Università degli Studi di Trieste

Corso di Laurea Magistrale in
INGEGNERIA CLINICA

HEALTH INFORMATICS STANDARD

Corso di Informatica Medica

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UNIVERSITÀ DEGLI STUDI DI TRIESTE

FHIR®

Fast Healthcare Interoperability Resources

FHIR USE

21st Century Cures Act: Interoperability, Information Blocking, and the ONC Health IT Certification Program Proposed Rule

The Office of the National Coordinator for Health Information Technology

We propose to adopt a new API criterion in § 170.315(g)(10), which would replace the "application access – data category request" certification criterion (§ 170.315(g)(8)) and become part of the 2015 Edition Base EHR definition. This new certification criterion would require the use of Health Level 7 (HL7®) Fast Healthcare Interoperability Resources (FHIR®) standards and several implementation specifications.

- 21st Century Cures Act passed Congress in December 2016 with strong bipartisan support

	All Votes		Republicans	Democrats	Independents
Yea	94 %	94	52	41	1
Nay	5 %	5	1	3	1
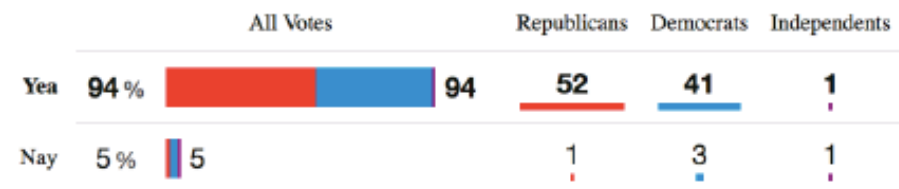
- Key interoperability provisions
  - Prevent information blocking
  - Establish FHIR as mechanism for moving data between EHRs (syntactic interoperability)
  - Establish standardized codes for moving data between EHRs (semantic interoperability)
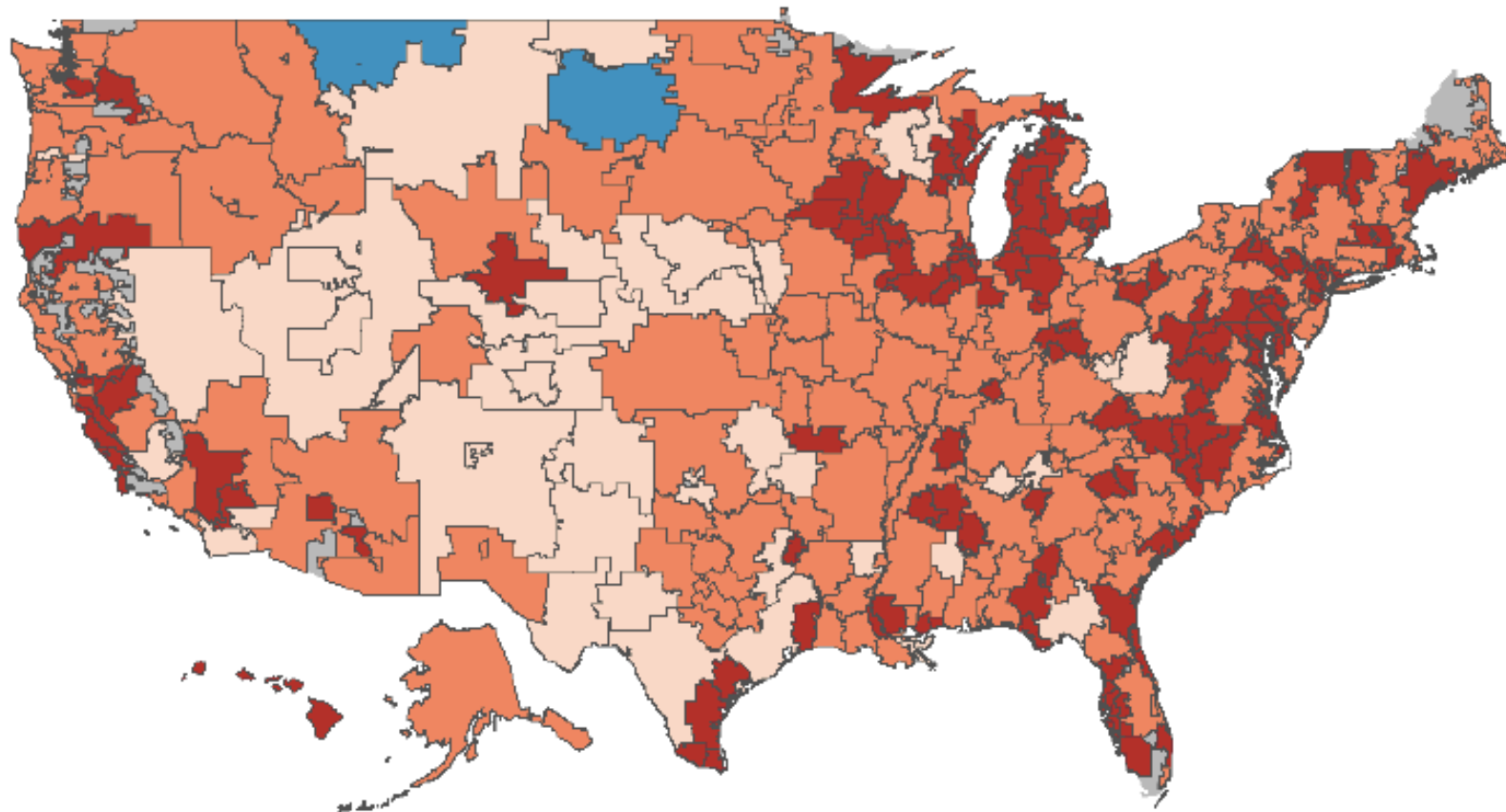
FHIR USE

