Minimizing Data Risks, Maximizing Benefits in a SOA Journey

The Singapore Experience

OMG SOA 2011

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13 Jul 2011

MOH HOLDINGS

Singapore Vision

" What does it mean when we say our population will be older? It means there will be more demand on healthcare because older people are sick more often.

But this also means it is a different pattern of healthcare

So we have to respond to this by putting in more resources into our hospital system, building new hospitals.

… get the whole system to be structured properly so that it will be adapted to cater o the ageing population. To structure it properly means we need step-down care."

Picture taken from asiaone.com

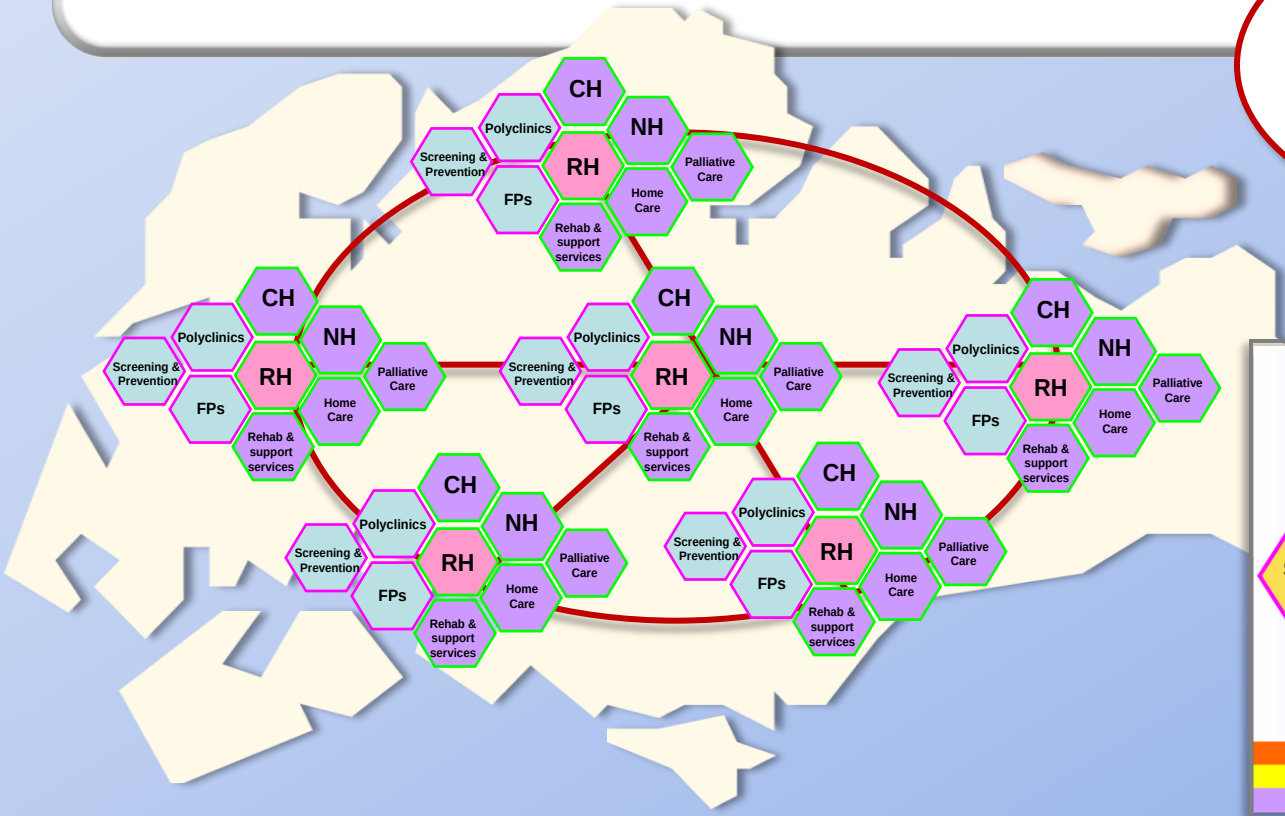
"And one key thing we must do with this step-down care is to link up our acute hospitals […] with community hospitals, so that you can have the best of both worlds."

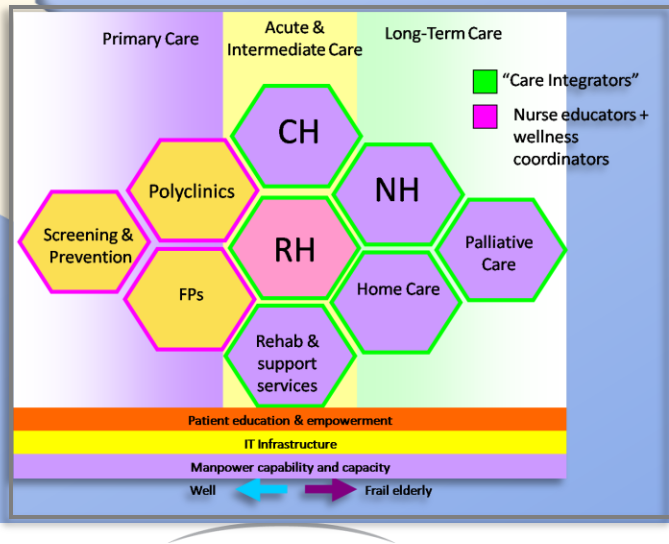
Prime Minister Lee Hsien Loong
National Day Rally 2009

Landscape to enable the future

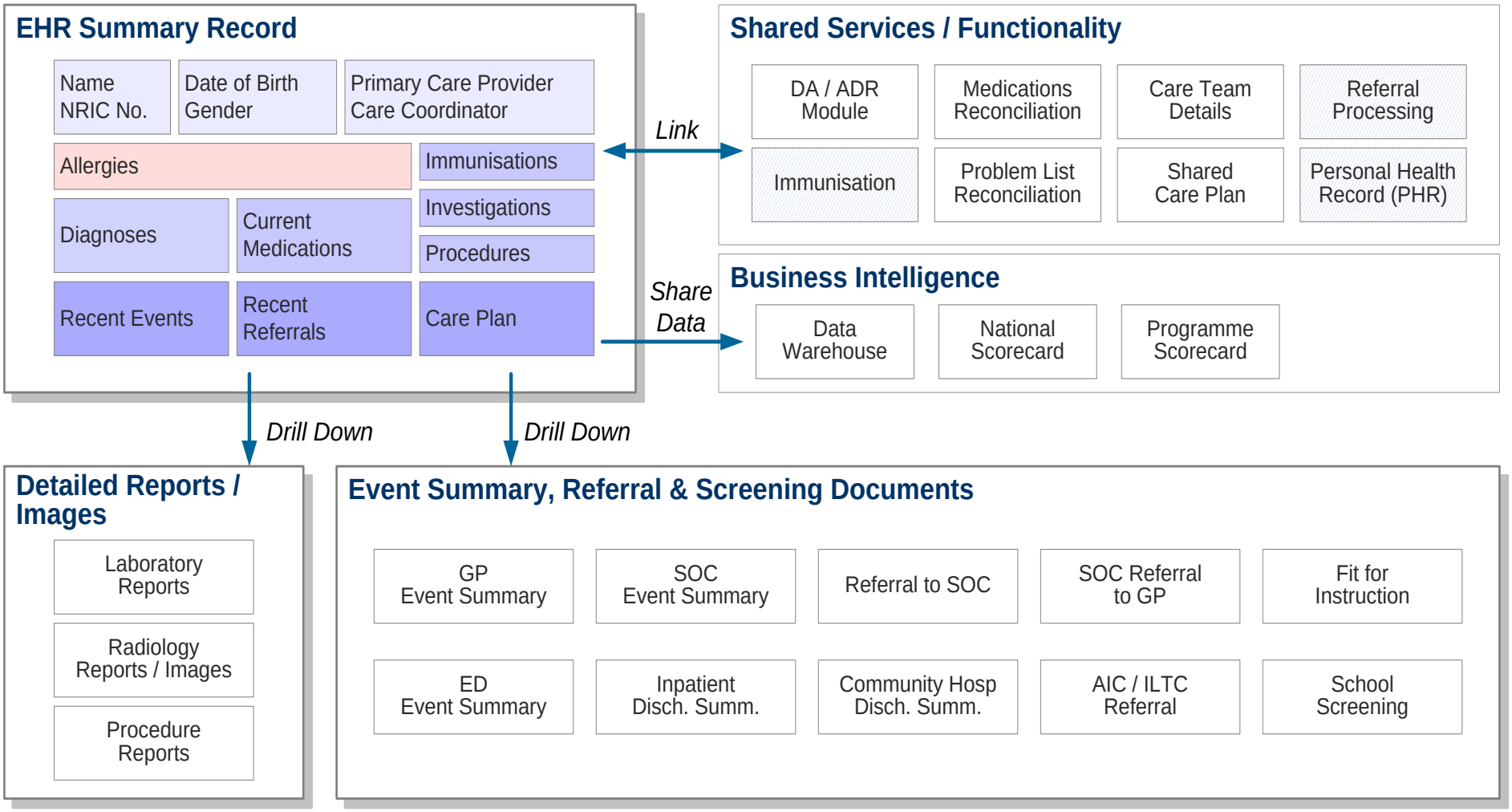
Strategic vision of patients moving seamlessly across the healthcare system, receiving coordinated patient-centric care at the most appropriate settings.

Enabled by the National Electronic Health Record (NEHR)





NEHR – Conceptual Long Term Vision



Applications that are not a part of the EHR solution, but will be integrated with the EHR

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Need to Unleash The Benefits of Healthcare IT

Key infrastructure and technology needed

Network Infrastructure

- High Speed Network

Leadership and Governance

Interoperability and Standards

- Enterprise Architecture
- National Data Standards

Change Management

Strengthening Analytics

- Exploit the power of technology

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Minimizing Data Risks – the Singapore Experience

What may have been the problem?

Vocabulary

- Knowledge of words

Grammar

- Understanding of the structural rules that govern the composition of sentences, phrases, and words in any given natural language
- Semantics

Syntax

- Understanding of principles and rules of the language
- Sentence construction, etc

Transmission Errors

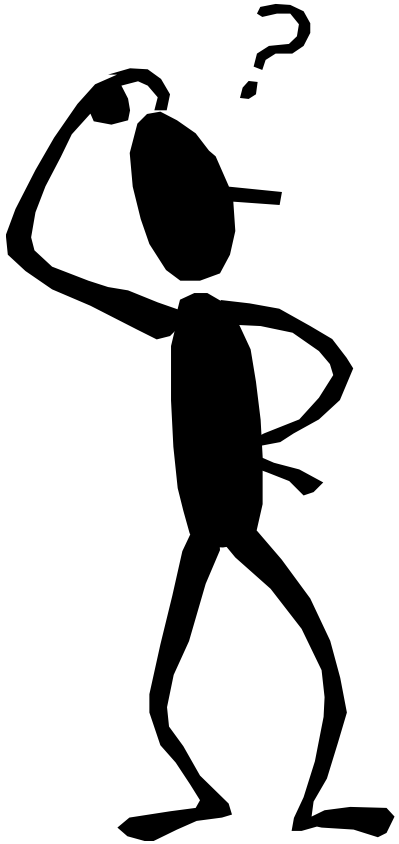
- e.g. typos, missing words, letters, etc
- Miscommunication

Translation

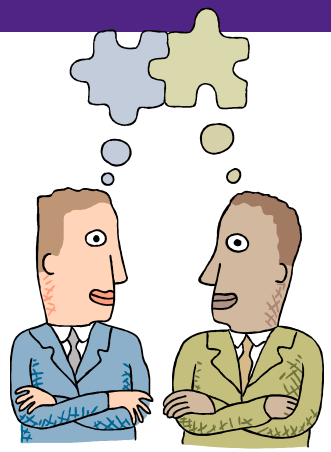
- Able to understand different language, grammar and Vocabulary

Knowledge

- Understand and analyse words from different languages



Communication



- **1-1 verbal communication**
  - Known target audience
  - Easy to agree on common understanding
  - Clarification
- Many to Many?

