COMP3342:
Health Systems Interoperability and Integration

Interoperability in Health Systems

Time: Mon/Wed : 14:00-15:20 Location: Masri304 Section: 1

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Prof Adel Taweel
Birzeit University

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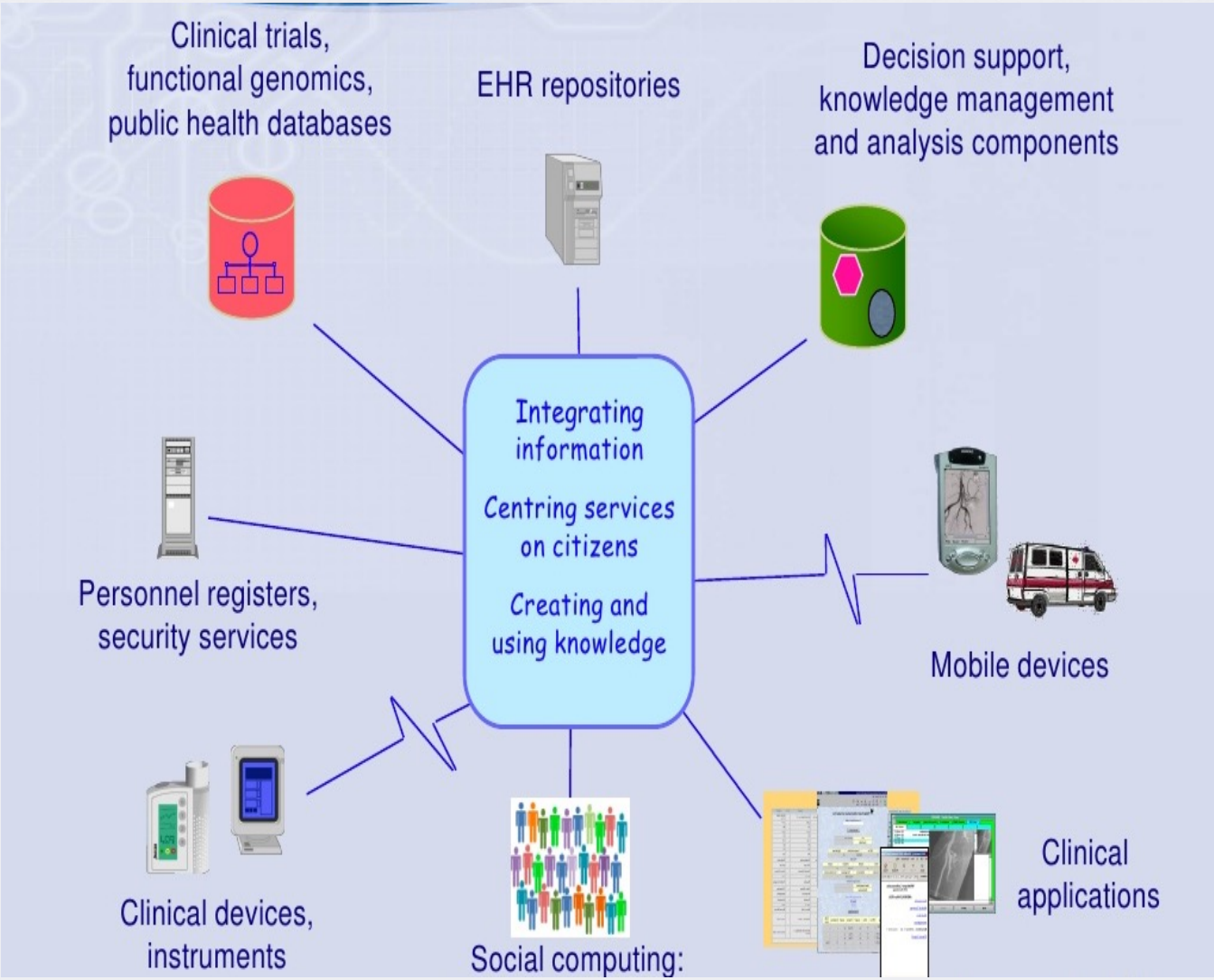
Interoperability in Health Systems

Learning Objectives:

1. Understand what is meant by Interoperability
    1. layers,
    2. types,
    3. benefits and challenges

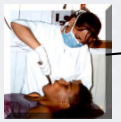
Electronic Health Records Land escape



Source: Eurorec

What to exchange or Interoperate?