Percent of hospitals with a 2015 Edition certified-API enabled with FHIR
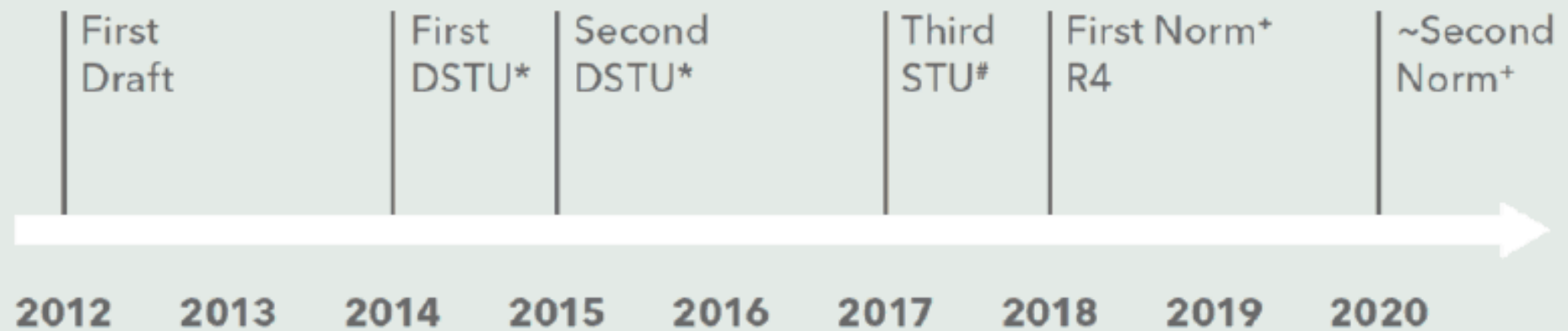*By Hospital Referral Region*

% w/ FHIR █ <50% ☐ 51-75% ☐ 76-99% ■ 100%

FHIR TIMELINE

FIGURE 2: HL7 FHIR TIMELINE

| First Draft | First DSTU* | Second DSTU* | Third STU# | First Norm+ R4 | ~Second Norm+ |

2012 2013 2014 2015 2016 2017 2018 2019 2020

* Draft Standard for Trial Use
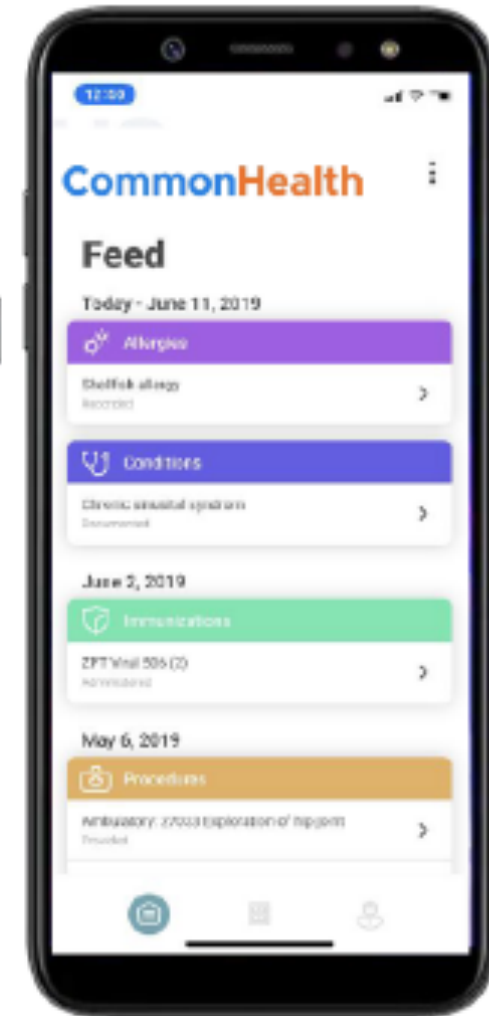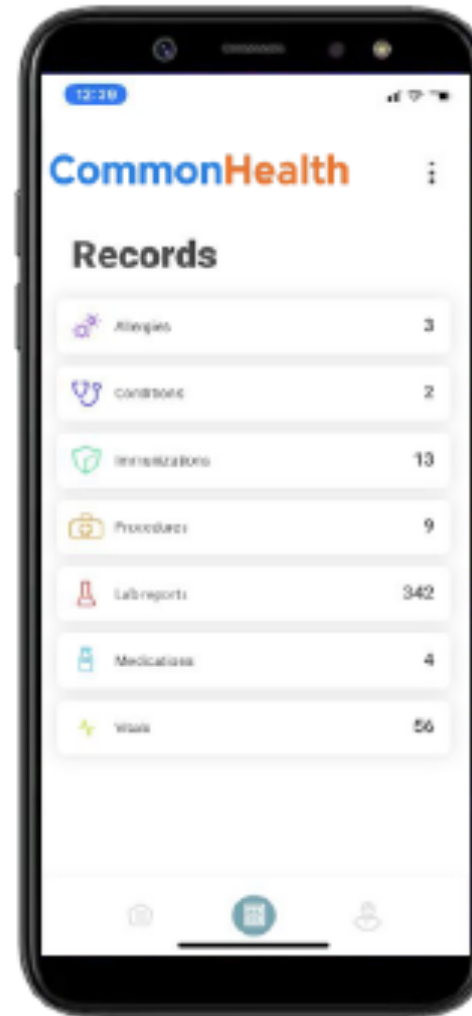# Standard for Trial Use
+ Normative Edition