- **Electronic communication**
  - Unknown audience
  - Common understanding?
  - Clarification?
- Many to Many?

Singapore's National Data Standards

Establishing a suite of Standards that are:

to ensure clinical data included in the NEHR can be:

- ✓ Shared and exchanged safely and reliably
- ✓ Relied on for the monitoring and care of patients
- ✓ Used meaningfully for secondary purposes including the production of clinical knowledge

Global Standards Engagements

- HL7 (Health Level Seven)
- IHTSDO (International Health Terminology Standards Development Organization)
- ISO TC215 on Health Informatics

Standards also provide a platform for long term semantic interoperability and research informatics

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Moving from one direction to two– Interoperability Levels

Existing level

- **Level 0**: no interoperability at all
- **Level 1**: technical and syntactical interoperability (no semantic interoperability)
- **Level 2**: two orthogonal levels of partial semantic interoperability
  - ***Level 2a****:* unidirectional semantic interoperability
  - ***Level 2b****:* bidirectional semantic interoperability of meaningful fragments

Required level

- **Level 3**: full semantic interoperability, sharable context, seamless co-operability

Semantic interoperability

- the ability to send human readable and computable records from place to place
- e.g. An electronic health record with vocabulary controlled, structured problem lists, medications, labs, and radiology studies sending this data into structured lists within a personal health record
- Semantic interoperability ensures that decision support software can interpret the transmitted data and perform quality and safety checks such as drug/drug or drug/allergy checking.

eHealth data Goals

- Improve availability, reliability & quality of shared healthcare data
- Safe exchange of messages and documents
- Safe interpretation, processing and reasoning over shared data
- Ability to apply decision support rules over shared data
- Meaningful querying over data from multiple sources
- Ability to persist shared data in native data stores of receiving clinical systems (bi-directional semantic interoperability)

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Interoperability Challenges

- Lack of message standardisation in Singapore has hindered information sharing between clusters, sectors and facilities
  - Many variations in local HL7 v2 message profiles
  - Widespread use of locally defined Z-segments/fields
  - Lack of conformance quality testing
  - Disconnected terminology sets, which differ in their degree of pre-coordination due to differing local interfaces and structures
- To achieve interoperability in both directions, each new message variation must be both produced and consumed by each system
- Each system may need to support dozens of interfaces.
- NEHR requires uni and bi-directional semantic interoperability
- Need to support a hybrid **SOA and MLLP** environment

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Standards follow the flow of information

Emergency Department

Acute-Care Hospital

Emergency Department

Name NRIC No.	Date of Birth Gender	Primary Care Provider Care Coordinator	
Allergies			Immunisations
Diagnoses	Current Medications		Investigations
			Procedures
Recent Events	Recent Referrals		Care Plan

Care Co-ordinator

Community Hospital

General Practitioner

General Practioner

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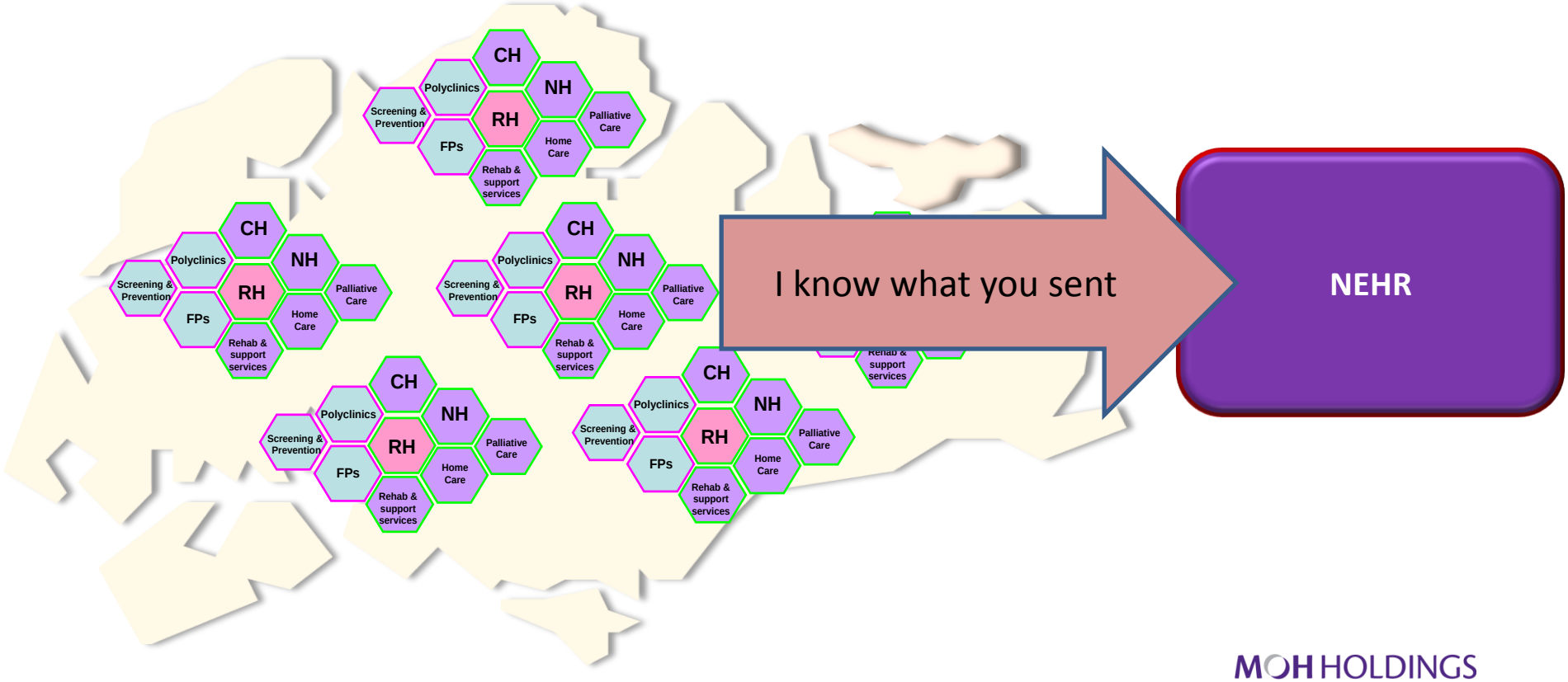
Uni-directional Semantic Interoperability

- NEHR can transform every message sent from any healthcare system into the form of single consistent structure and meaning



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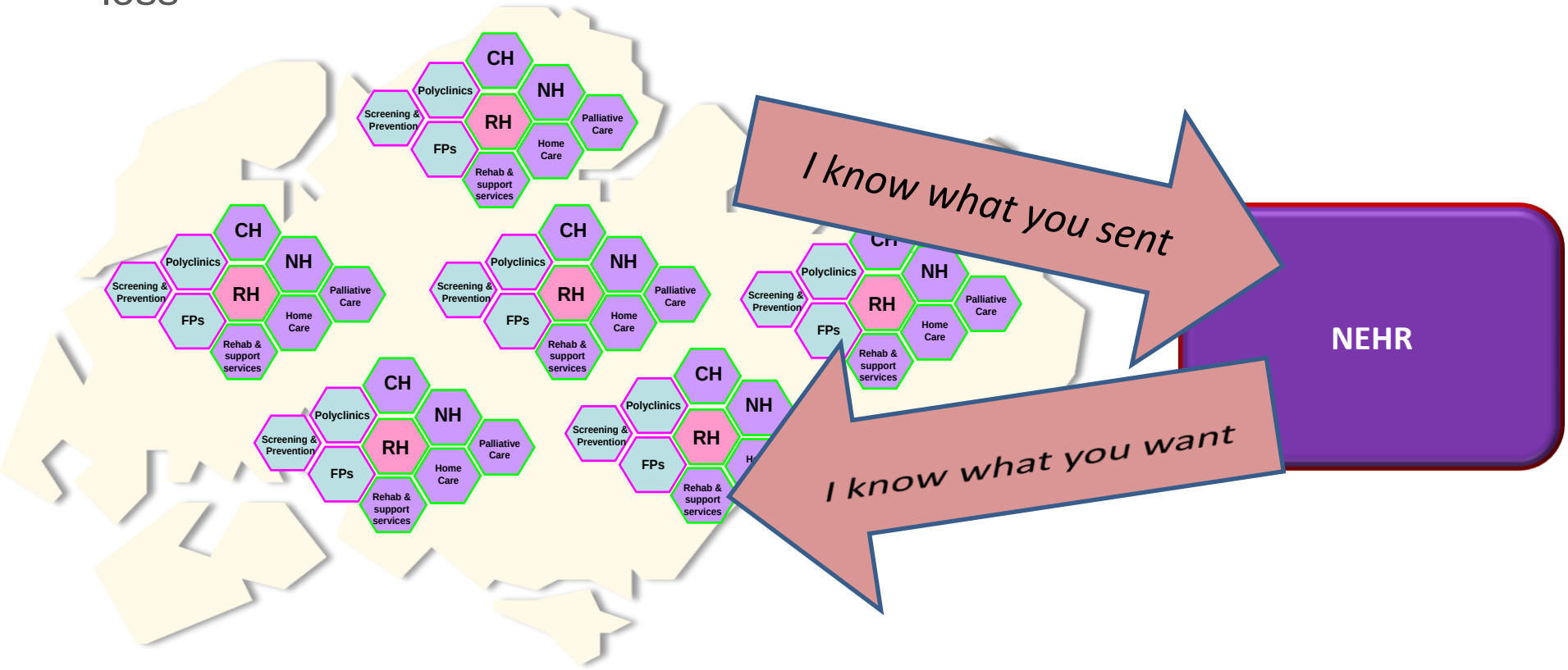
Bi-directional Semantic Interoperability

- NEHR can fully understand every message sent from any healthcare system as well as can exchange data among the systems without any loss



