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THE UNIVERSITY OF WARWICK

Institute of Digital Healthcare

Digital Health and the Challenge of Interoperability

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WARWICK MEDICAL SCHOOL

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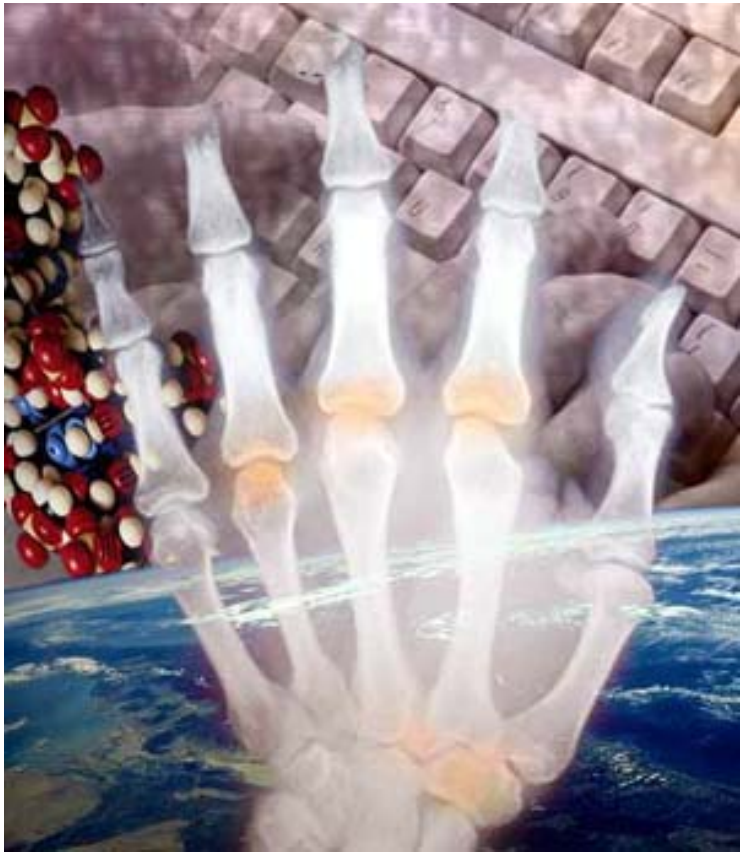
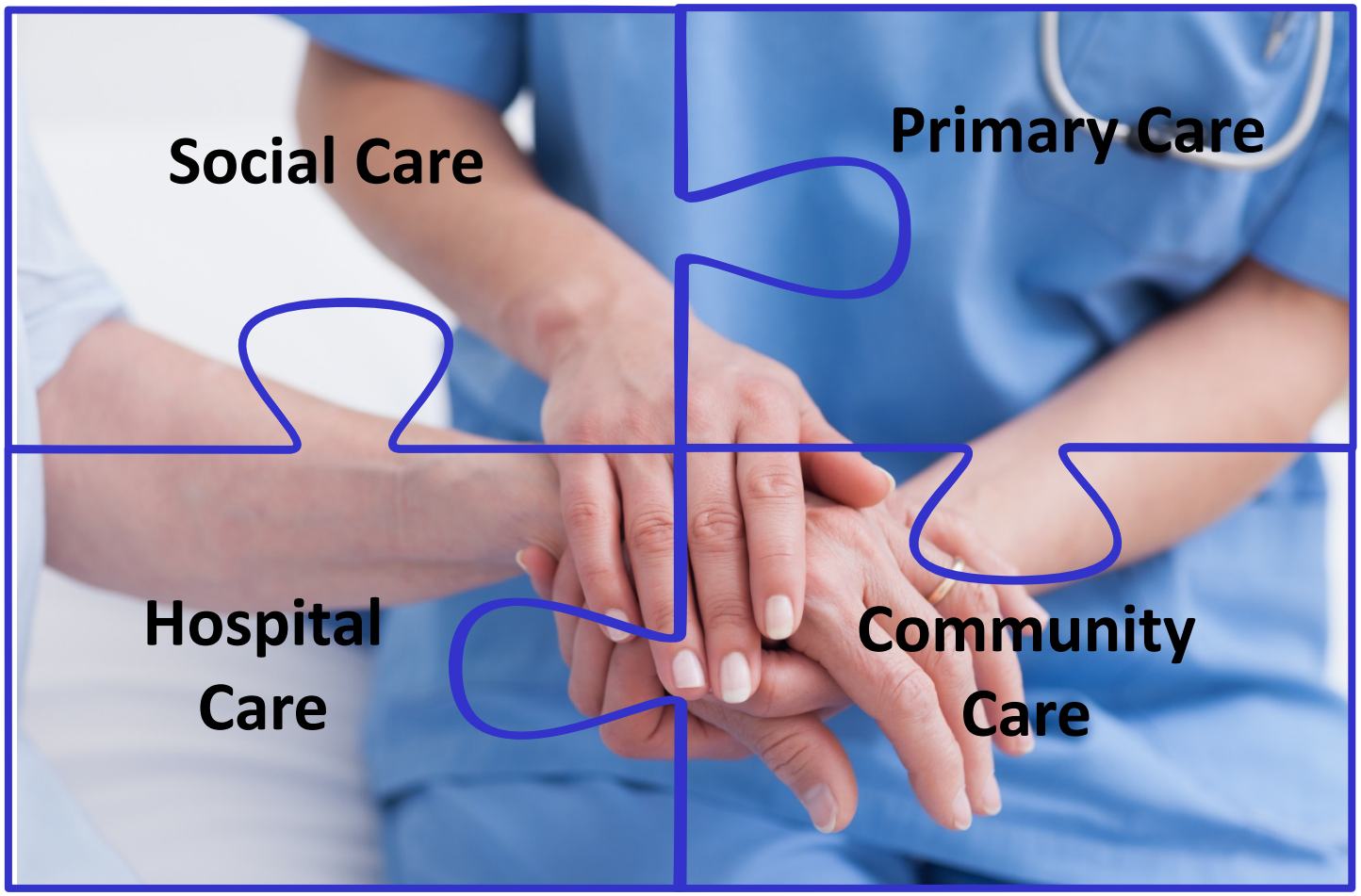
Power of Information

The improved understanding of the whole **healthcare and wellbeing pathway** for individuals depends on the **power of healthcare information**, being made readily available and easily interpretable by both humans and machines.