STANDARDS

DATA

Analysis

- Statistics
- Research
- Clinical Trials
- Surveillance

KNOWLEDGE

PROCESS

- Patient Safety
- Quality
- Low cost
- Accessible

- Public/Private Partnership
- Vendor/Provider Partnership

Privacy, Security, Trust, Integrity

Interoperability

Introduction: what is meant by interoperability?

What is Interoperability?

- According to IEEE: "*Interoperability is ability of two or more systems or components to exchange information and to use the information that has been exchanged"*
  (IEEE 1990)

- In the field of Health Informatics: "*Interoperability means that the ability to communicate and exchange data accurately, effectively, securely and consistently with different information technology systems, software applications, and networks in various settings and exchange data such that clinical or operational purpose and meaning of the data are preserved and unaltered"**

* *G. Patricia, A. Noam et al, "Coming to terms: Scoping Interoperability for Health Care", Health Level Seven, EHR Interoperability Work Group, Feb 7, 2007*

What is Interoperability?

- The capability of different systems to work together and share information within organizational boundaries
- It is necessary for systems, when integrated, to share information with different structures and formats
- The systems have to agree on the format of data and what is being shared

- Compatibility and interoperability is a challenging requirement for systems connectivity

Health Transactions

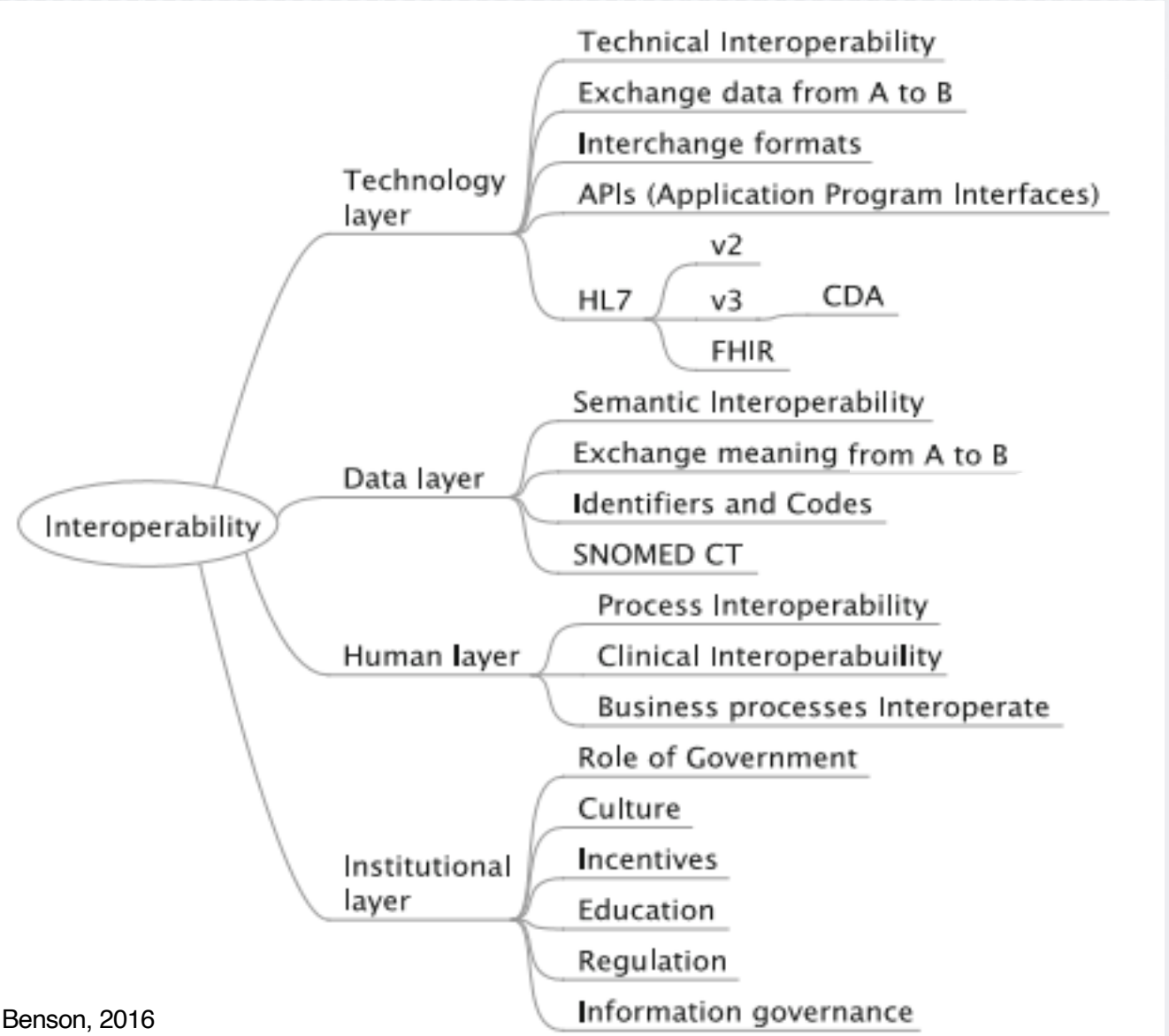
- Health Transactions/messages may include:
  - Lab Test requests
  - Lab Test reports/results
  - Radiology Test requests and reports/results
  - Prescriptions for medicines
  - Orders of nursing care, equipment, transports…
  - Letters between clinicians such as referral, clinic, and discharge letters
  - Aggregate information for management, audit, and monitoring
  - Billing and accountancy
  - Etc.