Information courtesy of HL7 International.

FHIR USE

Apple Health uses FHIR

CommonHealth is a similar initiative for Android

FHIR RESOURCES

- Specification of information structure in FHIR
- Basic building blocks to manage any type of information

https://www.hl7.org/fhir/condition.html

9.2.3 Resource Content

Structure | UML | XML | JSON | Turtle | R3 Diff | All

UML Diagram (Legend)

Condition (DomainResource)

identifier : Identifier [0..*]
clinicalStatus : CodeableConcept [0..1] «
    ConditionClinicalStatusCodes! »
verificationStatus : CodeableConcept [0..1] «
    ConditionVerificationStatus! »
category : CodeableConcept [0..*] « ConditionCategoryCodes+ »
severity : CodeableConcept [0..1] « Condition/DiagnosisSeverity? »
code : CodeableConcept [0..1] « Condition/Problem/DiagnosisCo...?? »
bodySite : CodeableConcept [0..*] « SNOMEDCTBodyStructures?? »
subject : Reference [1..1] « Patient|Group »
encounter : Reference [0..1] « Encounter »
onset[x] : Type [0..1] « dateTime|Age|Period|Range|string »
abatement[x] : Type [0..1] « dateTime|Age|Period|Range|string »
recordedDate : dateTime [0..1]
recorder : Reference [0..1] « Practitioner|PractitionerRole|Patient|
    RelatedPerson »
asserter : Reference [0..1] « Practitioner|PractitionerRole|Patient|
    RelatedPerson »
note : Annotation [0..*]

Stage

summary : CodeableConcept [0..1] « ConditionStage?? »
assessment : Reference [0..*] « ClinicalImpression|DiagnosticReport|
    Observation »
type : CodeableConcept [0..1] « ConditionStageType?? »

[0..*]
stage

[0..*]
evidence

Evidence

code : CodeableConcept [0..*] « ManifestationAndSymptomCodes?? »
detail : Reference [0..*] « Any »