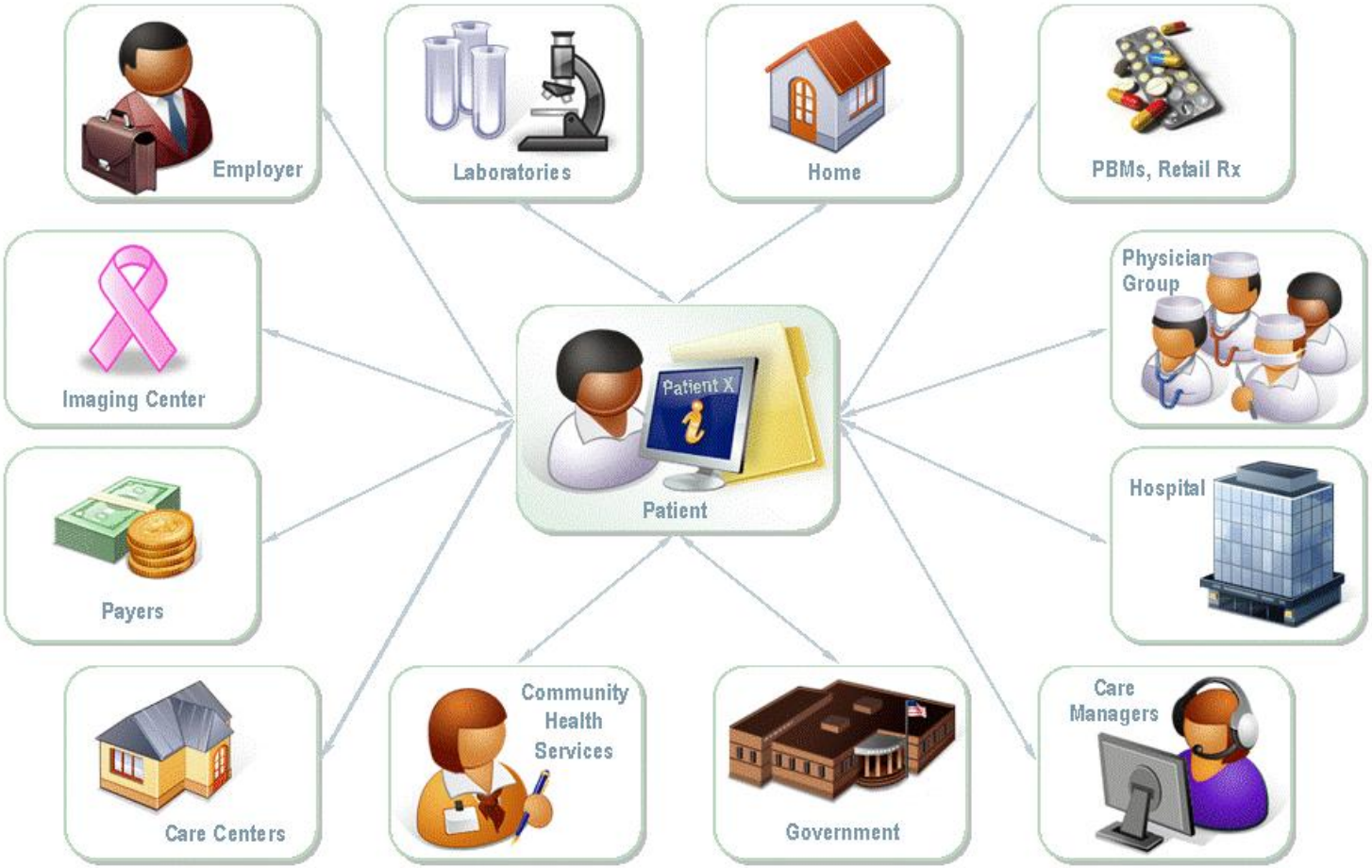


Motivation for Interoperability



towards an enhanced integrated care approach

The Challenge of Interoperability



Health Information Exchange

Source: https://himsshie.pbworks.com/w/page/4775490/HIEDefinition

Representing Healthcare Knowledge

- The foundation of interoperability lies with a shared understanding of data representation and concepts between systems:
  - it is necessary to establish **both syntactic (model-based)** and **semantic interoperability** to represent knowledge in a computable form

The Concept of Interoperability I

"Hello, Bob? It's your father again. I have another question about my new computer. Can I tape a movie from cable TV then fax it from my VCR to my CD-ROM then E-mail it to my brother's cellular phone so he can make a copy on his neighbor's camcorder?"

The Concept of Interoperability II

- Main Entry: **in·ter·op·er·a·bil·i·ty**
  : ability of a system ... to use the parts or equipment of another system
  Source: Merriam-Webster web site

- **interoperability**
  : ability of two or more systems or components to exchange information and to *predictably* use the information that has been exchanged.
  Source: IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries, IEEE, 1990]

Syntactic interoperability

(interchange)

