.0</codingSchemeVersion>  
      <codeValue>IC01</codeValue></item_category>  
    <value xsi:type="CV">  
      <codingScheme>  
        <oid>2.16.840.1.113883.6.96</oid>  
      </codingScheme>  
      <codingSchemeName>SNOMEDCT</codingSchemeName>  
      <codingSchemeVersion/>  
      <codeValue>8319008</codeValue>  
      <displayName>Main diagnosis</displayName></value></parts>
```

Observations

- As the major disadvantage, CEN 13606 does not provide a computer processable schema for its reference model.
- In relationship with the above item, the conformance of CEN 13606 cannot be tested since there is not a common schema for it.
- The expressivity of the reference model is too complicated and there are many redundant but mandatory elements.
 - 25 KBs CDA document is transformed into 174 KBs EHRcom document
 - 4 lines of CDA is transformed into 177 lines of EHRcom
 - It is not logical to request globally unique identifiers for leaf-level components that are used for presenting values (e.g. an ICD-10 code or moodCode)

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Related Work

- Our publications:
 - Kose I., Akpinar N., Gurel M., Arslan Y., Ozer H., Yurt N., Kabak Y., Yuksel M., Dogac A. Turkey's National Health Information System (NHIS). In the Proceedings of the eChallenges Conference, Stockholm, October 2008.
 - Kabak Y., Dogac A., Kose I., Akpinar N., Gurel M., Arslan Y., Ozer H., Yurt N., Ozcam A., Kirici S., Yuksel M., Sabur E. The Use of HL7 CDA in the National Health Information System (NHIS) of Turkey. 9th International HL7 Interoperability Conference (IHIC) 2008, Crete, Greece, October 2008.

- The European Healthcare Network proposed by the RIDE Project and recognized by the European Commission
 - The “Adaptor” model

- Kilic O., Dogac A. Achieving Clinical Statement Interoperability using R-MIM and Archetype-based Semantic Transformations.
 - How two different EHR standards (HL7 CDA and CEN EN 13606) derived from the same RIM can be mapped to each other by using archetypes
 - Our work is for mapping the entire reference model of the standards

Related Work

- Ongoing standardization effort for the harmonization of data types by ISO/TC 215, HL7 and Connecting for Health
- Ongoing work jointly by HL7 and CEN experts for modeling EHRcom with the HL7 Reference Information Model
- LinkEHR project intends to develop a tool which allows transformation and standardization of clinical data using a dual model approach (CEN/TC251 EN 13606 and OpenEHR)
- Belgium announced converting Kmehr instances to HL7 CDA with XSLT
- HL7 and ISO coordination for defining and standardizing Common Terminology Services (CTS)
 - Defines an Application Programming Interface (API)
 - WSDL bindings of the APIs are provided

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Conclusion

- Contributions of this work
 - Developments:
 - XSLT based Adaptor to automatically generate CDA conformant instances from the “Transmission Schema” instances.
 - UMLS based modular architecture enabling automatic generalization of the local coded terms
 - XSLT based Adaptor for automatically creating CEN EN 13606 conformant EHR instances from HL7 CDA R2 conformant EHRs
 - All these modules are ready to be deployed as Web Services to the MoH
 - Acting as a proxy between Turkey and other countries
 - Ability to store Transmission Schemas in native CDA
 - Achievements
 - Proved the applicability of RIDE approach on a real case; Turkey
 - Turkey is the first country to support cross-border EHR exchange with more than one international standard
 - One of the first implementations of the recently approved CEN EN 13606 standard

Future Work

- Plan to implement the Mapping interface of the HL7 Common Terminology Services
- The current transformation of CDA to EHRcom is rather NHIS, Turkey centric since we had instances from NHIS
 - More generic transformation capability when we have a collection of CDA instances from different settings

Questions

Thank you for your attention...

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