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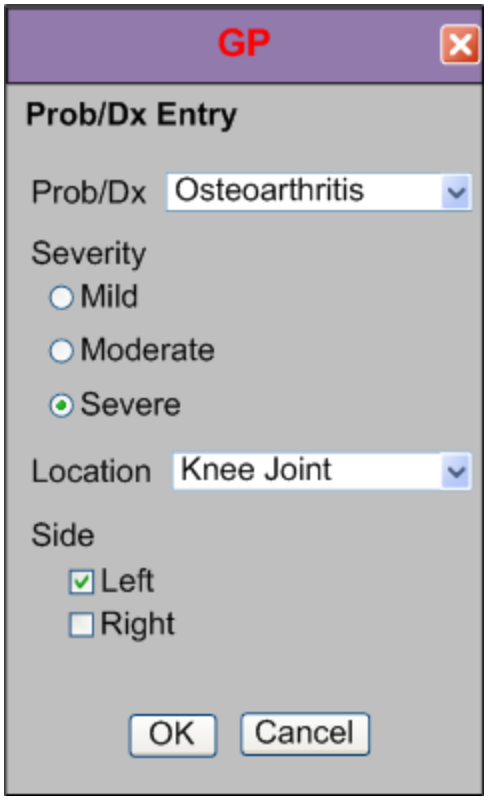
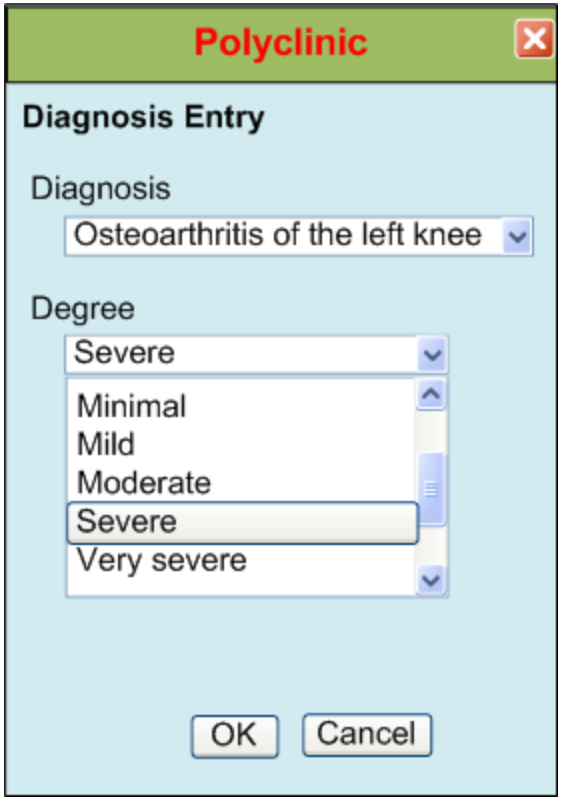
Different information models – Diagnosis

e.g., “Severe osteoarthritis of the left knee ”

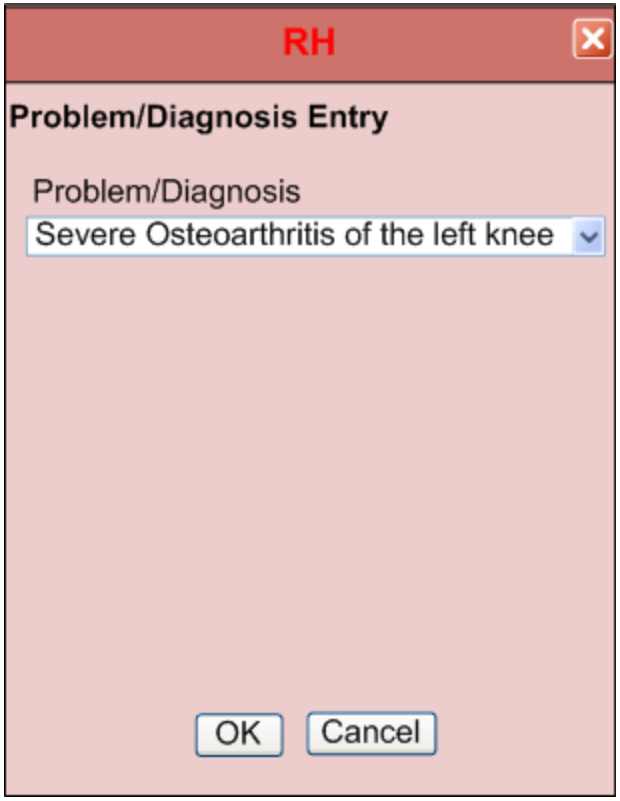
Data



Data



Data



All need to look the same in the NEHR.

What is the problem? – How are we tackling it?

Vocabulary
- Knowledge of words

Grammar
- Understanding of the structural rules that govern the composition of sentences, phrases, and words in any given natural language
- Semantics

Syntax
- Understanding of principles and rules of the language
- Sentence construction, etc

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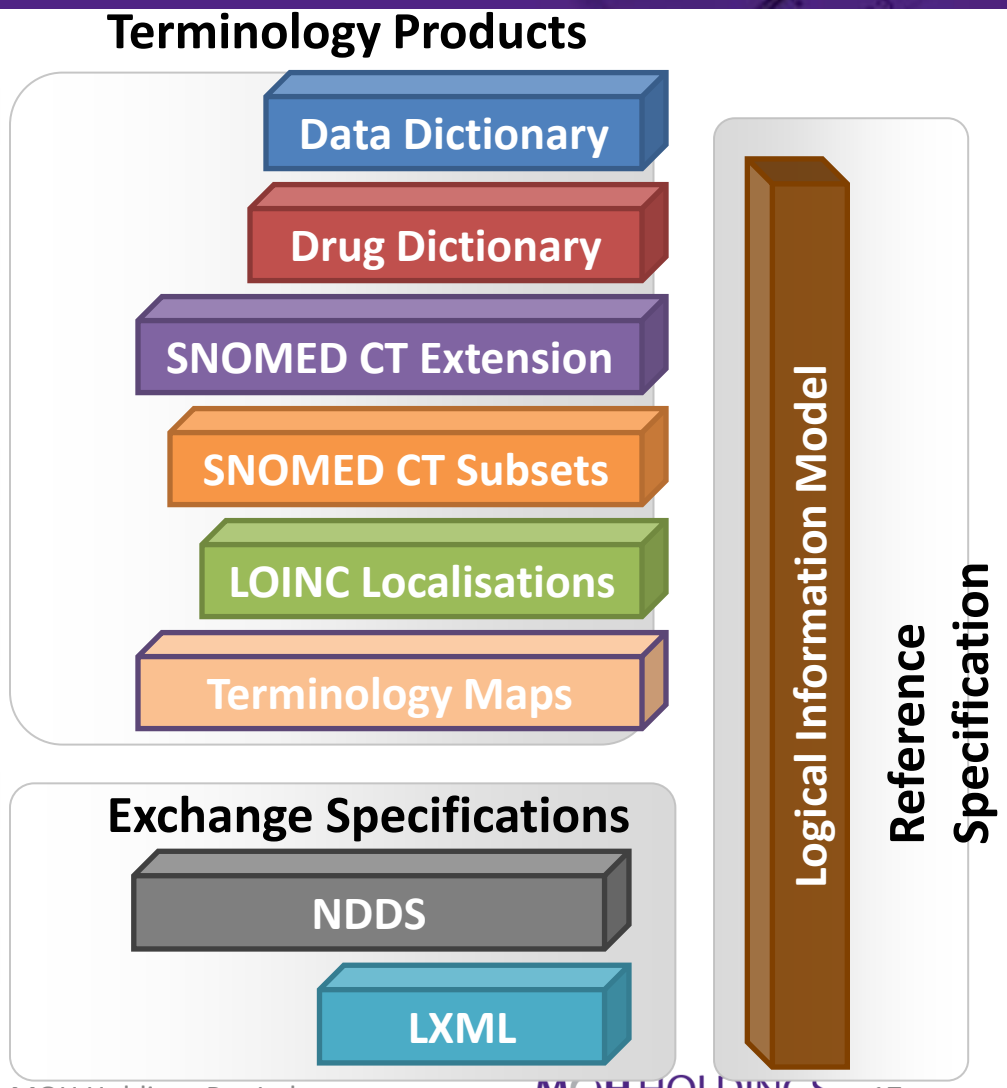

Standards Development Principles

- **Clinical validation**
  - Need models that clinicians can understand and validate
- **Automated Processes**
  - Directly generate standards from clinician-validated models
  - Reduce risk of manual/programmer error (and dev. costs, below)
- **Data Quality**
  - Consistent and complete automated conformance checking
  - Improve reliability, consistency of data sent/received
  - Minimise data transformations required
- **Ease of Implementation** – by vendors
  - Generic models require higher level of training.
  - Use-case specific models are easier to implement
- **Minimise Costs**
  - Reduce standards development costs
  - Minimise maintenance costs arising from changing business requirements and evolving modelling advancements
  - Minimise long term costs of systems and interfaces

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Clinically-Driven Logical Modelling

- We need to move to a single ‘source of truth’ that can support the entire journey.
- Achieving this begins with the articulation of our clinician and business information requirements within the Singapore Logical Information Model (LIM).
- The validation of these requirements by the clinical community (via user-friendly views of the LIM) is a critical part to minimizing the risk associated with misinterpretation of business needs.

Use Cases for Standards

- Messaging – exchanging transactional data
- Document Exchange
- Persistence – storing data in clinical systems
- Interoperability – semantics to enable bi-directional interoperability
- Querying – over NEHR + heterogeneous clinical systems
- Decision Support – national decision support rules over terminology and ‘LIM’

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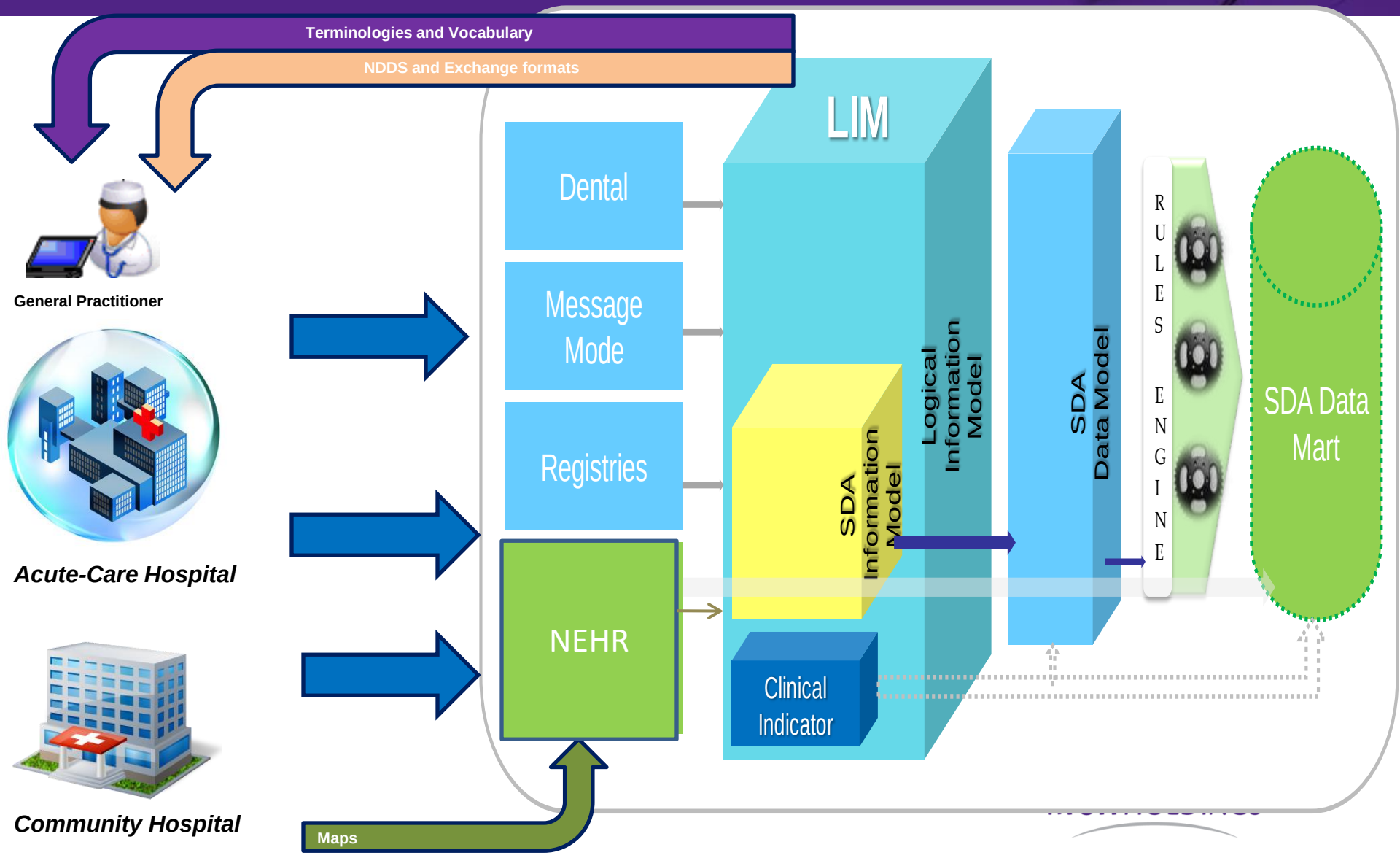
Data Improvement – Data ReUse