DIFFERENT VIEWS

Structure | UML | XML | **JSON** | Turtle | R3 Diff | All

JSON Template

```
{
  "resourceType" : "Condition",
  // from Resource: id, meta, implicitRules, and language
  // from DomainResource: text, contained, extension, and modifierExtension
  "identifier" : [{ Identifier }], // External Ids for this condition
  "clinicalStatus" : { CodeableConcept }, // C? active | recurrence | relapse | inactive | remis
sion | resolved
  "verificationStatus" : { CodeableConcept }, // C? unconfirmed | provisional | differential | c
onfirmed | refuted | entered-in-error
  "category" : [{ CodeableConcept }], // problem-list-item | encounter-diagnosis
  "severity" : { CodeableConcept }, // Subjective severity of condition
  "code" : { CodeableConcept }, // Identification of the condition, problem or diagnosis
  "bodySite" : [{ CodeableConcept }], // Anatomical location, if relevant
  "subject" : { Reference(Patient|Group) }, // R!  Who has the condition?
  "encounter" : { Reference(Encounter) }, // Encounter created as part of
  // onset[x]: Estimated or actual date, date-time, or age. One of these 5:
  "onsetDateTime" : "<dateTime>",
  "onsetAge" : { Age },
  "onsetPeriod" : { Period },
  "onsetRange" : { Range },
  "onsetString" : "<string>",
  // abatement[x]: When in resolution/remission. One of these 5:
  "abatementDateTime" : "<dateTime>",
  "abatementAge" : { Age },
  "abatementPeriod" : { Period },
  "abatementRange" : { Range },
  "abatementString" : "<string>",
  "recordedDate" : "<dateTime>", // Date record was first recorded
  "recorder" : { Reference(Practitioner|PractitionerRole|Patient|
  RelatedPerson) }, // Who recorded the condition
  "asserter" : { Reference(Practitioner|PractitionerRole|Patient|
  RelatedPerson) }, // Person who asserts this condition
  "stage" : [{ // Stage/grade, usually assessed formally
    "summary" : { CodeableConcept }, // C? Simple summary (disease specific)
    "assessment" : [{ Reference(ClinicalImpression|DiagnosticReport|Observation) }], // C? Forma
l record of assessment
    "type" : { CodeableConcept } // Kind of staging
  }],
  "evidence" : [{ // Supporting evidence
    "code" : [{ CodeableConcept }], // C? Manifestation/symptom
    "detail" : [{ Reference(Any) }] // C? Supporting information found elsewhere
  }],
  "note" : [{ Annotation }] // Additional information about the Condition
```

sition.html#tabs-struc

```json
{
  "resourceType": "Condition",
  "id": "example2",
  "category": [
    {
      "coding": [
        {
          "system": "http://snomed.info/sct",
          "code": "439401001",
          "display": "diagnosis"
        }
      ]
    }
  ],
  "severity": {
    "coding": [
      {
        "system": "http://snomed.info/sct",
        "code": "6736007",
        "display": "Moderate"
      }
    ]
  },
  "code": {
    "coding": [
      {
        "system": "http://snomed.info/sct",
        "code": "368009",
        "display": "Heart valve disorder"
      }
    ]
  },
  "bodySite": [
    {
      "coding": [
        {
          "system": "http://snomed.info/sct",
          "code": "40768004",
          "display": "Left thorax"
        }
      ],
      "text": "heart structure"
    }
  ],
  "subject": {
    "reference": "Patient/f001",
    "display": "P. van de Heuvel"
  },
  "encounter": {
    "reference": "Encounter/f001"
  },
  "onsetDateTime": "2011-08-05",
  "recordedDate": "2011-10-05",
```

REST API

- REST = REpresentational State Transfer

- It is an architectural style used to build Web services that are lightweight, maintainable, and scalable in nature.

- A service which is built on the REST architecture is called a RESTful service.

- The underlying protocol for REST is usually HTTP, which is the basic web protocol. However, other protocols (SMTP etc) can be used.

Resources – Element that contains the information.

Request Verbs - Description of what you want to do with the resource.

- The basic request is GET (= retrieve data)
- POST (=create a new element)
- PUT (= update an existing element)
- DELETE (= delete an element)

Request Headers – Additional instructions sent with the request (type of response required, authorization details)

Request Body - Data is sent with the request (usually in a POST call

Response Body – This is the main body of the response (XML document, JSON)

Response Status codes –General codes which are returned along with the response from the web server. (200 = OK, 404 = NOT FOUND)

JSON

JSON = JAVASCRIPT OBJECT NOTATION
Format to represent data exchanged in the Internet based on the concept of
key = value

HTTP 200 OK

Response Headers

```
X-Powered-By: HAPI FHIR 4.2.0-SNAPSHOT REST Server
Content-Type: application/fhir+xml;charset=utf-8
X-Request-ID: vQJLqXpBkhlx8A7J
```

Response Body

```json
1    {
2        "resourceType": "Observation",
3        "id": "839",
4        "meta": {
5          "versionId": "1",
6          "lastUpdated": "2019-09-18T20:40:37.908+00:00",
7          "source": "#77d2e7673cdb260d"
8        },
9        "status": "final",
10       "code": {
11         "text": "urineVolumeDelta"
12       },
13       "subject": {
14         "reference": "Patient/829"
15       },
16       "effectivePeriod": {
17         "start": "2019-09-18T20:40:37+00:00",
18         "end": "2019-09-18T20:40:47+00:00"
19       },
20       "issued": "2019-09-18T20:40:37.653+00:00",
21       "valueQuantity": {
22         "value": 4.0,
23         "unit": "ml"
24       }
25   }
```