Interoperability

Layers and Types

Layers of Interoperability

- There are four main layers for interoperability
  - Technology
  - Data
  - Human
  - Institutional



Benson, 2016

Types of Interoperability

- **Technical Interoperability**: also named, channel or connection/communication interoperability
- **Information Interoperability**: also named, (Syntactic and) Semantic interoperability
- **Process Interoperability**: also named, organisational or service interoperability

Technical Interoperability

- A **basic type** of interoperability
- Also known as connection interoperability
- Refers to the ability of exchanging data and information in terms of signals, at infrastructure levels
  - In other words, the ability to transfer data from A to B
  - Provides methods to establish physical and logical connections between two or more systems

Technical Interoperability

- **Domain independent**: independent of information or to what domain the information belongs to.
- **Does not care** about the **meaning** of what is exchanged
- Sending and receiving computers do not understand the message exchanged between them
  - e.g., emails, or SMS: they can be used only to transfer data, irrespective of the domains.

Information Interoperability

- Refers to the ability of different systems to
  - Interchange data
  - Share information
  - Share knowledge

to deliver new services

Information Interoperability

- **Information interoperability** has many forms
  - Morphological interoperability: also named structural interoperability
  - Syntactic interoperability
  - Semantic interoperability

Information Interoperability

- **Morphological (Structural) interoperability**
  - Structural interoperability
  - Validates that the same data has the same (or understandable structure and format

e.g. HTML document structure

<html>

…

</html>

```
<html>
  <head>
    <title>Title</title>
  </head>
  <body>
    <h1>Main Heading</h1>
    <p>Paragraph</p>
    <h2>Sub Heading</h2>
    <p>Paragraph</p>
  </body>
</html>
```

Information Interoperability

- **Syntactic interoperability**
  - *Information* interoperability - the interoperability between systems that **agreed** on exchanging information, with the agreed upon syntax of the transferred information.
  - **Guarantees** that a message **was delivered**
  - **Does not guarantee** that the receiver receives (or comprehend) the message
  - e.g. message syntax is consistent

tele no: 00970 2 233 2333

URL: http://www.w3.org

Information Interoperability

- **Semantic interoperability**
  - *Knowledge* level interoperability
  - Ability of different information systems to exchange information on the basis of *pre-established meanings* of terms and expressions
  - The basis for achieving interoperability in healthcare

e.g. Actionable message: a message can be understood and an action can be taken/invoked.