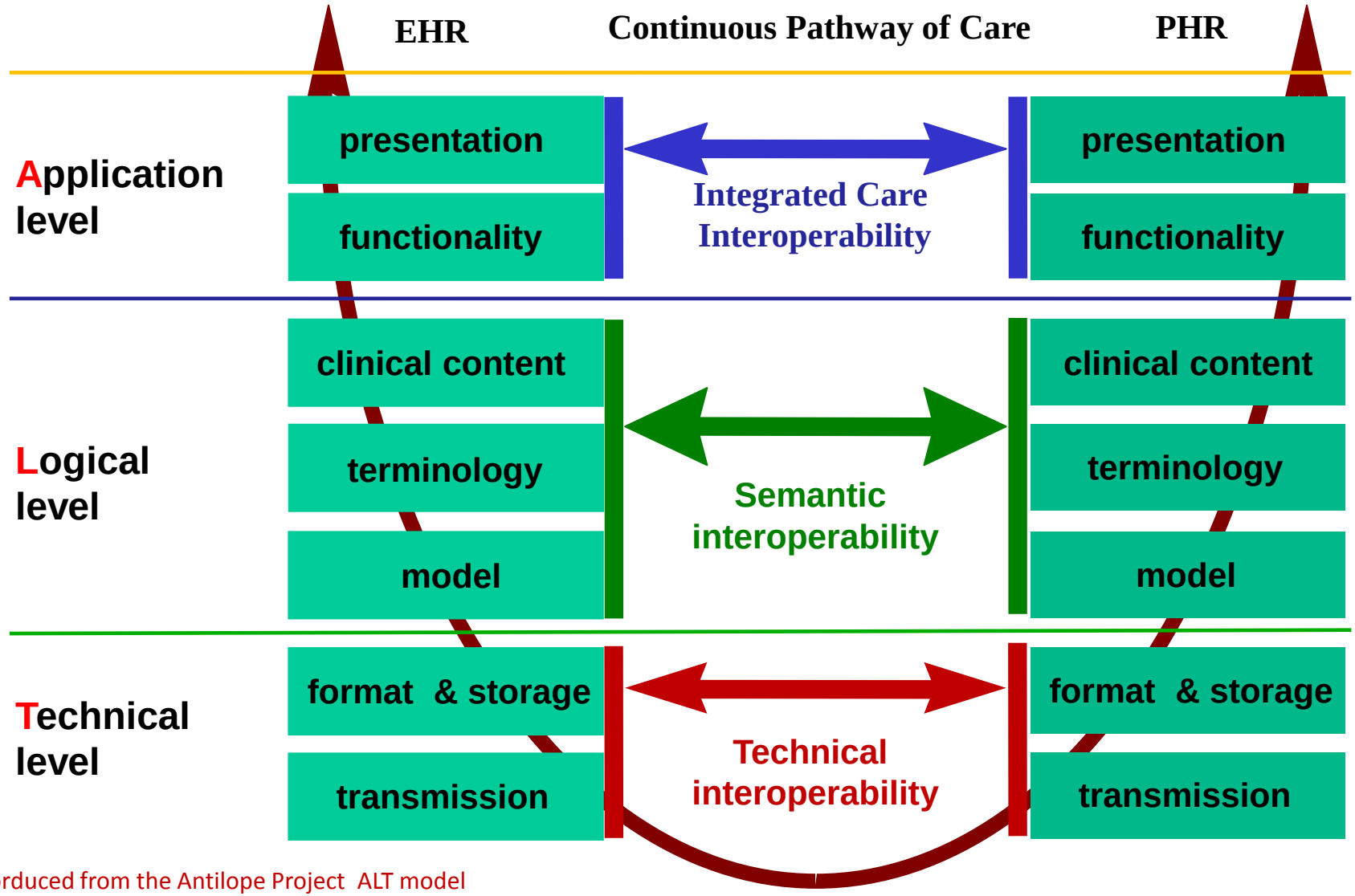
Semantic interoperability

Source: Charles Mead, CaBIG

Importance of interoperability

- The Goal: healthcare and patient-related information enrichment
- The Challenge: Developing a user understandable, computable and extensible knowledge representation scheme for capturing healthcare concepts and information (knowledge)
- Patient-Centric World: From EHR to PHR

Interoperability at Different Levels



Reporduced from the Antilope Project ALT model

Technical (Syntactic) Interoperability

```
MSH|^~\&|ADT1|MCM|LABADT|MCM|198808181126|SECURITY|ADT^A01|MSG00001-|P|2.4
EVN|A01|198808181123
PID|||PATID1234^5^M11||JONES^WILLIAM^A^III||19610615|M-||C
PV1|1|I|2000^2012^01||||004777^LEBAUER^SIDNEY^J.|||SUR||-||ADM|A0
AL1|1||^PENICILLIN||PRODUCES HIVES~RASH~LOSS OF APPETITE
DG1|001|I9|1550|MAL NEO LIVER, PRIMARY|19880501103005|F
PR1|2234|M11|111^CODE151|COMMON PROCEDURES|198809081123
```

Segments identify the type of information that appears in the message.
This HL7 message contains the following segments:

Composites/fields contain information related to the patient encounter or event.

MSH	message header
EVN	event type
PID	patient identification
PV1	patient visit information
AL1	patient allergy information
DG1	diagnosis
PR1	procedures

Source: http://www.altova.com/HL7_technology_primer.html

The Role of Standards

- Standards Development Organizations and associated groups are engaged in activities to develop and implement standards for elements of both syntactic and semantic interoperability, e.g.
  - Health Level Seven International (HL7) – clinical information systems standards
    - and others such as DICOM, ISO, W3C, etc.
  - Integrating the Healthcare Enterprise (IHE) – shaping the integration of standards by facilitating the concept of sharing information in the healthcare enterprise.
  - Clinical Data Interchange Standards Consortium (CDISC) providing standards to support the acquisition, exchange, submission and archive of clinical research data and metadata