Singapore Logical Information Model (1)

Implementation-independent information model for shared healthcare data but needs to support both MLLP and SOA

- Developed using an *evidence-based approach* (several million existing messages and profiles) *& clinician-driven approach* (new requirements)
- Built on ISO13606 Logical Reference Model (LRM) + ISO21090 data types
- Archetypes
  - Reusable clinical building blocks
  - Constrained & assembled into use-case specific templates
- Defines the structure, constraints and reference terminology binding for clinical concepts shared within Singapore

Singapore Logical Information Model (2)

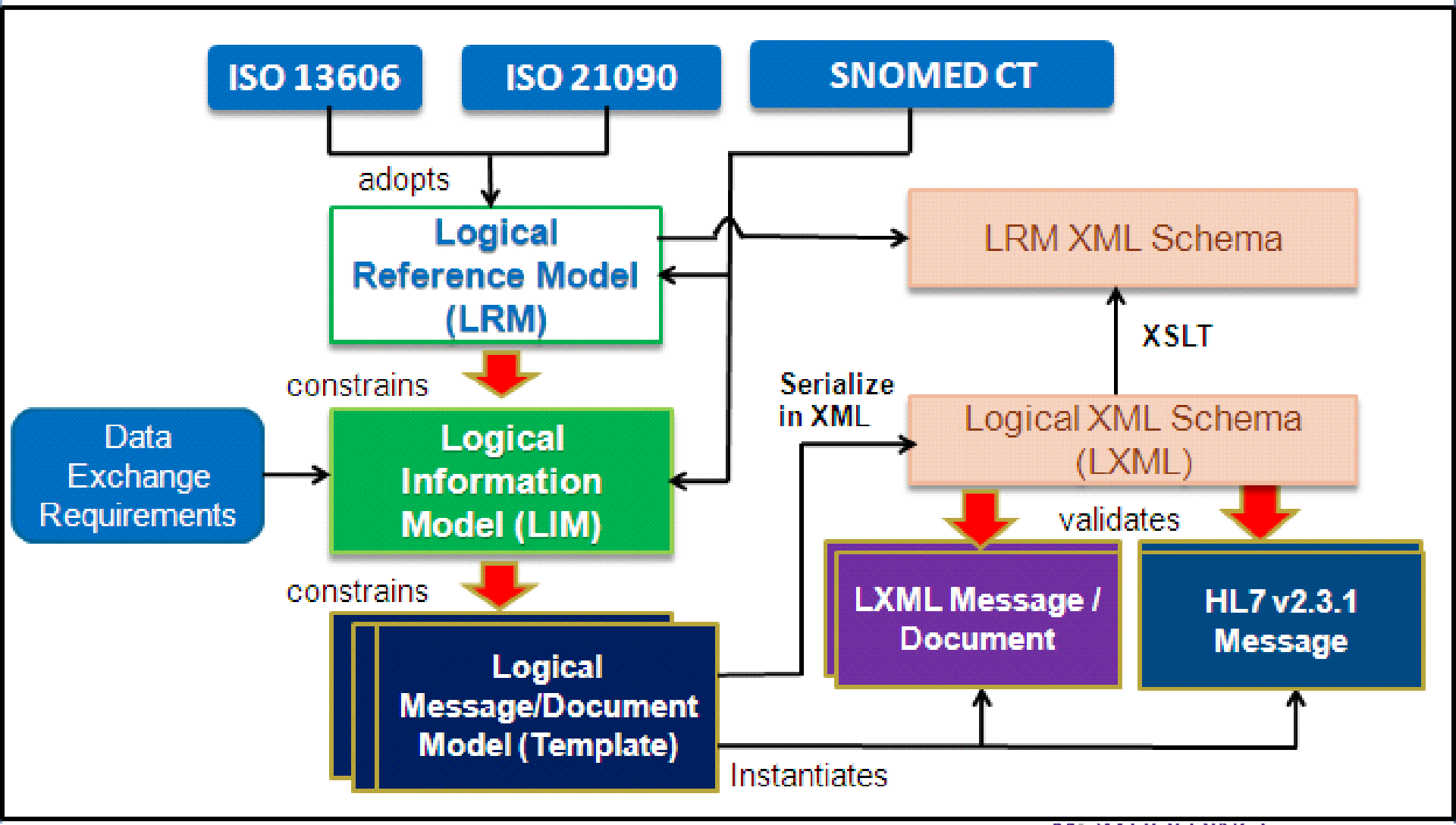
- Expressed using a machine-readable format (e.g. ADL, UML, XML)
- Used to automatically generate
  - exchange format specifications,
  - conformance validation software,
  - user interfaces,
  - human readable documentation
- Allows clinical systems to populate messages using either
  - their native interface terms, or
  - national reference terminology

  resolving pre-coordination differences with the help of specialised ***design pattern*** constructs

Archetype Reuse in NDDS

Sheet#	Worksheets	ADT	Lab	Radiology	Pharm Order	Pharm Dispense	ACIDS Phase 1	ACIDS Goal State
P1-P6	Participant	✓	✓	✓	✓	✓	X	X
CL1	Pharmacy Item				✓	✓		✓
CL2	Laboratory Test		✓					✓
E1	Patient Event Context	✓	✓	✓	✓	✓	✓	✓
E2	Composition Information	✓	✓	✓	✓	✓	✓	✓
E3	Problem Diagnosis	✓					✓	✓
E4	Pharmacy Activity							
E5	Pharmacy Order				✓	✓		✓
E6	Pharmacy Dispense					✓		✓
E7	Investigation Order		✓	✓				✓
E8	Investigation		✓	✓				✓
E9	Procedure						✓	✓
E10	Adverse Reaction	✓			✓	✓		✓
E11	Alert	✓						✓
E12	Observation	✓			✓	✓	✓	✓
E13	Clinical Synopsis		✓	✓				✓
S1	Problem Diagnosis List	✓					✓	✓
S2	Medication List						✓	✓
C1	Investigation Composition		✓	✓				
C2	Patient Event Composition	✓					✓	✓
C3	Pharmacy Composition				✓	✓		
X1	Investigation Extract		✓	✓				
X2	Patient Event Extract	✓					✓	✓
X3	Pharmacy Extract				✓	✓		
M1	Investigation Message		✓	✓				
M2	Patient Event Message	✓						
M3	Pharmacy Message				✓	✓		
R1	Data Types	✓	✓	✓	✓	✓	X	X
R2-R8	Classes	✓	✓	✓	✓	✓	X	X

LIM Development Process



Exchange Formats

- Logical XML (LXML) / ‘Green-13606’
  - Automated, serialisation of a Template
  - Has simple, generic XSLT to convert to/from LRM
  - Forms HL7 SOA Service Definitions
  - Can be used to generate ‘Green-CDA’ or ‘CDA-r1’
- HL7 v2.3.1 messages
  - Required by some systems in Singapore
  - Extended with LIM-semantics using ‘Structured-OBX-segments’
  - Uses some HL7 v2.6 data types (e.g. some CE fields have been upgraded to CNE/CWE to support Singapore’s terminology requirements).

Sample Logical XML (LXML) Snippet

NDDS snippet

E8.21			Investigation Item	item	CLUSTER	1
	E8.21.1		Investigation Name	part	ELEMENT.value: CD.CWE (Concept Descriptor - Coded or Text)	1
	E8.21.2		Additional Description	part	ELEMENT.value: CD.CWE (Concept Descriptor - Coded or Text)	0..1
	E8.21.4		Context	part	CLUSTER	0..1
	E8.21.5		Procedure Site Direct Laterality	part	CLUSTER	0..Many
	E8.21.6		Specimen	part	CLUSTER	0..1
	E8.21.7		Priority	part	ELEMENT.value: CD.CWE (Concept Descriptor - Coded or Text)	0..1
	E8.21.8		POCT Indicator	part	ELEMENT.value: CD.CNE (Concept Descriptor - Coded)	0..1
	E8.21.9		Category	part	ELEMENT.value: CD.CNE (Concept Descriptor - Coded)	1
	E8.21.10		Type	part	ELEMENT (Concept I	

NXDS LXML XSD

```
<xs:element name="investigation_item">
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="SG_CLUSTER">
        <xs:sequence>
          <xs:element name="investigation_name" type="CD_ELEMENT"/>
          <xs:element name="additional_description" type="CD_ELEMENT" minOccurs="0"/>
          <xs:element name="context" minOccurs="0">
          <xs:element name="procedure_site_direct_laterality" minOccurs="0">
          <xs:element name="specimen" minOccurs="0">
          <xs:element name="priority" type="CD_ELEMENT" minOccurs="0"/>
          <xs:element name="poct_indicator" type="CD_ELEMENT" minOccurs="0"/>
          <xs:element name="category" type="CD_ELEMENT"/>
          <xs:element name="type" type="CD_ELEMENT" minOccurs="0"/>
          <xs:element name="clinical_notes" type="ST_ELEMENT" minOccurs="0"/>
        </xs:sequence>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
```

NXDS LXML Instance

```
<investigation_item component_type="CLUSTER">
  <investigation_name component_type="ELEMENT">
    <value codeSystem="2.16.840.1.113883.6.96" code="16254007">
      <displayName value="Lipid Panel"/>
    </value>
  </investigation_name>
  <category component_type="ELEMENT">
    <value codeSystem="MOHH-DD" code="Laboratory"/>
  </category>
  <type component_type="ELEMENT">
    <value codeSystem="2.16.840.1.113883.6.96" code="15220000" >
      <displayName value="laboratory test"/>
    </value>
  </type>
</investigation_item>
```