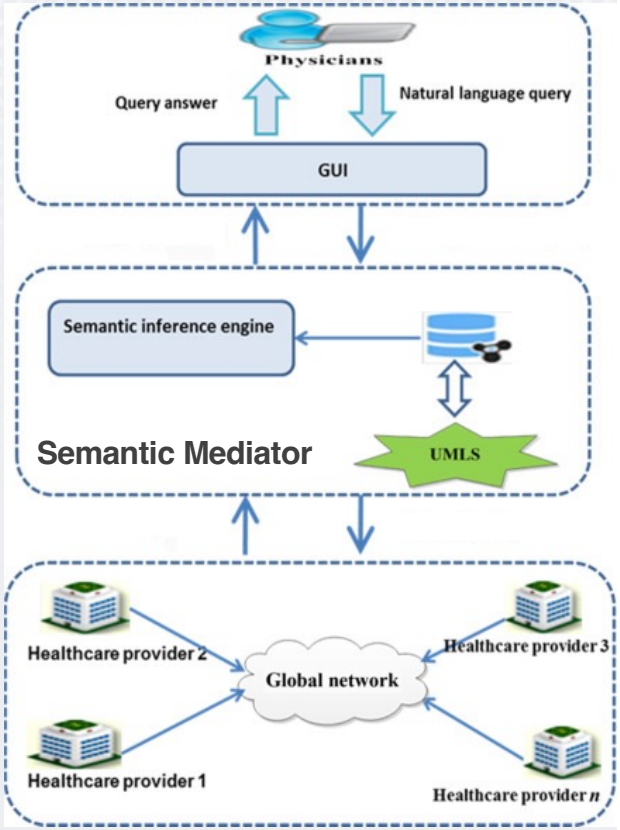
<Message: "Ring Adel", Coding System: "English">

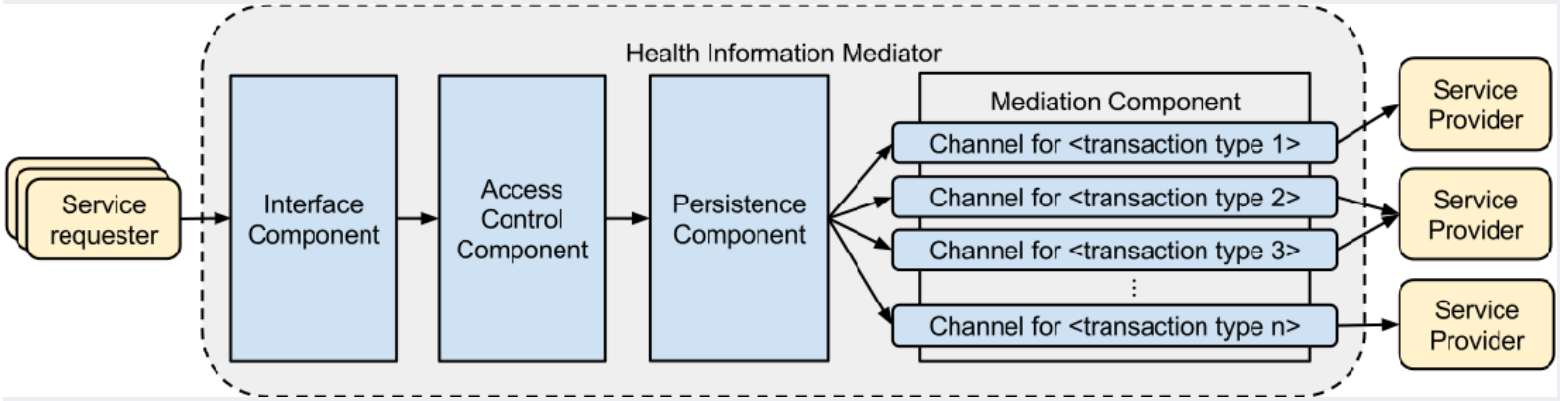
<Message: "5778-6", Coding System: "LOINC">

→request to do a lab test on Colour of Urine

Information Interoperability

- **Semantic interoperability**
  - **Guarantees** message recipient (or comprehension)
  - Uses *semantic mediation* to combine data from heterogeneous sources
  - *Semantic mediation*: converts clinical messages from their standard/common format into another local format or vice versa