An Example from the Clinical Care Perspective

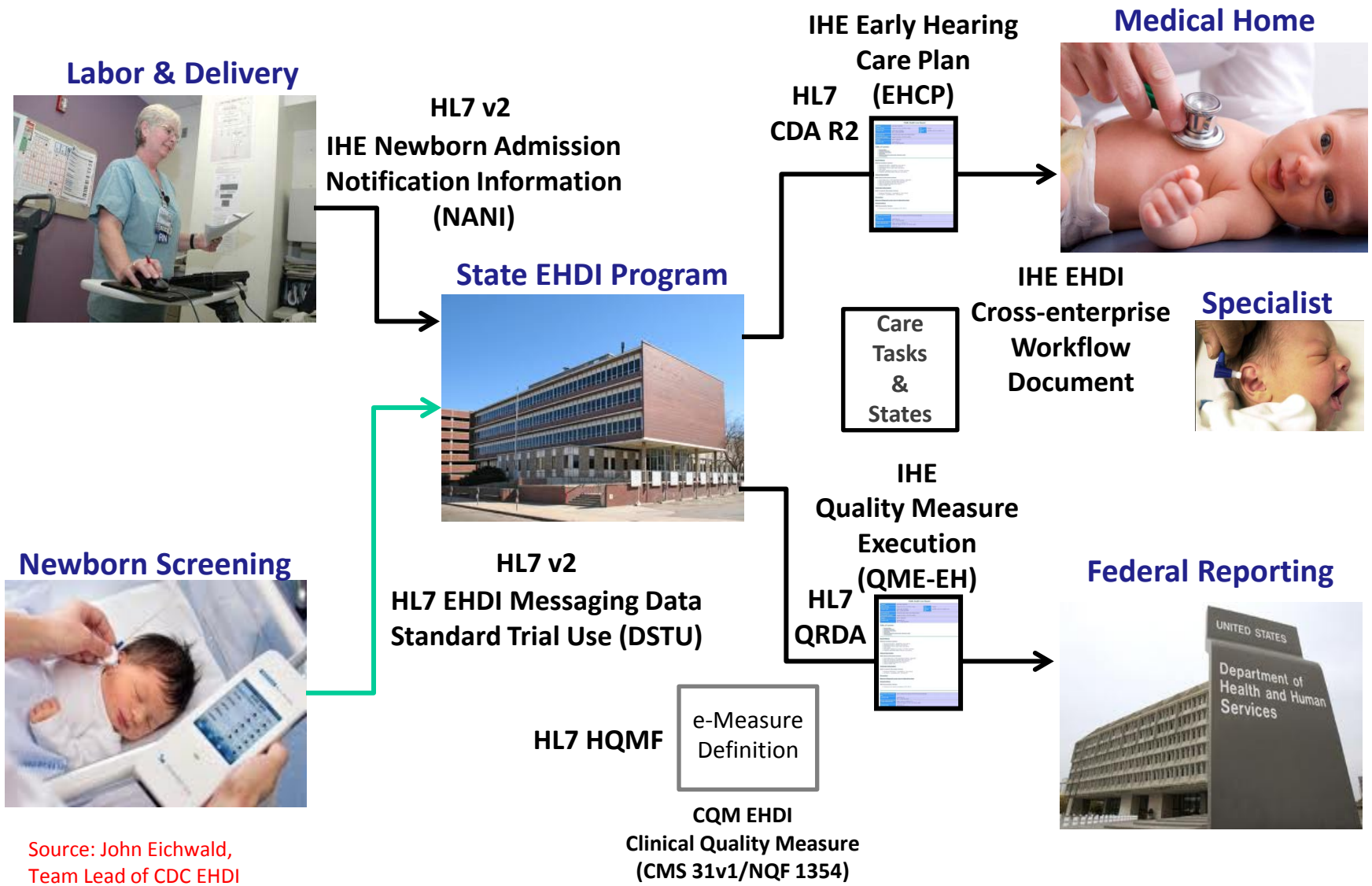
- The screening for hearing loss in newborns before hospital discharge is now considered a standard of health care in the United States and is referred to as **Early Hearing Detection and Intervention** (EHDI)

- Sponsored by CDC - an ambitious program that can potentially capture the whole of the newborn population

- Establishes bi-directional information exchange between clinical care and public health in a relatively simple and feasible way by using HL7 standards and IHE implementation approaches

CENTERS FOR DISEASE CONTROL AND PREVENTION

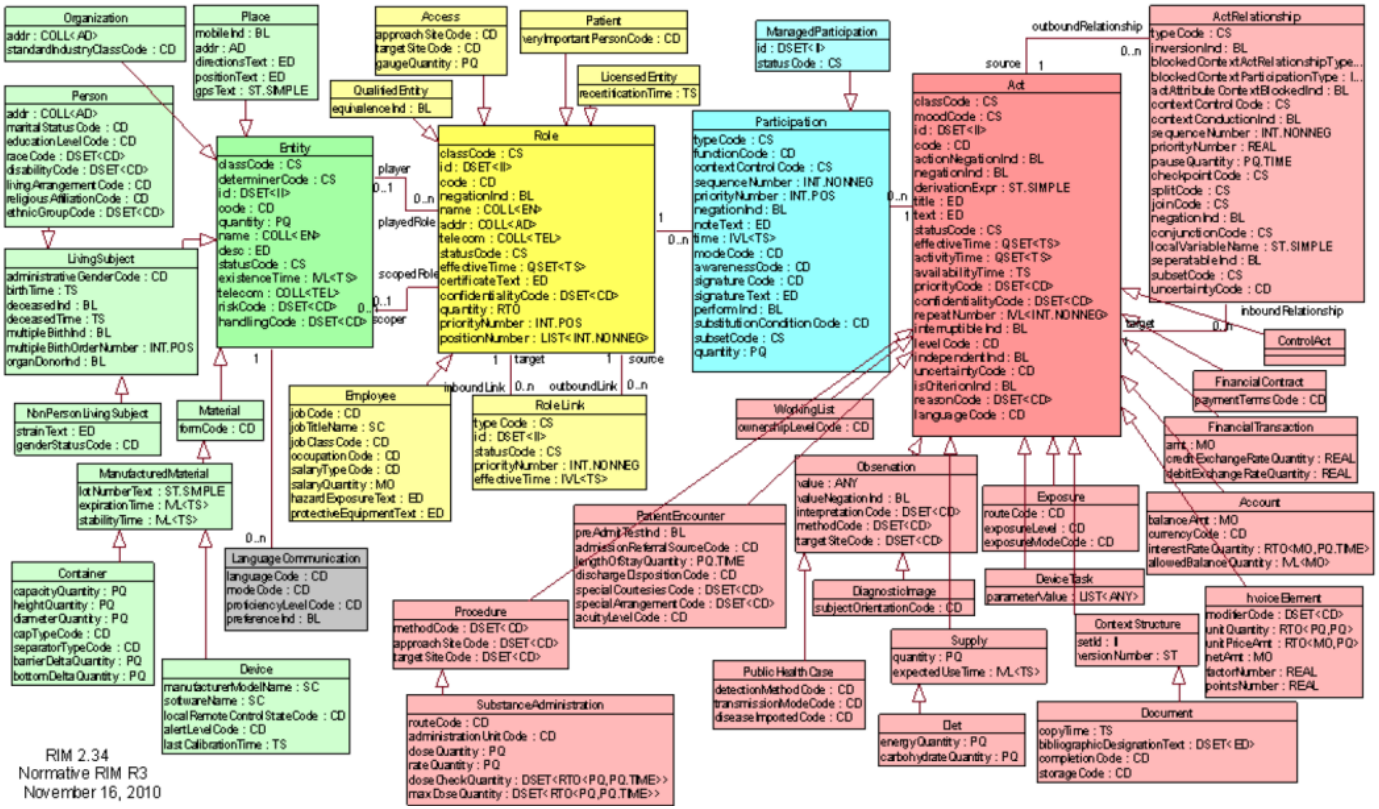
EHDI Standards-based Information Exchange