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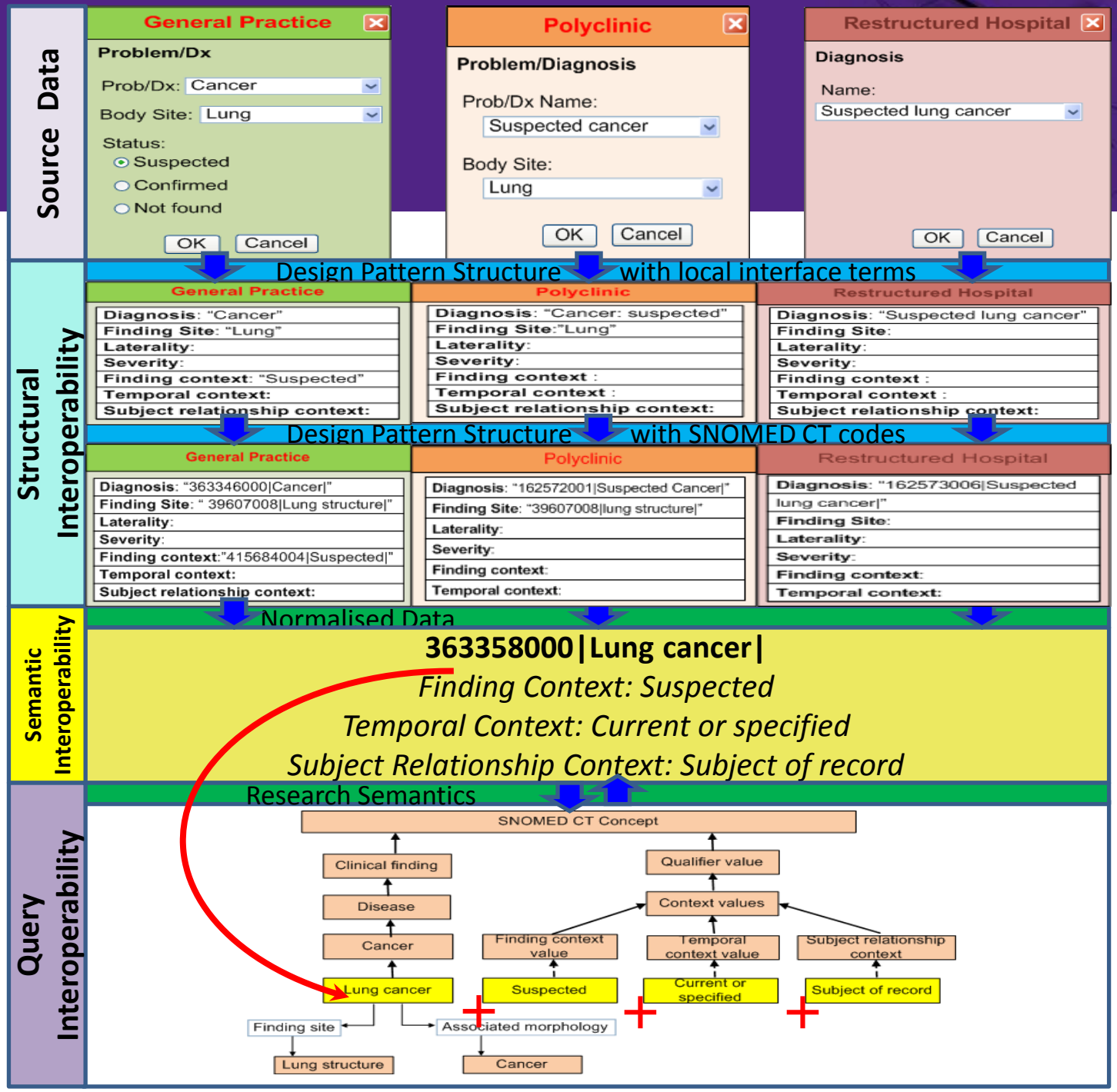
Design Pattern Process




Maximizing Benefits in a SOA Journey – Singapore Future

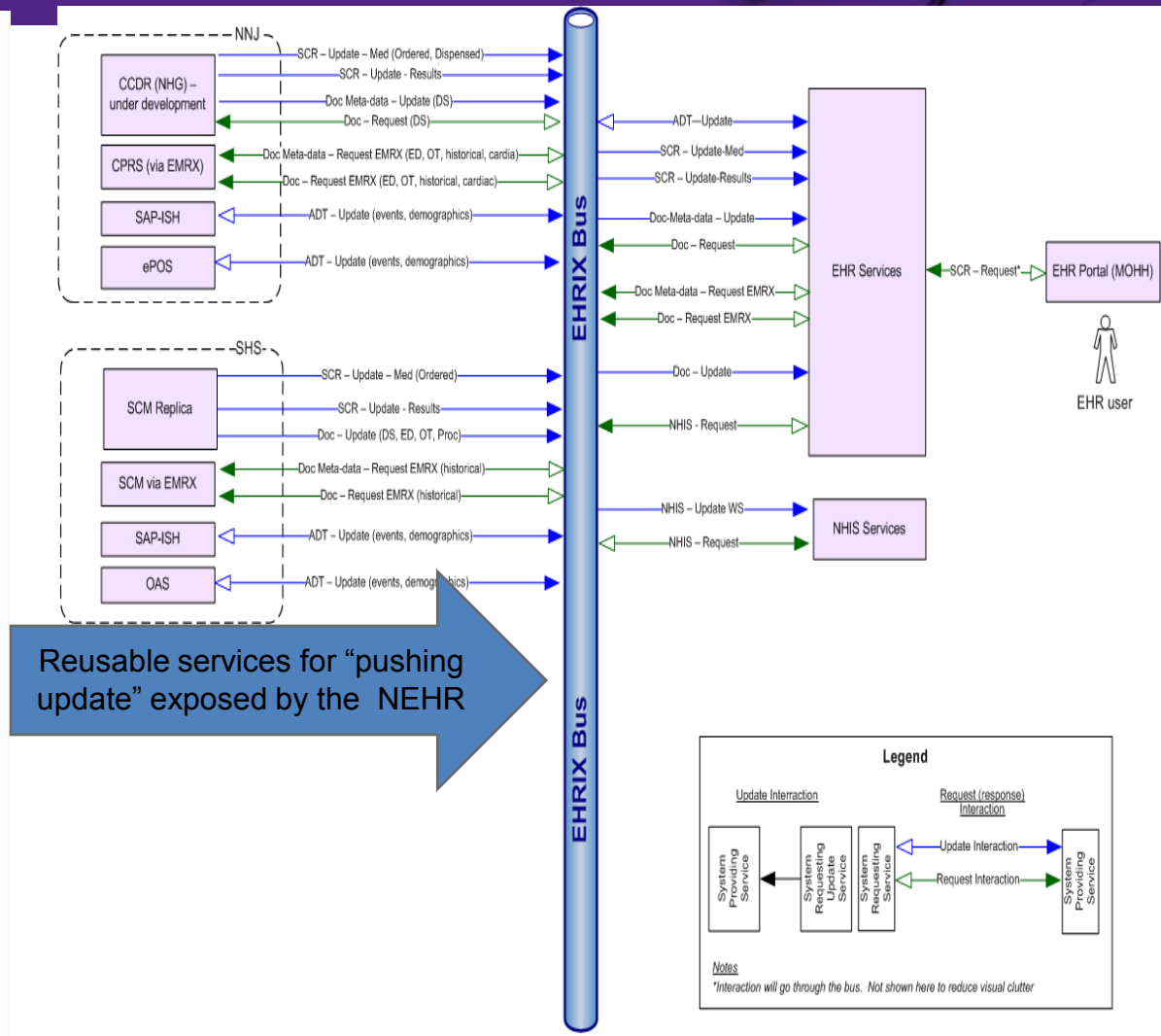
NEHR R1 – Cluster EMR Integration (1/2)

Services are exposed by the NEHR for external parties to “put” updates to the NEHR.

Below is the list the key reusable services using the “put” style design pattern in NEHR R1

- putLabResult
- putPatient
- putOrderedMedications
- putDispensedMedications
- putLabResult
- putRadiologyResult
- putOTNotes
- putEDSummaryNotes
- putDischargeSummary
- putEvent
- putExternalAlertIndicator
- putExternalAllergyIndicator
- putAlertADR

Details and update on the services, available in the MOHH Services Catalogue and NEHR design specification.



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NEHR R1 – Cluster EMR Integration (2/2)

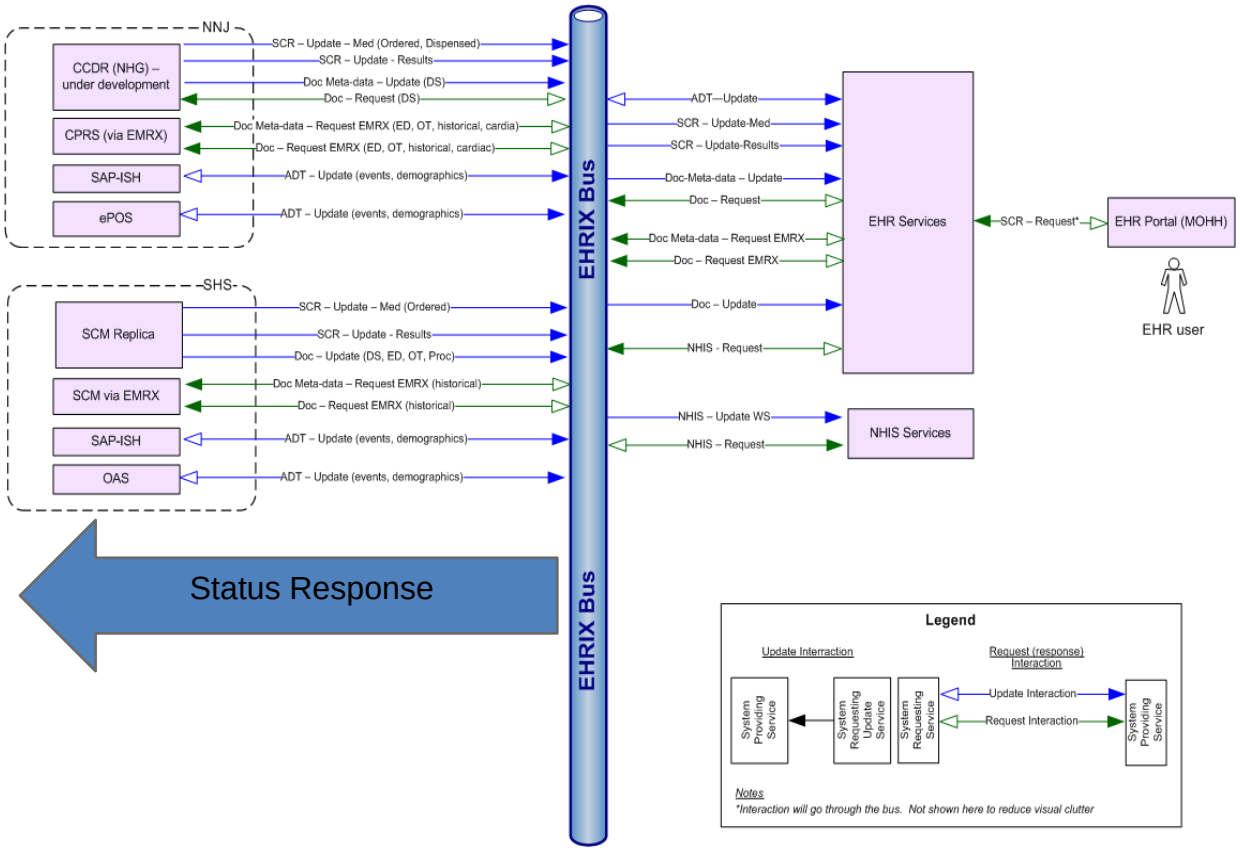
Key Status Codes

"**00" Success** – update has been successfully received and processed.