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Process Interoperability

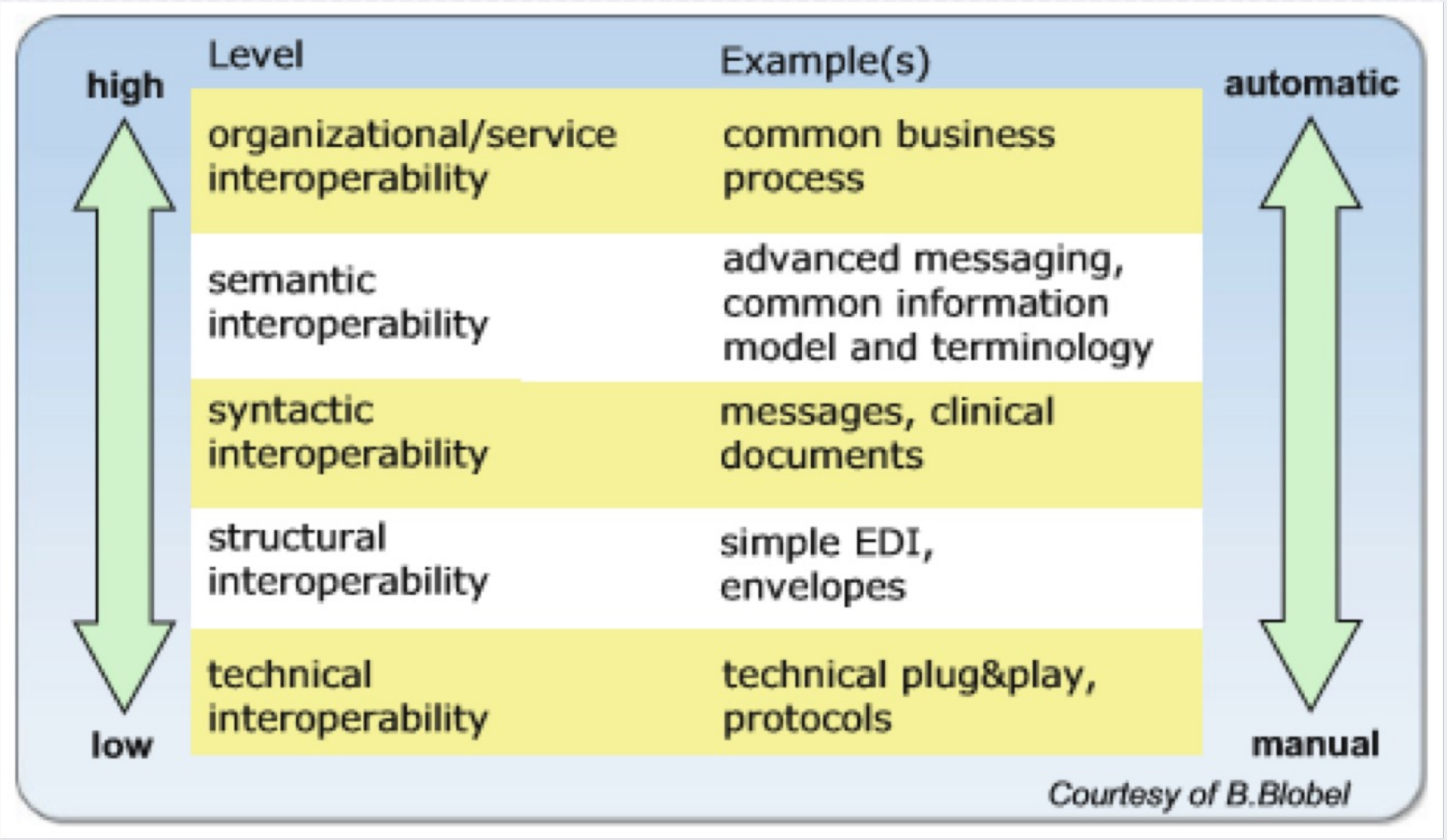
- Refers to the ability of different systems to
  - Exchange *clinical processes* and *workflows* between clinical systems associated with clinical data

- A critical feature in healthcare is *clinical process* interoperability
- "Clinical process interoperability is the ability for two or more clinicians in different care teams [or organisations] to transfer patients [and/or their data] and continue to provide seamless care to the patient"
- To achieve clinical process interoperability, transfer of workflow and standards supported by clinical systems is needed.

Interoperability

Levels

Interoperability Levels



Interoperability levels

Source: F. Oemig and R. Snelick, Healthcare Interoperability Standards Compliance Handbook, DOI 10.1007/978-3-319-44839-8_2

Interoperability Levels

- Non-electronic information
- Machine Transportable
- Machine Organizable
- Machine interpretable

} Machine Readable

Interoperability Levels

- **Non-electronic information**
  - Health information is recorded and shared on paper

  e.g., a referral letter from a general practitioner to a specialist; a prescription from a doctor to a pharmacist

- **Machine Transportable**
  - Information technology is utilized
  - Shared messages are not standardized

  e.g. using fax or emails to share information

Interoperability Levels

- **Machine Organizable**
  - Structured messages
  - Messages do not contain structured data
  - Interface between different information systems is required to *translate* the *structures* from one system to another

Interoperability Levels

- **Machine interpretable**
  - Structured messages
  - Standardized data
  - Receiver understands the format and terms in the message without the need of external interface to interpret the message

e.g., discharge summary can be transmitted from hospital health information systems to general physician, using structured format, used by both systems