FHIR JSON EXAMPLE

```
"entry": [
  {
    "fullUrl": "http://gt-apps.hdap.gatech.edu/gt-fhir/fhir/Condition/364163",
    "resource": {
      "resourceType": "Condition",
      "id": "364163",
      "category": [
        {
          "coding": [
            {
              "system": "None",
              "code": "OMOP generated",
              "display": "Inpatient detail - 5th position"
            }
          ]
        }
      ],
      "code": {
        "coding": [
          {
            "system": "http://snomed.info/sct",
            "code": "269214009",
            "display": "Contusion of face, scalp and neck, excluding eye(s)"
          }
        ]
      },
      "subject": {
        "reference": "Patient/29610",
        "display": "CAITLYN BOHAC"
      },
      "context": {
        "reference": "Encounter/1346"
      },
      "onsetDateTime": "2149-04-22T00:00:00+00:00",
      "abatementDateTime": "2149-05-02T00:00:00+00:00"
    }
  }
```

RESOURCES EVOLVE IN TIME

LIST OF
RESOURCES FOR
THE DRAFT
STANDARD FOR
TRIAL USE (DSTU)

Alphabetical

A-D:

- AllergyIntolerance 1
- Appointment 1
- AppointmentResponse 1
- AuditEvent 2
- Basic 1
- Binary 1
- BodySite 0
- Bundle 2
- CarePlan 1
- Claim 0
- ClaimResponse 0
- ClinicalImpression 0
- Communication 1
- CommunicationRequest 1
- Composition 2
- ConceptMap 2
- Condition (aka Problem) 2
- Conformance 2
- Contract 0
- DetectedIssue 1
- Coverage 0
- DataElement 1
- Device 1

D-L:

- DeviceComponent 1
- DeviceMetric 1
- DeviceUseRequest 0
- DeviceUseStatement 0
- DiagnosticOrder 1
- DiagnosticReport 3
- DocumentManifest 1
- DocumentReference 2
- EligibilityRequest 0
- EligibilityResponse 0
- Encounter 1
- EnrollmentRequest 0
- EnrollmentResponse 0
- EpisodeOfCare 1
- ExplanationOfBenefit 0
- FamilyMemberHistory 1
- Flag 1
- Goal 1
- Group 1
- HealthcareService 1
- ImagingObjectSelection 1
- ImagingStudy 2
- Immunization 1

I-P:

- ImmunizationRecommendation 1
- ImplementationGuide 0
- List 1
- Location 1
- Media 1
- Medication 1
- MedicationAdministration 1
- MedicationDispense 1
- MedicationOrder 1
- MedicationStatement 1
- MessageHeader 2
- NamingSystem 1
- NutritionOrder 1
- Observation 3
- OperationDefinition 1
- OperationOutcome 2
- Order 0
- OrderResponse 0
- Organization 1
- Parameters 1
- Patient 3
- PaymentNotice 0
- PaymentReconciliation 0
- Person 1

P-Z:

- Practitioner 1
- Procedure 1
- ProcessRequest 0
- ProcessResponse 0
- ProcedureRequest 1
- Provenance 1
- Questionnaire 2
- QuestionnaireResponse 2
- ReferralRequest 1
- RelatedPerson 1
- RiskAssessment 0
- Schedule 1
- SearchParameter 1
- Slot 1
- Specimen 1
- StructureDefinition 2
- Subscription 1
- Substance 1
- SupplyRequest 0
- SupplyDelivery 0
- TestScript 0
- ValueSet 3
- VisionPrescription 0

RESOURCES EVOLVE IN TIME

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LIST OF
RESOURCES FOR R4
(FIRST
NORMATIVE)

A-D:

- Account 2
- ActivityDefinition 2
- AdverseEvent 0
- AllergyIntolerance 3
- Appointment 3
- AppointmentResponse 3
- AuditEvent 3
- Basic 1
- Binary [N]
- BiologicallyDerivedProduct 0
- BodyStructure 1
- Bundle [N]
- CapabilityStatement [N]
- CarePlan 2
- CareTeam 2
- CatalogEntry 0
- ChargeItem 0
- ChargeItemDefinition 0
- Claim 2
- ClaimResponse 2
- ClinicalImpression 0
- CodeSystem [N]
- Communication 2
- CommunicationRequest 2
- CompartmentDefinition 1
- Composition 2
- ConceptMap 3
- Condition (aka Problem) 3
- Consent 2
- Contract 1
- Coverage 2
- CoverageEligibilityRequest 2
- CoverageEligibilityResponse 2
- DetectedIssue 1
- Device 2

D-L:

- DeviceMetric 1
- DeviceRequest 1
- DeviceUseStatement 0
- DiagnosticReport 3
- DocumentManifest 2
- DocumentReference 3
- EffectEvidenceSynthesis 0
- Encounter 2
- Endpoint 2
- EnrollmentRequest 0
- EnrollmentResponse 0
- EpisodeOfCare 2
- EventDefinition 0
- Evidence 0
- EvidenceVariable 0
- ExampleScenario 0
- ExplanationOfBenefit 2
- FamilyMemberHistory 2
- Flag 1
- Goal 2
- GraphDefinition 1
- Group 1
- GuidanceResponse 2
- HealthcareService 2
- ImagingStudy 3
- Immunization 3
- ImmunizationEvaluation 0
- ImmunizationRecommendation 1
- ImplementationGuide 1
- InsurancePlan 0
- Invoice 0
- Library 2
- Linkage 0
- List 1
- Location 3