"**01" System Error** - unexpected error at the destination, message is not received. Need for retry).

"02" Message Error (e.g. invalid XML). The error should be fixed at the source before retry.

Details and update on the services, available in the MOHH Services Catalogue and NEHR design specification.



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SOA Design Principle

- **Services are loosely coupled** – Services are defined by explicit, implementation-independent interfaces
- **Services are location transparent** – Service consumer does not hard-code the specific location of the service provider
- **Services are interoperable** – Services shall be interoperable in a variety of platforms and protocol
- **Services are composable** – Services at one level of granularity or abstraction can be composed and aggregated to implement services at higher level of granularity or abstraction

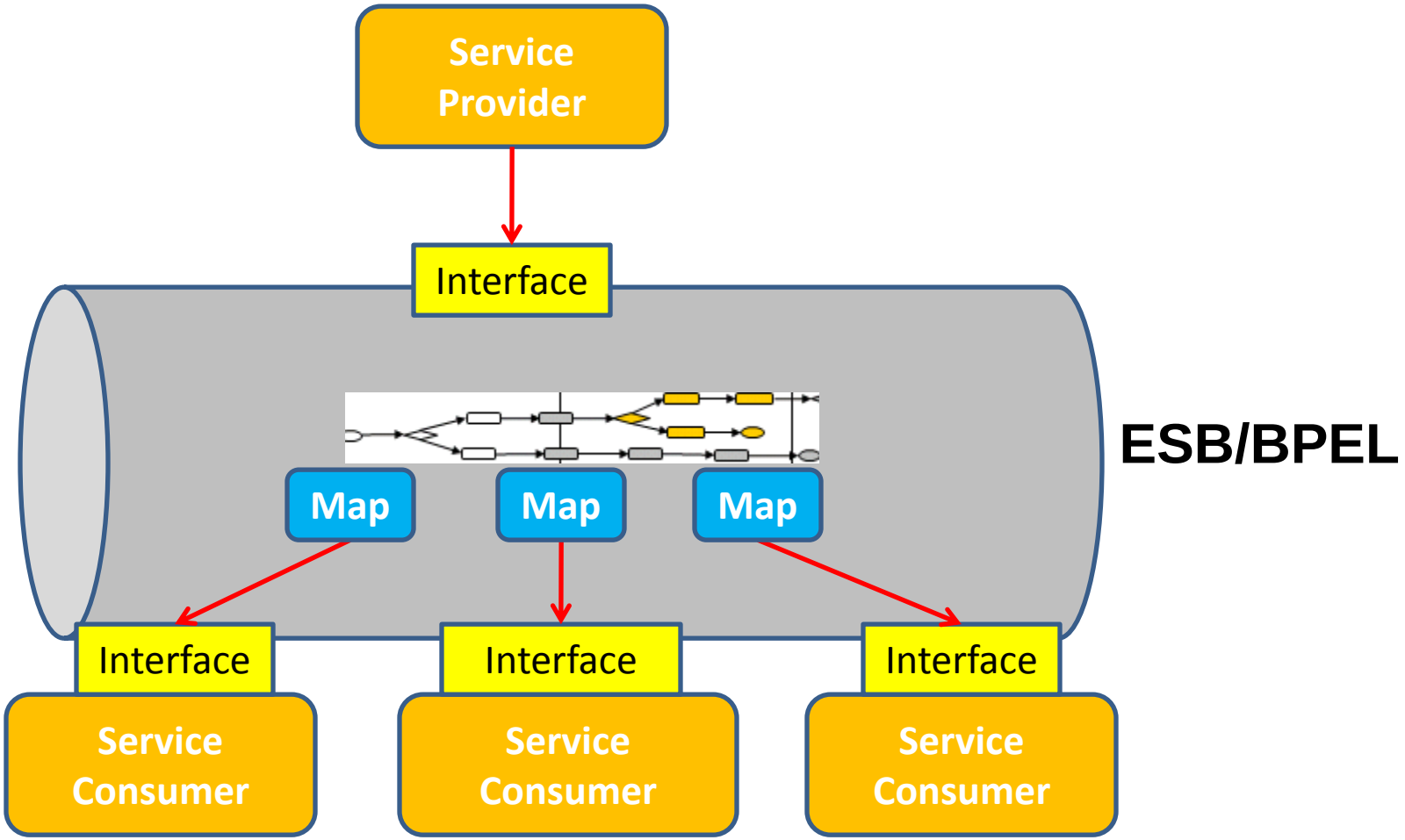
How to ensure “Services are composable”

- **Ensure services have appropriate granularity -** The scope of the business function that has the widest possible reuse potential is a key driver to determining the service granularity

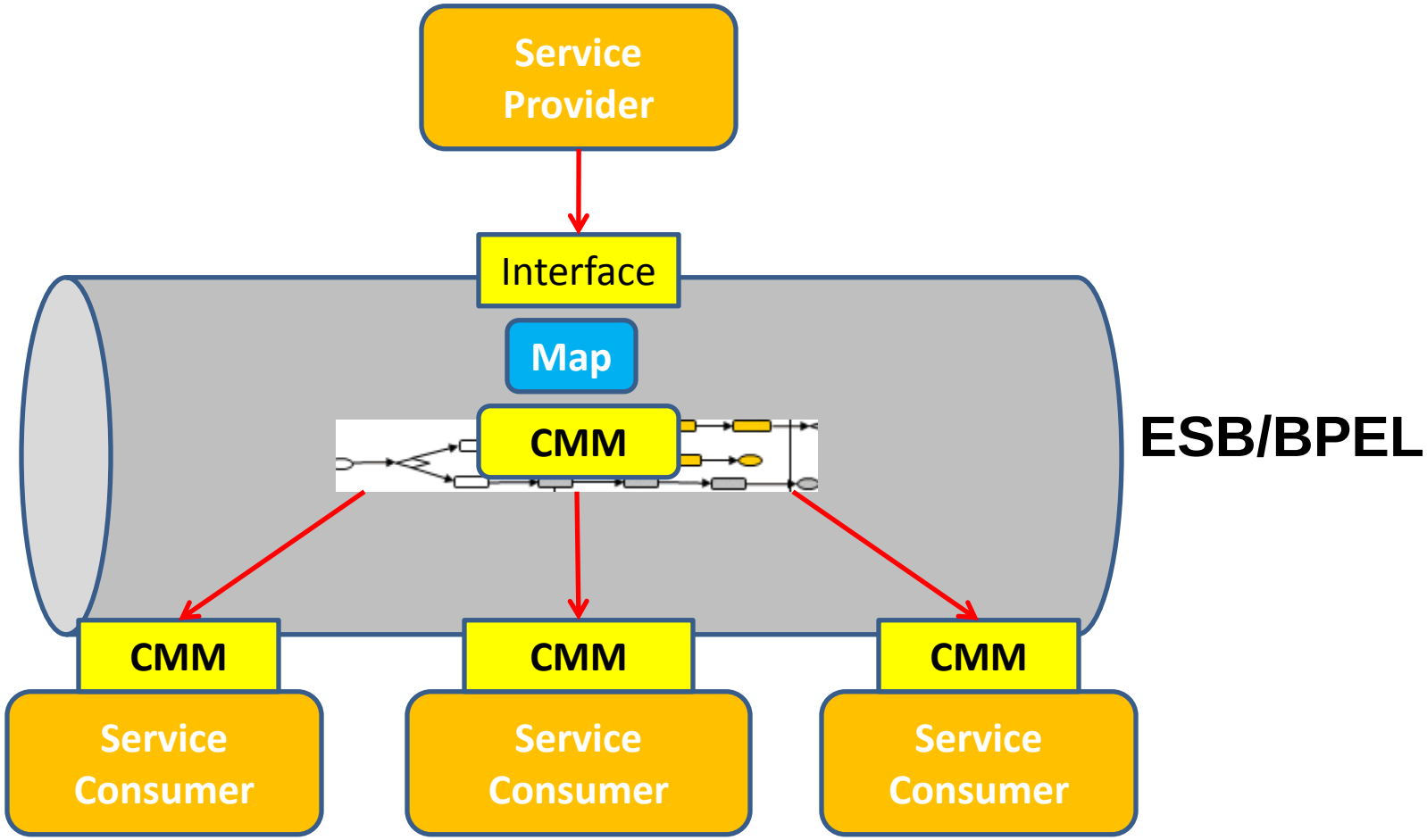
- **Use of Canonical Message Model (CMM) –** CMM ensures that every service speak “the same language” so that they can interact with each other, and the ability to be composed to form higher level of services without the need to transform back and forth between different interfaces exposed by the SOA Service, so as not to clutter BPEL orchestration logic and improve overall system performance

- **Use of Common Information Model** – Use of CMM is first step to ensure syntactic interoperability, use common information model will ensure the semantics of the services is understood by each service, thereby achieve semantic interoperability