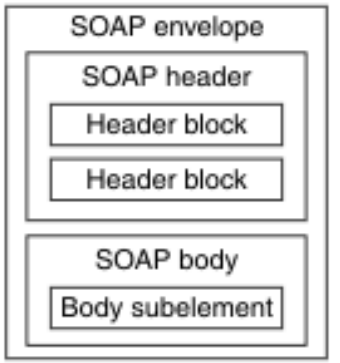
Interoperability

Syntactic

Syntactic Interoperability

- Syntax: *the grammar and formal rules for defining a set of data*
- Syntactic interoperability is the ability of exchanging messages between systems
- Syntactic interoperability is domain independent; it does NOT know the *meaning* of the message being exchanged
- The data formats and communication protocols should be defined beforehand to establish syntactic interoperability
- e.g. XML and SQL standards - are examples of tools for syntactic interoperability

Structure of SOAP message *is example of* ***Structural (morphological) Interoperability***



SOAP message uses XML

```
<?xml version="1.0"?>

<soap:Envelope
xmlns:soap="http://www.w3.org/2003/05/soap-envelope/"
soap:encodingStyle="http://www.w3.org/2003/05/soap-encoding

<soap:Header>
...
</soap:Header>

<soap:Body>
...
  <soap:Fault>
  ...
  </soap:Fault>
</soap:Body>

</soap:Envelope>
```

XML defines the syntax to construct the message, thus syntactic interoperability

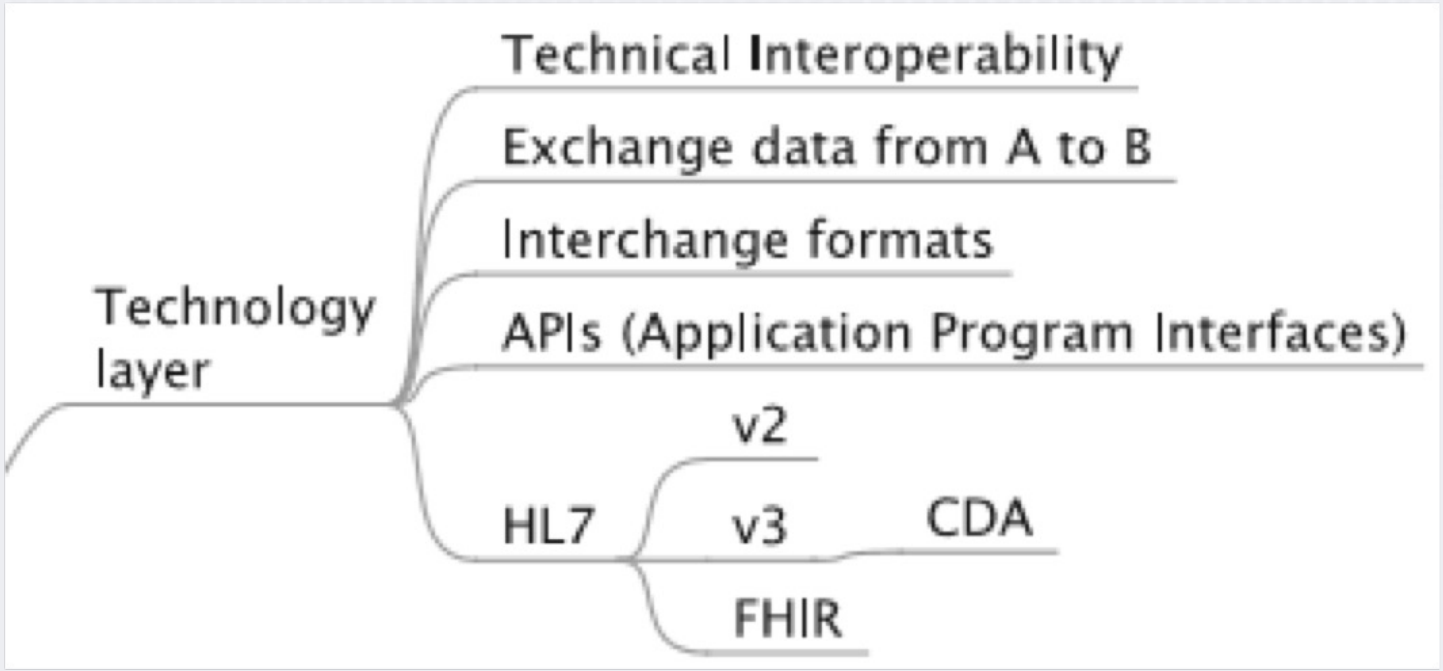
Syntactic Interoperability

- It can be defined on
  - "*...is usually associated with hardware/software components, systems and platforms that enable machine-to-machine communication to take place. This kind of interoperability is often centered on (communication) protocols and the infrastructure needed for those protocols to operate*" [ETSI 2006]