M-P:

- Measure 2
- MeasureReport 2
- Media 1
- Medication 3
- MedicationAdministration 2
- MedicationDispense 2
- MedicationKnowledge 0
- MedicationRequest 3
- MedicationStatement 3
- MedicinalProduct 0
- MedicinalProductAuthorization 0
- MedicinalProductContraindication 0
- MedicinalProductIndication 0
- MedicinalProductIngredient 0
- MedicinalProductInteraction 0
- MedicinalProductManufactured 0
- MedicinalProductPackaged 0
- MedicinalProductPharmaceutical 0
- MedicinalProductUndesirableEffect 0
- MessageDefinition 1
- MessageHeader 4
- MolecularSequence 1
- NamingSystem 1
- NutritionOrder 2
- Observation [N]
- ObservationDefinition 0
- OperationDefinition [N]
- OperationOutcome [N]
- Organization 3
- OrganizationAffiliation 0
- Parameters [N]
- Patient [N]
- PaymentNotice 2
- PaymentReconciliation 2
- Person 2

P-Z:

- PractitionerRole 2
- Procedure 3
- Provenance 3
- Questionnaire 3
- QuestionnaireResponse 3
- RelatedPerson 2
- RequestGroup 2
- ResearchDefinition 0
- ResearchElementDefinition 0
- ResearchStudy 1
- ResearchSubject 1
- RiskAssessment 1
- RiskEvidenceSynthesis 0
- Schedule 3
- SearchParameter 3
- ServiceRequest 2
- Slot 3
- Specimen 2
- SpecimenDefinition 0
- StructureDefinition [N]
- StructureMap 2
- Subscription 3
- Substance 2
- SubstancePolymer 0
- SubstanceProtein 0
- SubstanceReferenceInformation 0
- SubstanceSpecification 0
- SubstanceSourceMaterial 0
- SupplyDelivery 1
- SupplyRequest 1
- Task 2
- TerminologyCapabilities 0
- TestReport 0
- TestScript 2
- ValueSet [N]

FHIR SERVER

https://fhirtest.uhn.ca/home?encoding=null&pretty=true

CONFORMANCE STATEMENT

EXAMPLES

FHIR Resource	Allscripts	athenahealth	Cerner	Epic	Meditech
Patient	Read	Read, Write	Read, Write	Read, Write	Read
Provider	Read	Read	Read	Read	Read
Allergy	Read	Read	Read, Write	Read, Write	Read
Care Plan	Read	Read	Read	Read	Read
Condition	Read	Read	Read, Write	Read, Write	Read
Contract			Read		
Device	Read	Read	Read	Read	Read
Diagnostic Report	Read	Read	Read	Read	Read
Document	Read	Read	Read, Write	Read	Read
Encounter		Read	Read	Read	
Family history				Read	
Immunization	Read	Read	Read	Read	Read
Location				Read	
Medication	Read	Read	Read	Read	Read
Medication Order	Read	Read	Read	Read	Read
Observation	Read	Read	Read	Read, Write	Read
Person			Read		
Procedure	Read	Read	Read	Read	Read
ProcedureRequest			Read		
RelatedPerson			Read		
Schedule			Read, Write	Read, Write	