Service Orchestration without SOA CMM



Service Orchestration with SOA CMM

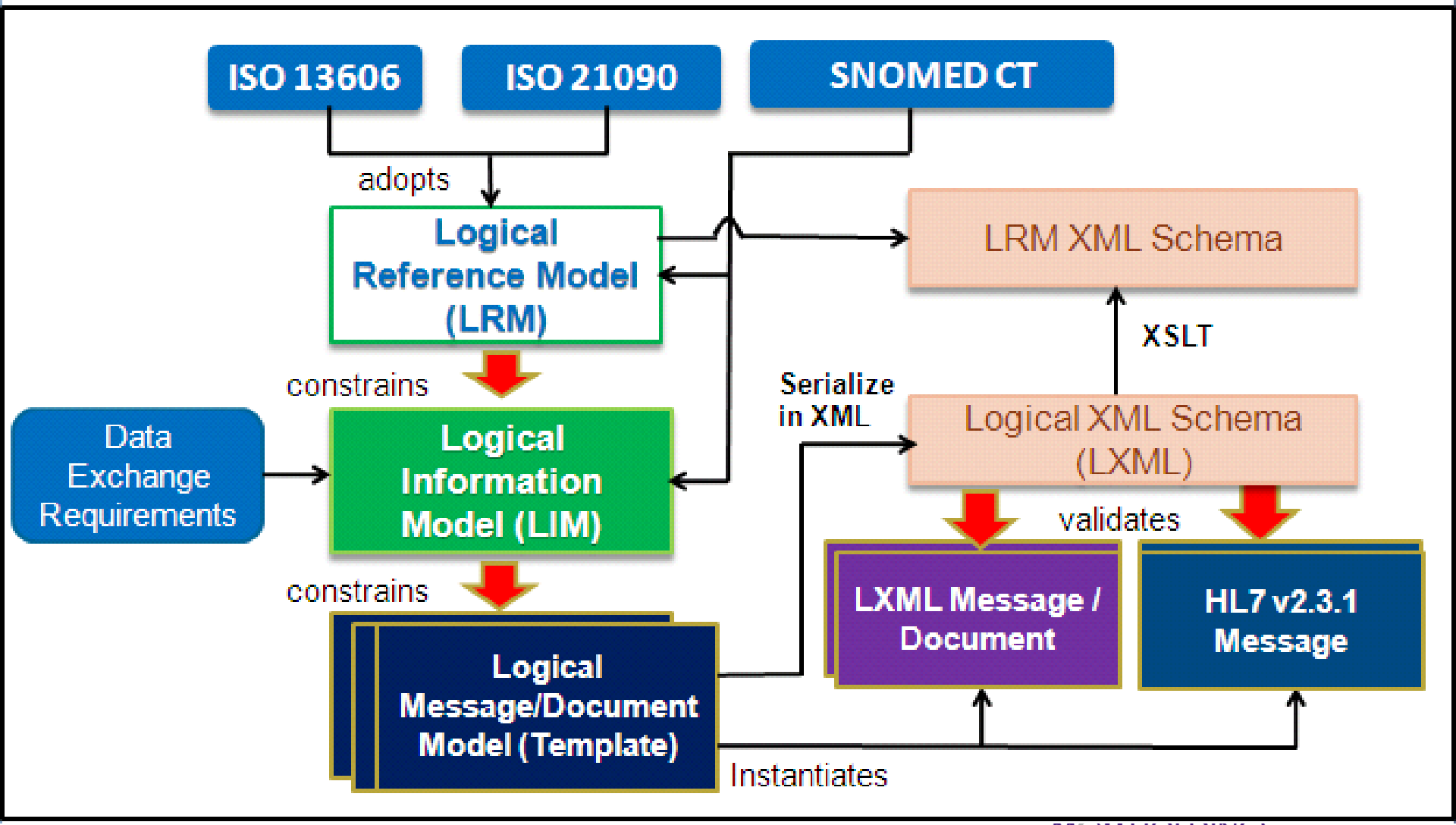


So How Do We get there?

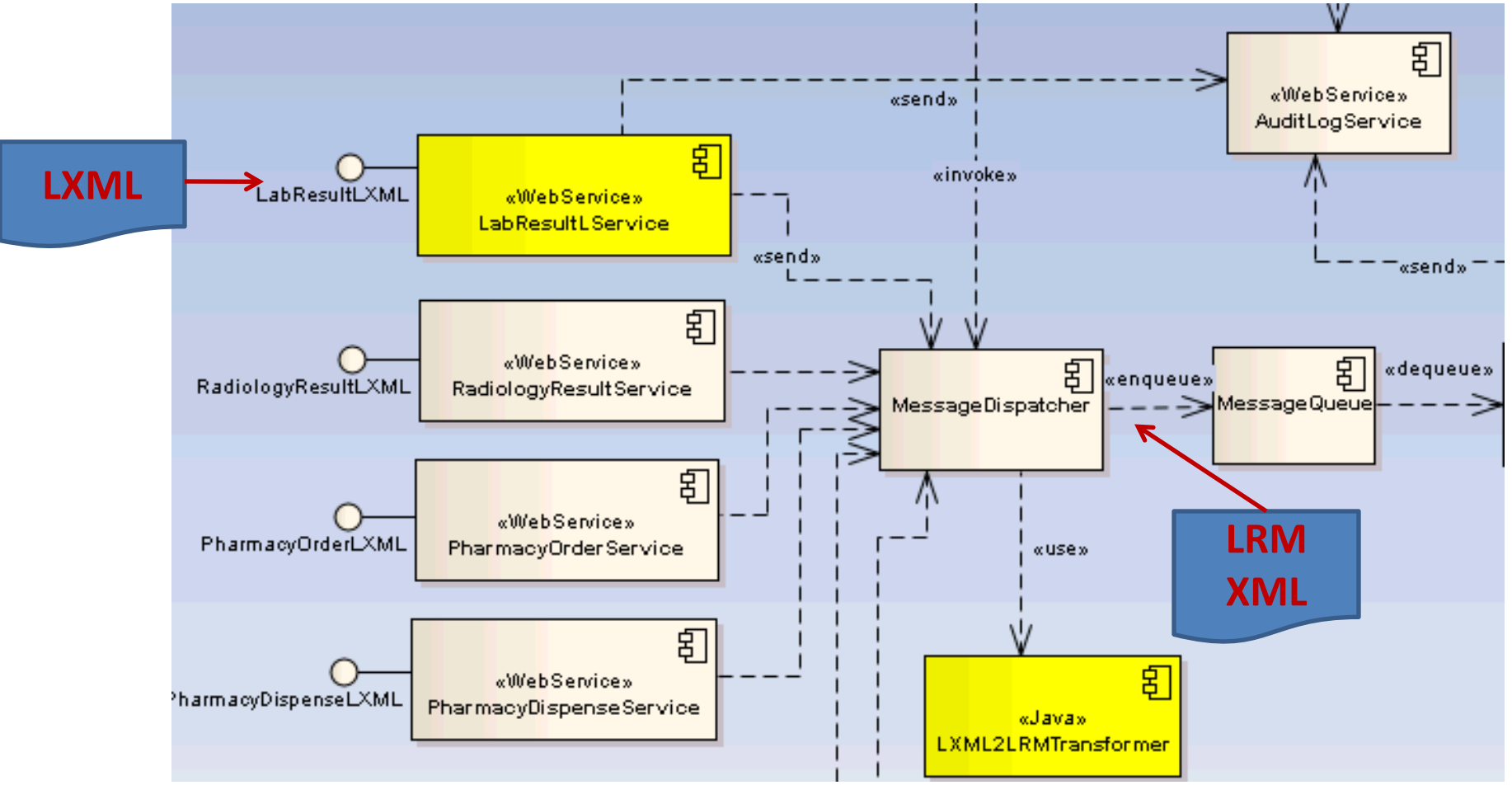
- **SOA Services for external consumer –** Use LXML to ensure stronger conformance and easy-to-understand XML element name for users and developers.

- **SOA Services for internal interaction within ESB –** Use LRM (Logical Reference Model) XML as the canonical message model for service interface, thereby
  - removing the need for constant service interface format transformation between each service invocation,
  - ensure ‘plug-and-play’ feature since all the internal services conform to the same interface format.