Source: John Eichwald, Team Lead of CDC EHDI

Semantic Interoperability

Towards Semantics: Models



Source: HL7

Containers of clinical content
"dialect" and meaning is needed

Informatics Tower of Babel: The Grand challenge

- Common Semantics?
- Each part of the health community speaks its own scientific "dialect" (e.g. lab values, genetic profile, clinical data)
- Lack of consensus on common standards and terms
- Recently, convergence of **terminology-base** standardisation efforts
- Enterprise vocabulary services: ontology-based to drive mappings between various terminologies
- Avoiding the informatics "Tower of Babel" problem (coined by caBIG project)

Aspects of "Terminological" Systems

Enterprise-level Vocabulary Services Efforts	Terminology-based standardisation efforts	Practitioner-based technologies
Language independence	Language Dependence	Language Dependence
Ontology	Terminology	Natural Language/ structured language (epistemology based)
Model of the domain: Taxonomy, relationships & constraints	Expert domain Representation Unique preferred terms Well defined of terms	Pragmatic Representation of domain Clinical use and dissemination The "Tower of Babel" effect

Example Project: TRANSFoRm I

TRANSFoRm

- Translational Research and Patient Safety in Europe
- 5-year project (2010-2015)
- EU funding
- 21 partners
- 10 EU member states
- Aims to deliver a digital infrastructure that facilitates the reuse of primary care electronic Health Records (eHR) data to improve both patient safety and the conduct and volume of clinical research in Europe

Example project: TRANSFoRm II

Tools For GPs And Researchers

Data Quality Browser	Query Workbench	Study Designer	Study Manager	Diagnostic Support	Data Mining & Analytics
• Enables assessment of data quality in EHR systems and repositories for inclusion in research studies	• Assists with the identification of eligible patients for research studies • Assists with query formulation & execution	• Design of eligibility rules, protocol, Common Data Elements (CDE), electronic Case Report Forms (eCRF) and study timelines	• Recruitment and randomisation of eligible patients • Assist with storing patient consent • Capture and reporting of adverse effects • Capture of Patient-Reported Outcomes	• Interactive patient-specific advice at the moment of consultation • Triggering of diagnostic support for GPs • Warehouses derived Clinical Prediction Rules in a semantically-enabled store	• Collaborative tools for validation and improvement of generated clinical evidence • Visual insight into derived decision support models

Core Technologies

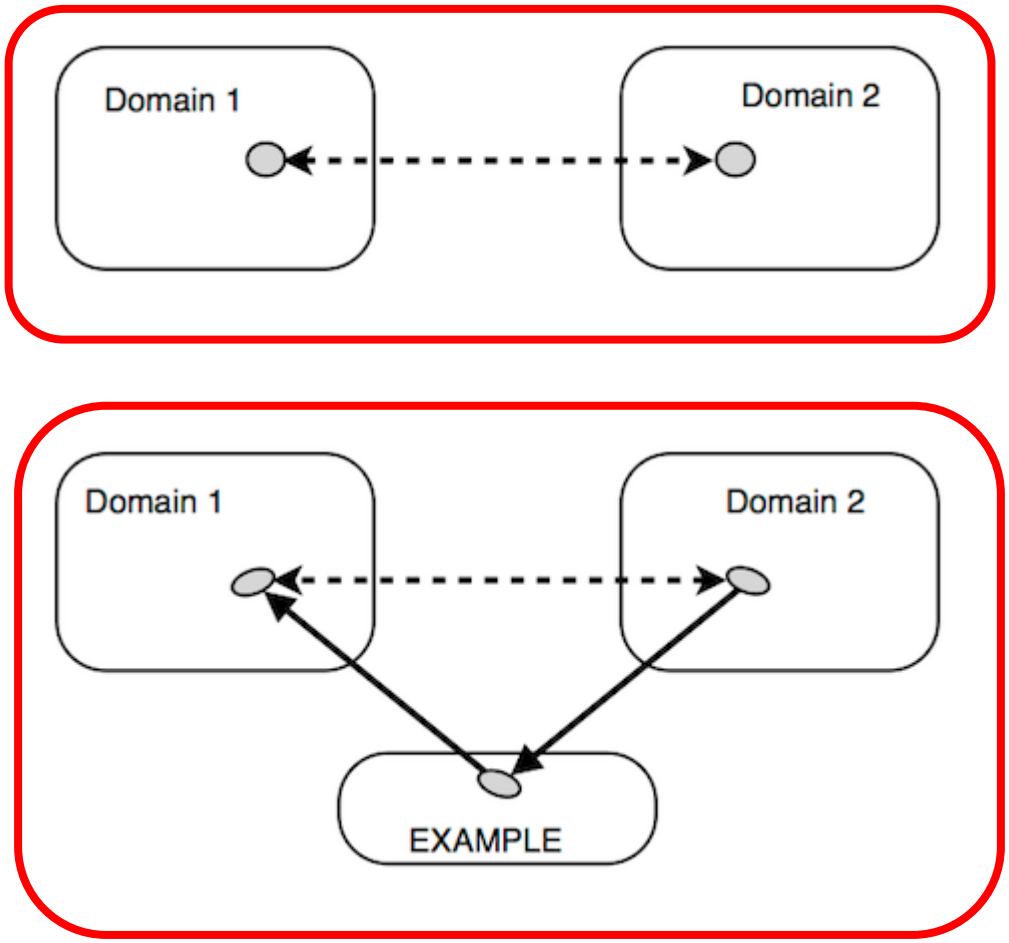
Data Provenance	Semantic Integration	Security Framework
• Provenance information capture, analysis and presentation from the provenance service • Enables auditability and accountability across all tools	• Simplified data access to various and heterogeneous data sources based on a view relevant to the Primary Care field • Integrated Vocabulary Services for searching and retrieving clinical vocabulary concepts and associated content	• Lightweight Shibboleth based infrastructure plugs into local authentication services • Study based user roles and permissions