SMART ON FHIR

SMART

smarthealthit.org
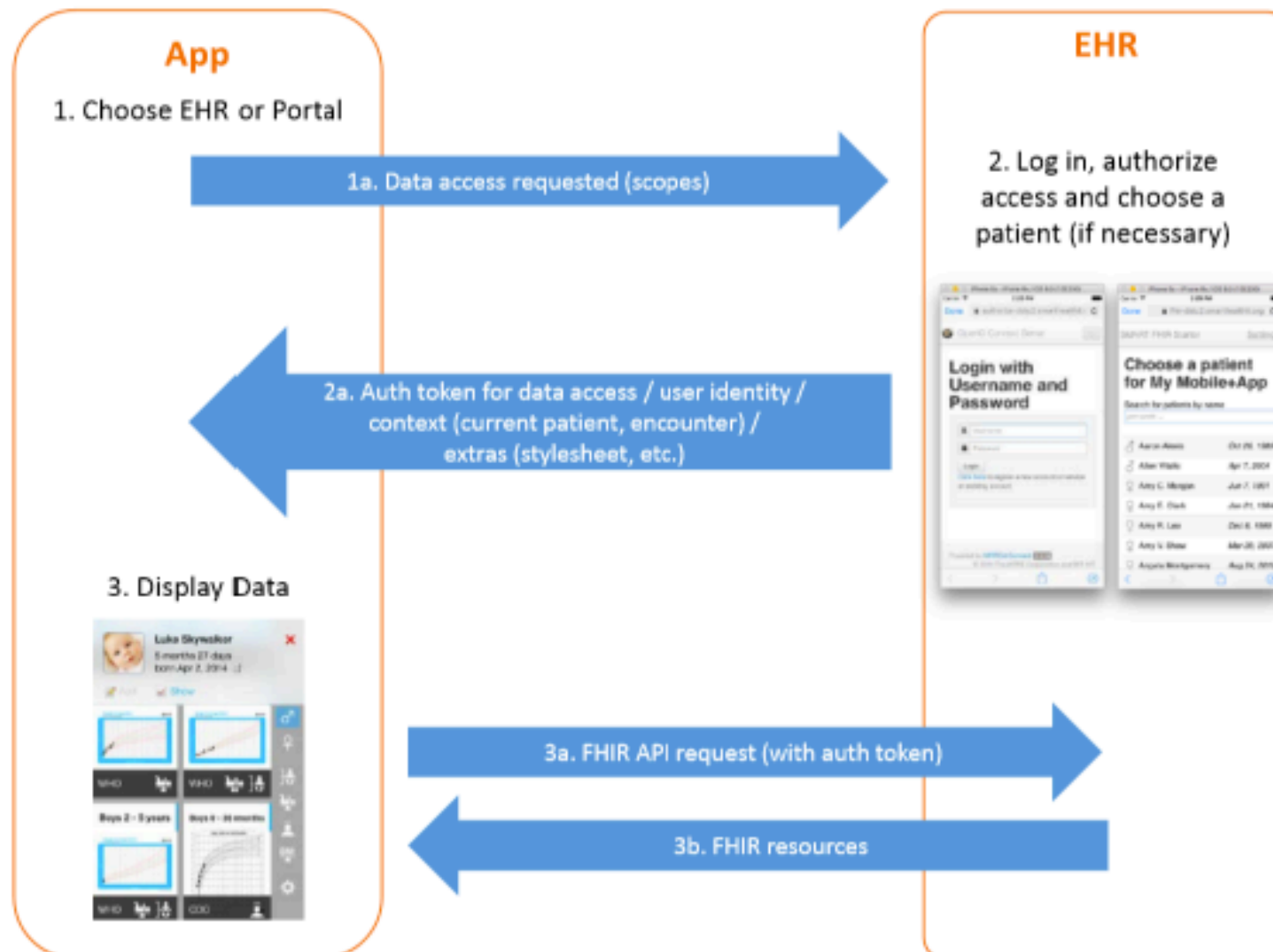
- Authentication framework between EHR and FHIR

- Allows the FHIR app to work without knowing the FHIR server

- When the patient's authentication is done, you can retrieve data without knowing the patient (works with the "current" patient) → smart.patient.api

```
// Search for the current patient's conditions
smart.patient.api.search({type: 'Condition'});

// Search for the current patient's prescriptions
smart.patient.api.search({type: 'MedicationOrder'});
```

- At the population level→ smart.api

```
// Search for conditions added today
var todaysDiagnoses = smart.api.search({type: 'Condition', query: {dateRecorded: '2014-05-01'}});

// Search for all statins prescribed today
var statinRxs = smart.api.search({type: 'MedicationOrder', query: {dateWritten: '2014-05-01', name: 'statin'}});
```

Integrating the Healthcare Enterprises

IHE International
Enable seamless and secure access to health information whenever and wherever needed.

Integrating the Healthcare Enterprise (IHE)

BECOME A MEMBER

IHE is **an initiative by healthcare professionals and industry** to improve the way computer systems in healthcare share information. IHE **promotes the coordinated use of established standards such as DICOM and HL7** to address specific clinical needs in support of optimal patient care**. Systems** developed in accordance with IHE **communicate with one another better**, are easier to implement, and enable care providers to use information more effectively.

IHE aims

- Born in 1998 in USA from *Radiological Society of North America* (RSNA) e *Healthcare Information and Management Systems Society* (HIMSS)

- IHE is not a communication standard → it has the aim to define how the available standards have to be used in practice to implement system integration:
    - To facilitate health information integration;
    - To provide support functionalities for EHRs;
    - To boost standard adoption;
    - To promote the communication aming vendors;
    - To improve efficacy and efficiency in clinical practice;
    - To improve ICT security and privacy;

- Interoperability → definition of an information exchange process known as **profile.**

IHE domains

IHE Domains

- Anatomic Pathology
- Cardiology
- Dental
- Eye Care
- IT Infrastructure
- Laboratory
- Patient Care Coordination
- Patient Care Devices
- Pharmacy
- Quality, Research and Public Health
- Radiation Oncology
- Radiology

- IHE is organized by clinical and operational domains.

- In each domain users with clinical and operational experience identify integration and information sharing priorities and vendors develop consensus, standards-based solutions to address them.