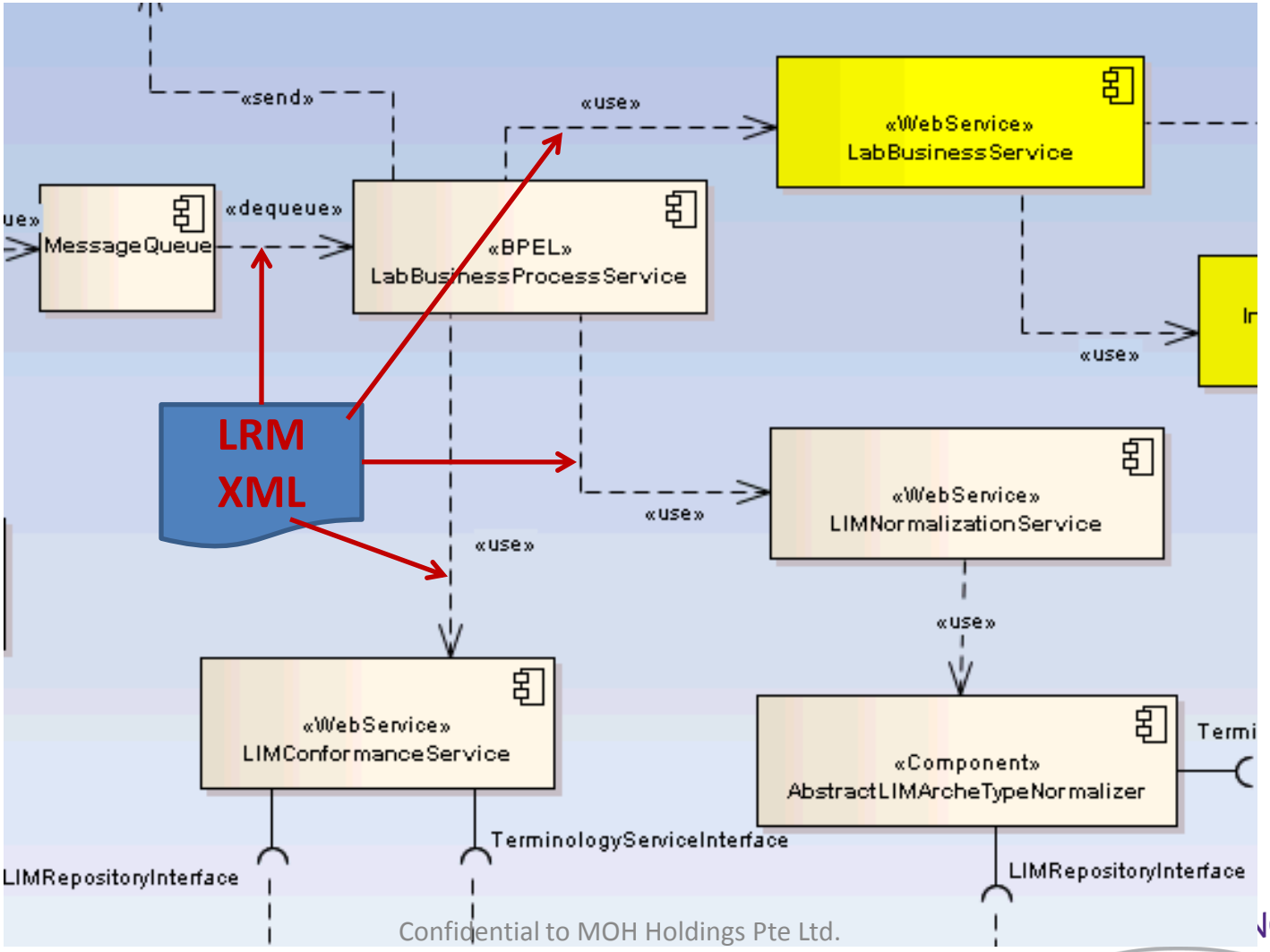
LIM Development Process



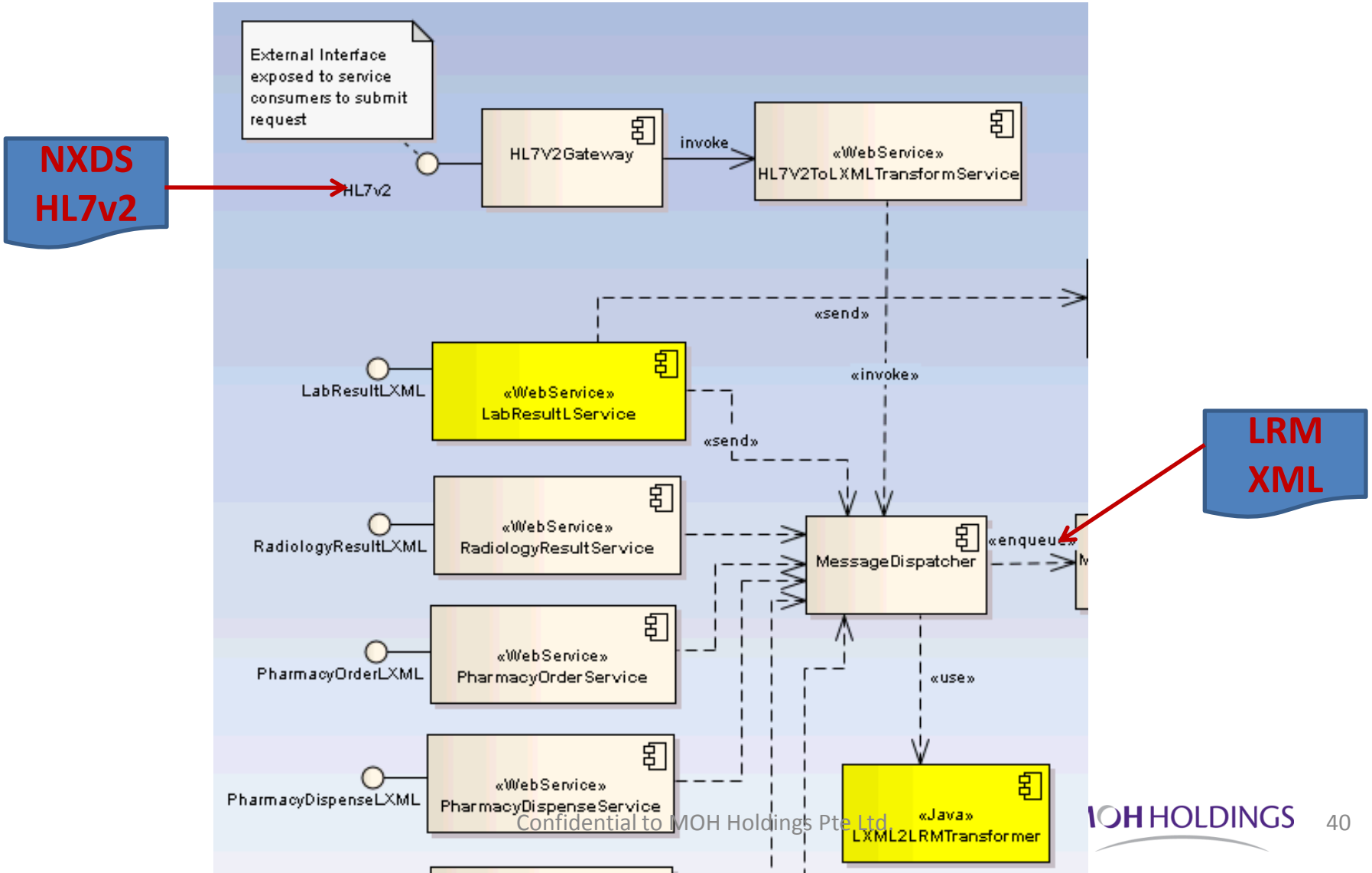
Reference SOA Service Model (1/3)



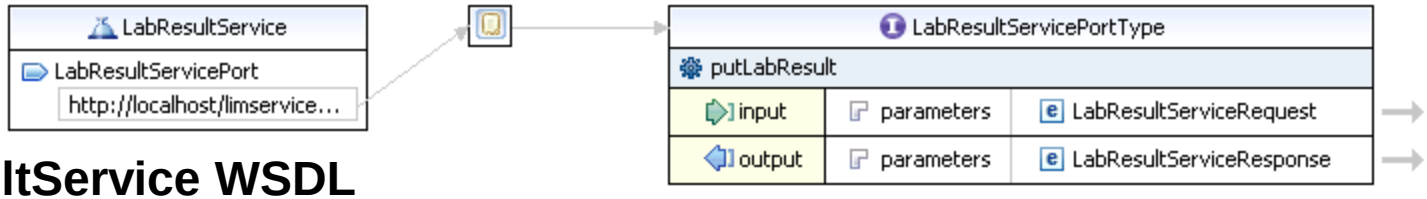
Reference SOA Service Model (2/3)



Reference SOA Service Model (3/3)



External SOA Service Definition

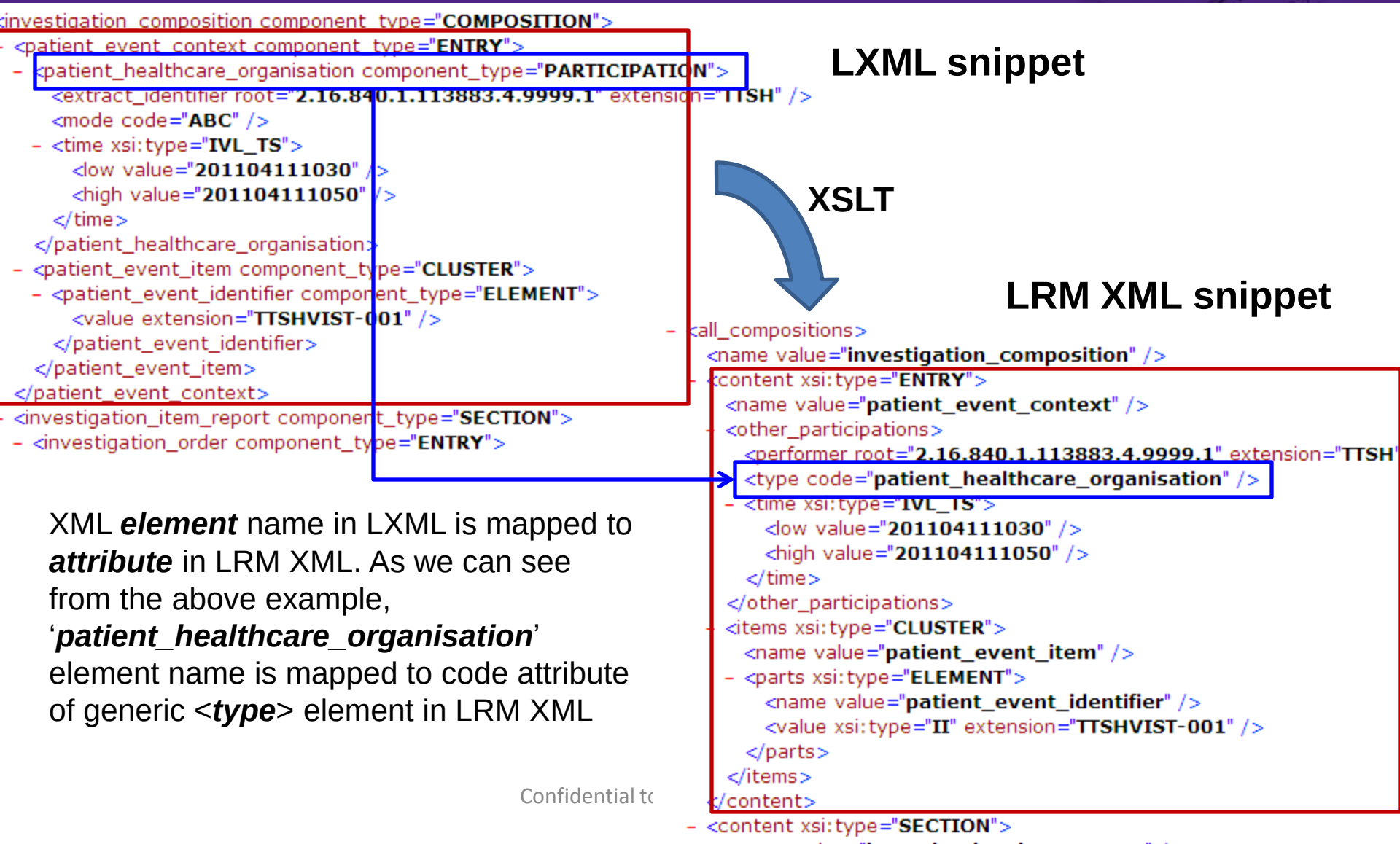


LabResultService WSDL

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<wsdl:definitions
        name="LabResultService"
        xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
        xmlns:tns="http://www.mohh.com/limservice"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns:xsd="http://www.w3.org/2001/XMLSchema"
        xmlns:lim="urn:mohh-sg:lim"
        targetNamespace="http://www.mohh.com/limservice">
  <wsdl:types>
        <xsd:schema
            xmlns="http://www.w3.org/2001/XMLSchema"
            targetNamespace="http://www.mohh.com/limservice"
            xmlns:lim="urn:mohh-sg:lim"
            elementFormDefault="qualified">
            <import namespace="urn:mohh-sg:lim" schemaLocation="LR_SG_LXML_V020.xsd"/>
            <xsd:element name="LabResultServiceRequest" type="lim:INVESTIGATION_MESSAGE"></xsd:element>
            <xsd:element name="LabResultServiceResponse" type="lim:SERVICE_RESPONSE"></xsd:element>
        </xsd:schema>
  </wsdl:types>
  <wsdl:message name="LabResultServiceRequestMessage">
    <wsdl:part element="tns:LabResultServiceRequest" name="parameters"/>
  </wsdl:message>
  <wsdl:message name="LabResultServiceResponseMessage">
    <wsdl:part element="tns:LabResultServiceResponse" name="parameters"/>
  </wsdl:message>
```

Lab Result LXML XSD

How to get LRM XML from LXML



XML ***element*** name in LXML is mapped to ***attribute*** in LRM XML. As we can see from the above example, '***patient_healthcare_organisation***' element name is mapped to code attribute of generic <***type***> element in LRM XML

XSLT for Mapping LXML to LRM XML

```
<!-- transforming COMPOSITION -->
- <xsl:template mode="composition" match="lim:*[@component_type='COMPOSITION']">
    <xsl:message>transforming COMPOSITION class ...</xsl:message>
    <xsl:text></xsl:text>
  - <all_compositions>
      <name value="{fn:node-name(.)}" />
      <xsl:apply-templates mode="participations" select="./lim:*
        [@component_type='PARTICIPATION']" />
      <xsl:apply-templates mode="content-class" select="./lim:*[@component_type='SECTION']
        | ./lim:*[@component_type='ENTRY']" />
    </all_compositions>
  </xsl:template>
  <!-- transform CONTENT SECTION with nested SECTION -->
- <xsl:template mode="content-class" match="lim:*[@component_type='SECTION']">
    <xsl:message>transforming SECTION class ...</xsl:message>
  - <xsl:choose>
    - <xsl:when test="parent::lim:*[@component_type = 'COMPOSITION']">
      - <content xsi:type="{@component_type}">
          <name value="{fn:node-name(.)}" />
          <xsl:apply-templates mode="content-class" select="./lim:*[@component_type='SECTION']
            | ./lim:*[@component_type='ENTRY']" />
        </content>
      </xsl:when>
    - <xsl:otherwise>
      - <members xsi:type="{@component_type}">
          <name value="{fn:node-name(.)}" />
          <xsl:apply-templates mode="content-class" select="./lim:*[@component_type='SECTION']
            | ./lim:*[@component_type='ENTRY']" />
        </members>
      </xsl:otherwise>
    </xsl:choose>
  </xsl:template>
```

Apply this template

SECTION with immediate parent as COMPOSITION or as nested SECTION

COMPOSITION can contain either SECTION or ENTRY class

Conclusion

- Clinician-driven and validated logical modelling drives all information standards
- Artifacts can be automatically generated from clinician-validated models (reduces clinical risk)
- Enables normalization of structure and terminology semantics (design patterns) for safer interoperable querying
- Enables services to be composable (using CMM & CIM)
- Supports hybrid transport protocol environment (e.g. SOA, MLLP)
- Establishment of LIM is a critical step in achieving clinically-driven bi-directional semantic interoperability in Singapore

Ultimate goal: Greater clinical safety in the interchange of healthcare information and maximize SOA benefits

MOH HOLDINGS

Thank You

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