TRANSFoRm Itegrated VS

- The TRANSFoRm Integrated Vocabulary Service is designed to allow end users to search and retrieve clinical vocabulary concepts and associated content
  - a web interface and a web service API
  - the service uses the LexEVS (version 5.1 and 6.0) technology to access a backend UMLS vocabulary database
  - the service uses direct Java Database Connectivity (JDBC) to access other vocabulary databases (e.g. Read Codes V2, ICPC2)

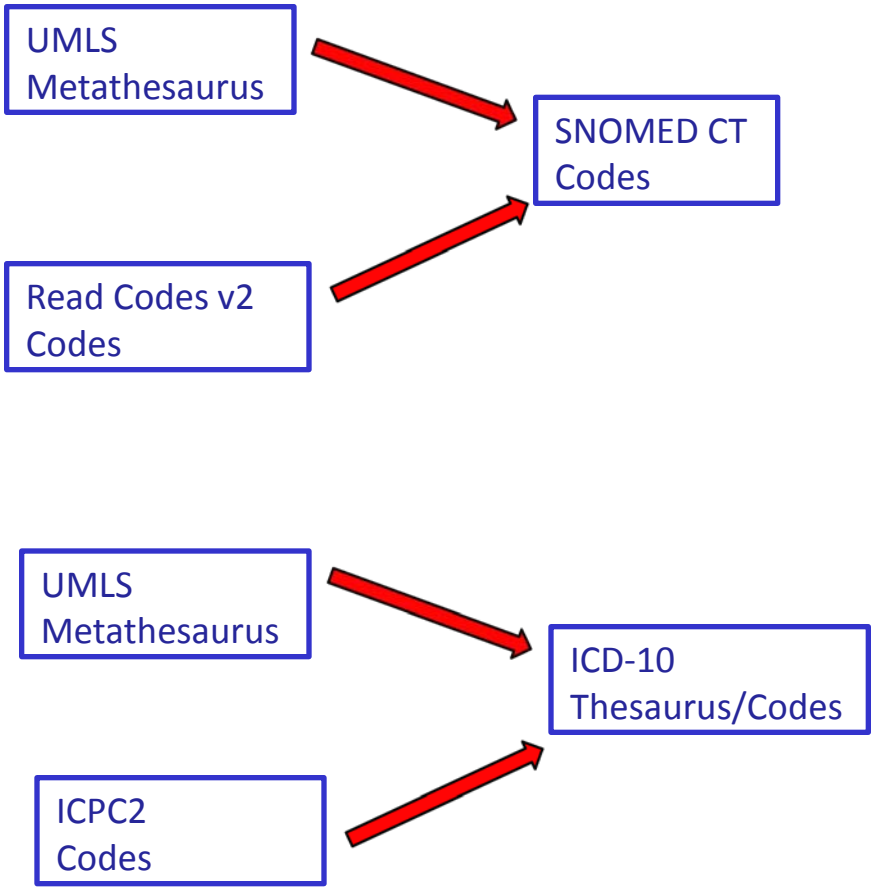
Approach

UMLS as the basis of terminology cross mappings

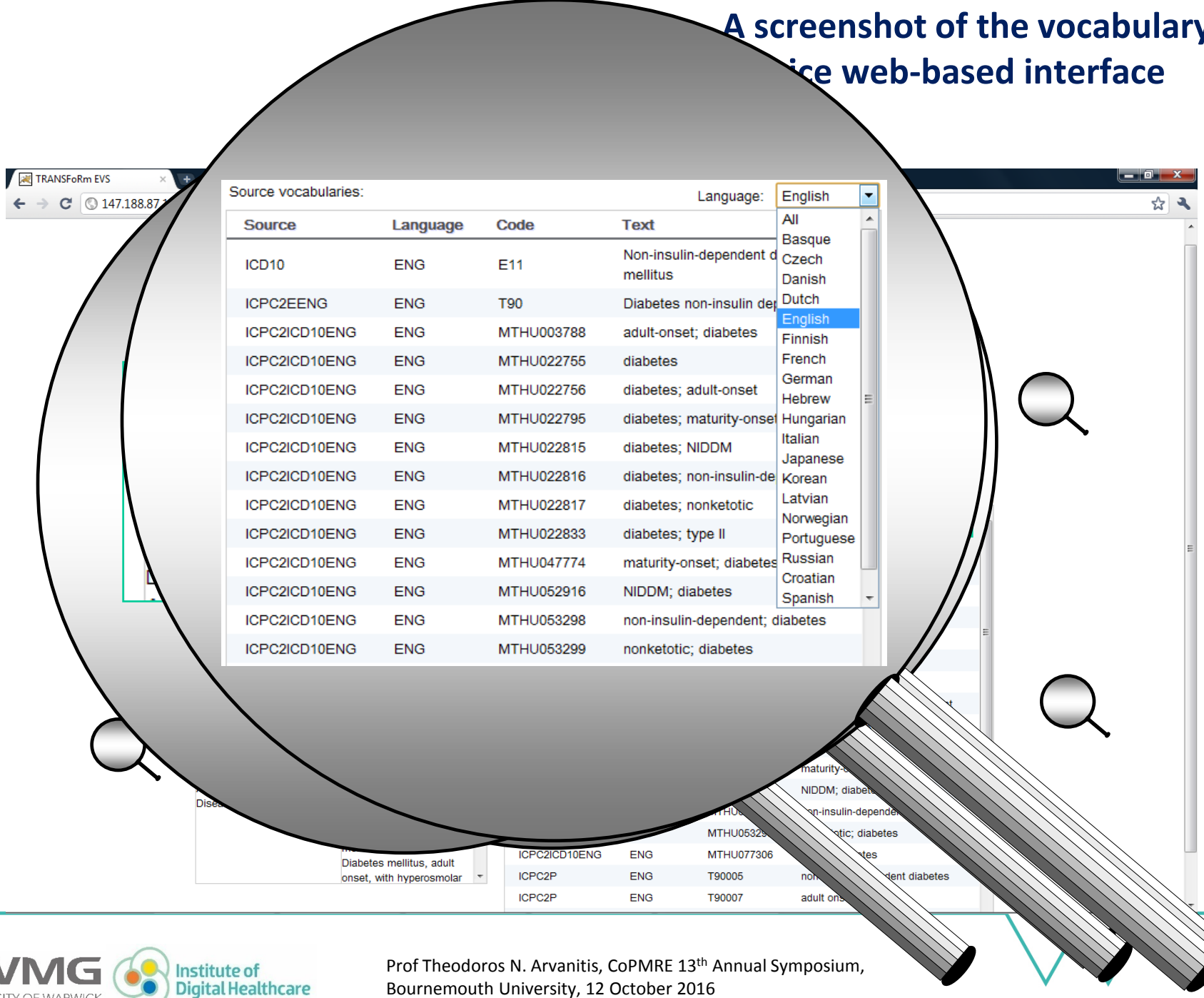


Example Terminological Mappings

- Read Codes (RCDv2) and International Classification of Primary Care (ICPC2) corpus of terms and their associated mappings
  - created to cater for the initial need of the existence of specific primary care oriented terminologies.
- The UK NHS Connecting for Health Terminology Centre - mappings from Read Codes version 2 to SNOMED CT.
- The Read Codes v2 database in Transform VS is set up based on this mapping so that Read Codes 2 concepts can be linked to a UMLS search. Similar approach for ICPC2.
- ICPC2-ICD10 Thesaurus and mappings - Transition Project @ University of Amsterdam
- The TRANSFoRm team has updating the ICPC2-ICD 10 mapping and Thesaurus



A screenshot of the vocabulary ice web-based interface



Example: Selecting an Event Type

Eligibility Criteria

localhost:8080/queryworkbenchsaml/ec/edit#.

TRANSFoRm Query Workbench

Enter Event Information

Diagnosis Made

Select Event Category...
Surgical Intervention
Healthcare Encounter Date
Diastolic Blood Pressure
Date of Birth
Weight Measurement Taken
Diagnosis Made
Sign
Gender
Prescription
Height Measurement Taken
Symptom
Systolic Blood Pressure
Laboratory Measurement Taken

Select Category Type

Add Event to Eligibility Criteria

Cancel

Select Diagnosis Codes

Eligibility Criteria

localhost:8080/queryworkbenchsaml/ec/edit#.

TRANSFoRm Query Workbench

Enter Event Information

Diagnosis Made

Diagnosis

Select Category Type

Date of Diagnosis =

Add Event to Eligibility Criteria

Cancel

Add Concept to Diagnosis

Eligibility Criteria

localhost:8080/queryworkbenchsaml/ec/edit#.