- It is associated with data formats
  - i.e. *it requires communication protocols that have a well-defined syntax and encoding, which simply carry data or content, such as HTML, XML or ASN.12*

Syntactic Interoperability

- In the interoperability layers, Syntactic is considered addressed in the technical layer



Source: Principles of Health Interoperability

- remember: Technical interoperability only guarantees the correct transmission of bits (i.e., messages), but nothing about the meaning of these bits and what they represent

Syntactic Interoperability

- Syntactic interoperability is achieved when two (or more) systems are capable of communicating and exchanging data
  - No domain specific knowledge is necessary in this level
  - It allows the exchange of messages without any consideration of their contents

- For example,
  - the string, “20170115” can be identified as a string, a code or a date
  - the string, “4548-4” may represent a code
  - However, these without any further identifying information is *meaningless*

- Syntactic interoperability is *necessarily required* to achieve next levels of interoperability

Interoperability

Semantic

Semantic Interoperability

- It can be defined as
  - "*the ability to import utterances from another computer without prior negotiation and have your decision support, data queries and business rules continue to work reliably against these utterances*", [Dollin and Alschuler]

- In semantic interoperability, both the sender and receiver of the clinical message should **understand** the same data in the same way
- It allows computers to share, understand, interpret, and use data without ambiguity

* Dolin R, Alschuler L. Approaching semantic interoperability in health level seven. JAMIA. 2011;18:99–103.

Semantic Interoperability

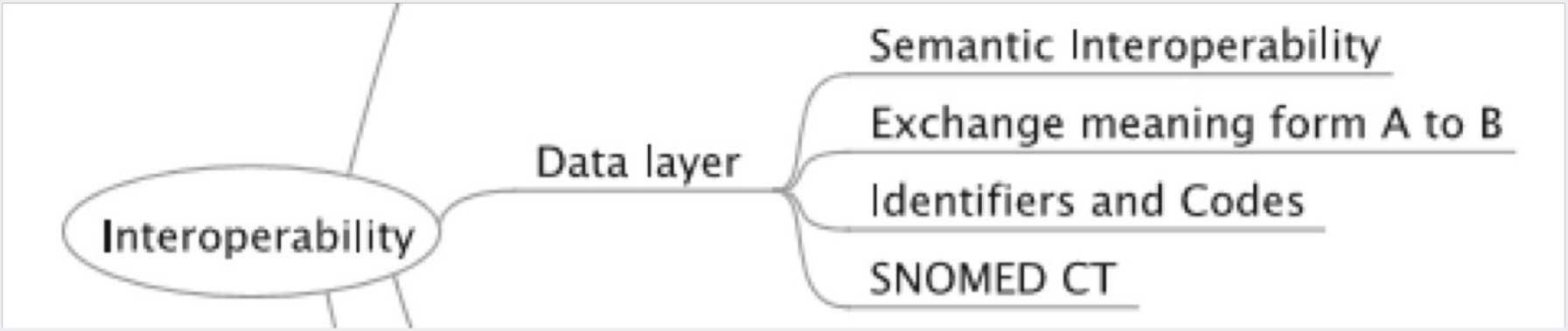
- Semantic interoperability is beyond the ability of computer systems to just exchange messages,
  - It is the ability to communicate information and have that information correctly *interpreted* by the receiving system
  - It can be achieved by having both sides (i.e., the sender and receiver) to refer to the exchanged information to a *reference model*

- The correct *interpretation* of the received message is a necessary precondition to define, process, and store data entity correctly and *meaningfully*

- Syntactic interoperability is a necessary *pre-requisite* for semantic interoperability (which defines the data format and communication protocols to structure the data being exchanged)

Semantic Interoperability

- Semantic interoperability is *domain* specific (e.g. clinical)
- Semantic interoperability is *context* specific (see next slides)
- It requires the use of unambiguous codes and identifiers
- Semantic interoperability addressed at the "Data Layer"



Source: Principles of Health Interoperability

Context: General Medical Summary

List of diagnoses and procedures

1993	Procedure	Appendicectomy
1996	Diagnosis	Meningococcal meningitis
1997	Procedure	Termination of pregnancy
2003	Diagnosis	Acute psychosis
2006	Diagnosis	Schizophrenia

Can we safely interpret a diagnosis without its context?