TRANSFoRm Vocabulary Service search

Search Term: diabetes Vocabulary: umls Search

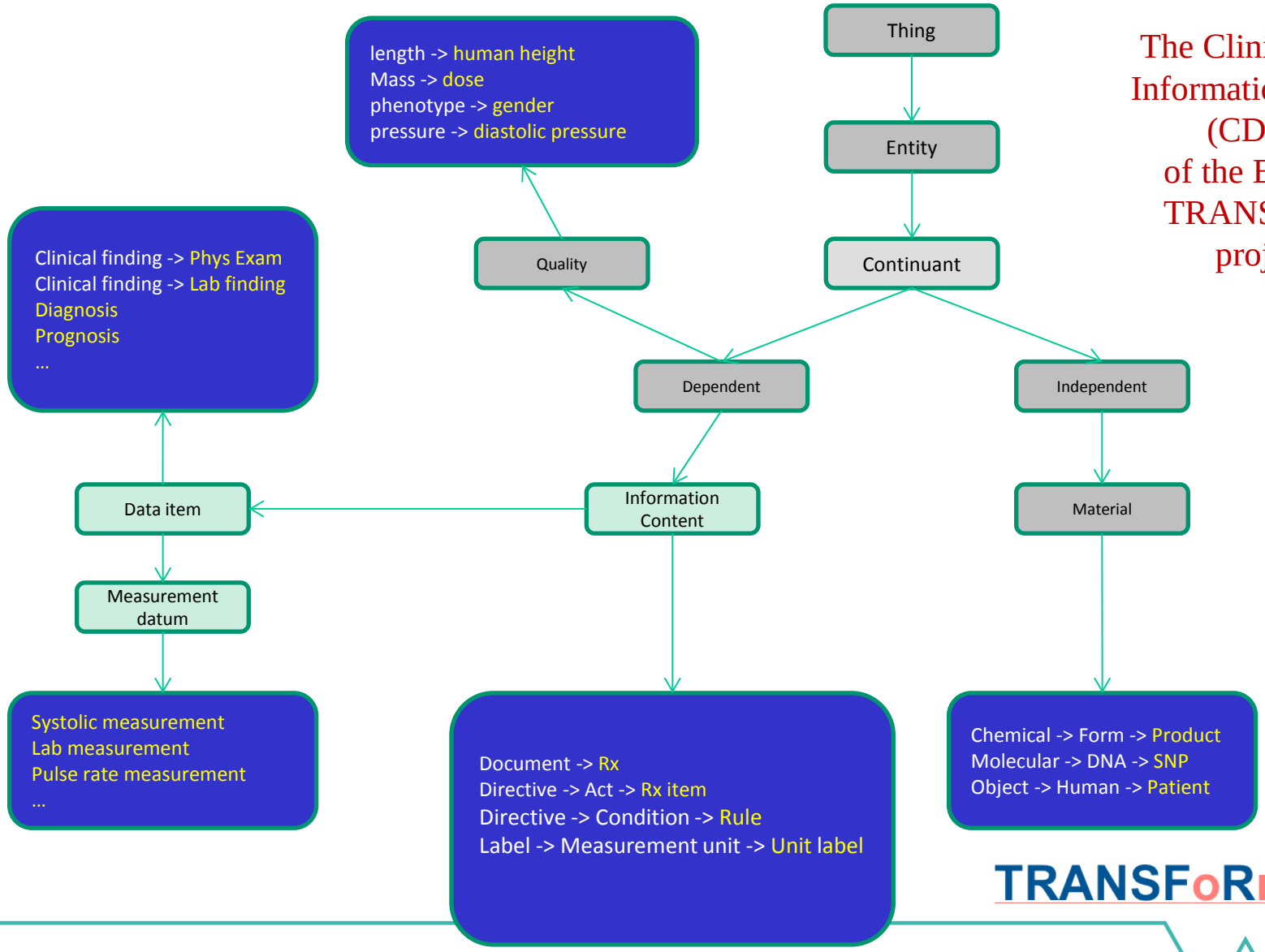
- Diabetes
- Diabetes Mellitus
- Diabetes Mellitus, Non-Insulin-Dependent
- Diabetes Insipidus
- Diabetes Mellitus, Insulin-Dependent
- Lipoatrophic Diabetes Mellitus
- Diabetic peripheral angiopathy
- Diabetic angiopathy
- Diabetic cataract
- Diabetic Nephropathy
- Diabetic Neuropathies
- Glycosuria, Renal
- Hemochromatosis
- Pregnancy in Diabetics
- Gestational Diabetes

Code: C0011860
Semantic Type: Disease or Syndrome
Definition: A type of diabetes mellitus that is characterized by insulin resistance or desensitization and increased blood glucose levels. This is a chronic disease that can develop gradually over the life of a patient and can be linked to both environmental factors and heredity.

Source	Language	Code	Text
DMDICD10	GER	E11	Nicht primaer insulinabhaengiger Diabetes mellitus [Typ-II-Diabetes]
ICD10	ENG	E11	Non-insulin-dependent diabetes mellitus
ICD10AM	ENG	E11	Type 2 diabetes mellitus
ICD10CM	ENG	E11	Type 2 diabetes mellitus
ICD10DUT	DUT	E11	Niet-insuline-afhankelijke diabetes mellitus
ICPC2EDUT	DUT	T90	Niet insuline-afhankelijke diabetes
ICPC2EENG	ENG	T90	Diabetes non-insulin dependent
ICPC2ICD10DUT	DUT	MTHU003788	adult-onset; diabetes
ICPC2ICD10DUT	DUT	MTHU022756	diabetes; adult-onset
ICPC2ICD10DUT	DUT	MTHU022795	diabetes; maturity-onset
ICPC2ICD10DUT	DUT	MTHU022815	diabetes; NIDDM
ICPC2ICD10DUT	DUT	MTHU022816	diabetes; niet-insuline-afhankelijk
ICPC2ICD10DUT	DUT	MTHU022817	diabetes; niet-ketotisch
ICPC2ICD10DUT	DUT	MTHU022833	diabetes; type II
ICPC2ICD10DUT	DUT	MTHU047774	maturity-onset; diabetes
ICPC2ICD10DUT	DUT	MTHU052916	NIDDM; diabetes
ICPC2ICD10DUT	DUT	MTHU053298	niet-insuline-afhankelijk; diabetes

Add Concept Cancel

Models of How Clinical Content is Organised



The Clinical Data Information Model (CDIM) of the EU FP7 TRANSFoRm project

TRANSFoRm

Current Challenges

- International or European “terminological” systems
- Challenge of multilingual systems in Europe
- Importance of appropriate existing “terminological” systems
- Politics, Ethics, Tradition – specialty specific, Social organization – e.g. NHS/Primary-care, Standardization
- Different use of data at the national
  - Clinical care, secondary use, research, etc.
- Issues of implementation
- Issues of user acceptance
- Can these be used in patient-centric integrated care paradigm?

Summary

- The impact of digital technology and information can be transformative for healthcare.
- Digitally-enabled healthcare provides the way forward: The benefits to individuals and society are multiple. People's health journeys are better understood and appropriate lifestyle choices can be better tailored and promoted to the individual:
    - linked **electronic records** to support the delivery of care;
    - **harnessing data** to support research and real-time public health **decision making**;
    - **integrated decision support systems** which aim to maximize **effectiveness and patient safety**;
    - tools for delivering **remote monitoring** and **self-management**
- **Interoperability**: an opportunity and challenge

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Thank You

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