Clinical Interpretation Context

Emergency Department	Seen by junior doctor
Reason for encounter	Brought to ED by family
Symptoms	"They are tryi
Mental state exam	Hallucinat
	Delusions
	Disordered
Diagnosis	Schizophrenia
Certainty	Working hypothesis
Management plan	Admission etc.....

Junior doctor,
emergency situation,
a working hypothesis
so
schizophrenia is not a
reliable diagnosis

Semantic Interoperability

- Syntactic interoperability Versus Semantic interoperability
  - *Syntax: the grammar and formal rules for defining a set of data => Syntactic interoperability enables the exchange of clearly defined classes of data*
  - *Semantic: the meaning and the use of these data => Semantic interoperability enables the automatic recognition/interpretation of the individual data exchanged*

In the semantic layer, data becomes [meaningful] information

[Woods 1975]

Semantic Interoperability

- Semantic interoperability, can be achieved only if:
  - The semantics of data are *defined and shared.*
  - The data can be processed and sent from one system to another and it can be *recognized* and *processed automatically, i.e. machine processable*

- This requires a common definition for each data in every field of a data set
- The main issue is defining common definitions of exchanged data
- The problem is in the diversity and heterogeneity of existing codes
  - e.g. A non-health example: an electronic invoices sent from a supplier's computer system are automatically recognized, compared to the delivery notification, and processed by the accounting system of the customer. This can be achieved by identifying the date of the invoice, its number, and the amount to pay

Semantic Interoperability

- One of the solutions, from the Computer Science perspective
  - Using *Ontologies*: ontologies map objects within dedicated *domains*
  - Terminology standards are built using/as ontologies: terminology standards are developed for different clinical domains.

  e.g. ICD10: diseases, LOINC: lab tests, RxNORM: Drugs)

- e.g. in healthcare system, the code "4548-4" is associated with an exchanged clinical message/data made with a LOINC system, a specific meaning is derived (i.e., "Hemoglobin Alc/Hemoglobing.total in Blood")
- If this code is conveyed within an order to laboratory, a receiver may initiate a specific action

Interoperability

Benefits and Challenges

Benefits of Interoperability

- Patients to benefit from ***enhanced treatment*** received
- Delivery of healthcare when/where **required** - at any point of care.
- ***Integrated care*** plans by providers- across one or more organisations
- National interoperability will facilitate emergency care **internationally**.
- Some health services can be become as **eHealth services**, provided when needed
- Reduce **Clinical/medication Errors**, e.g. possible interoperability with pharmacy systems to reduce potential harm from drug interactions
- Better clinical **decision making** that leads to **safer quality care** by accessing health information linked to electronic patient record

Benefits of Interoperability

- Better **decision making process** by integrating healthcare systems across various points/organisations of care delivery
- Reduction of **duplication** of data entry
- **Cost saving** by reducing redundancy in duplicate diagnostic tests
- Benefit the software industry by enabling a single market for **digital healthcare**, which leads to reduced cost of health information system development
- **Faster access** to care, diagnosis, tests, and treatments for health care providers, individuals, and insurance companies
- Patients can seek **alternative medical** treatment easily

Challenges of Interoperability

- A key challenge in implementing interoperability standards is the **heterogeneity** of information systems
- Different **software suppliers** have different **proprietary** standards
- No single health information system able to support all health services e.g. administrative, clinical, technical, and laboratory requirements

- Hence, interoperability standards became evident

References

- Benson, Tim. Principles of Health Interoperability. Springer, 2016.
- Azam, Muhammad, and Izhar Hussain. "The Role of Interoperability in eHealth." (2009).
- Overview of healthcare interoperability standards, available at https://www.hiqa.ie/system/files/Healthcare-Interoperability-Standards.pdf
- Pradeep Sinha, Gaur Sunder, Prashant Bendale, Manisha Mantri, Atreya Dande, Electronic Health Record - Standards, Coding Systems, Frameworks, and Infrastructures, John Wiley, 2012

Thanks!

Any questions?

You can find me at:
Email: @ritaj