- Each domain includes a technical committee, whose primary task is developing and documenting the solutions (= integration profiles).

- Each domain includes a planning committee → long-term scope planning and organizing deployment activities.

- Each domain develops and maintains its own set of Technical Framework documents.

IHE profiles

- A **profile** is an abstract representation of the real world that defines the implementaion specifications of one or more "use cases":

- Communication processes

- Type of information exchanges

- Actions to be done when the information is received

- Each profile is characterized by:

- **ACTORS**: healthcare information systems that mange the communication activities (es. ADT, Order Placer, Order Filler, etc.);

- **TRANSITIONS**: standard-based information exchange among actors (ex. HL7). Each transaction is characterized by the refernce standard and other information.

- In each profile, a **table** lists the actors and the transactions of the specific case.

Example: the Laboratory Testing Workflow (LTW) overview
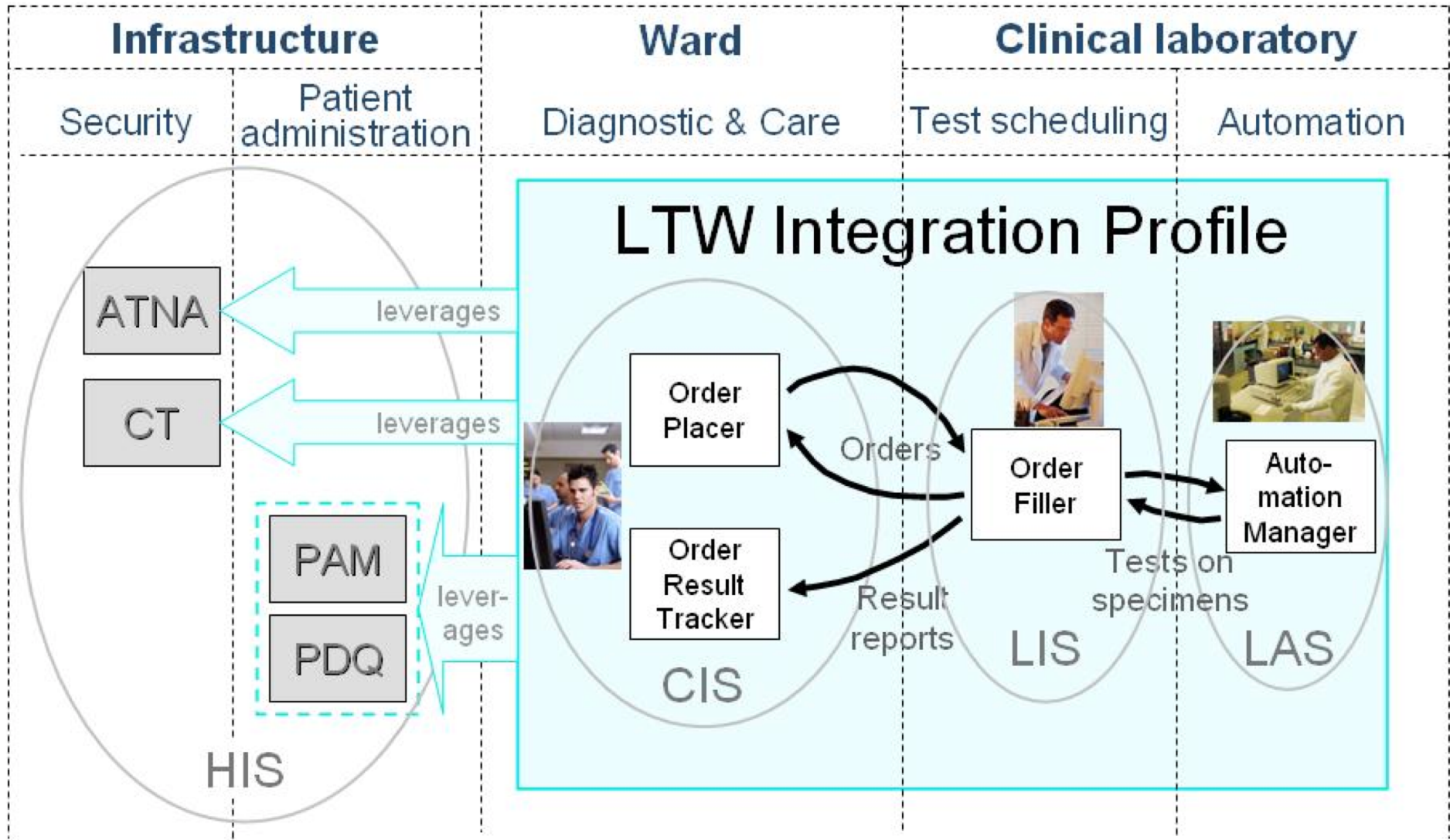
# Example: LTW actors and transactions
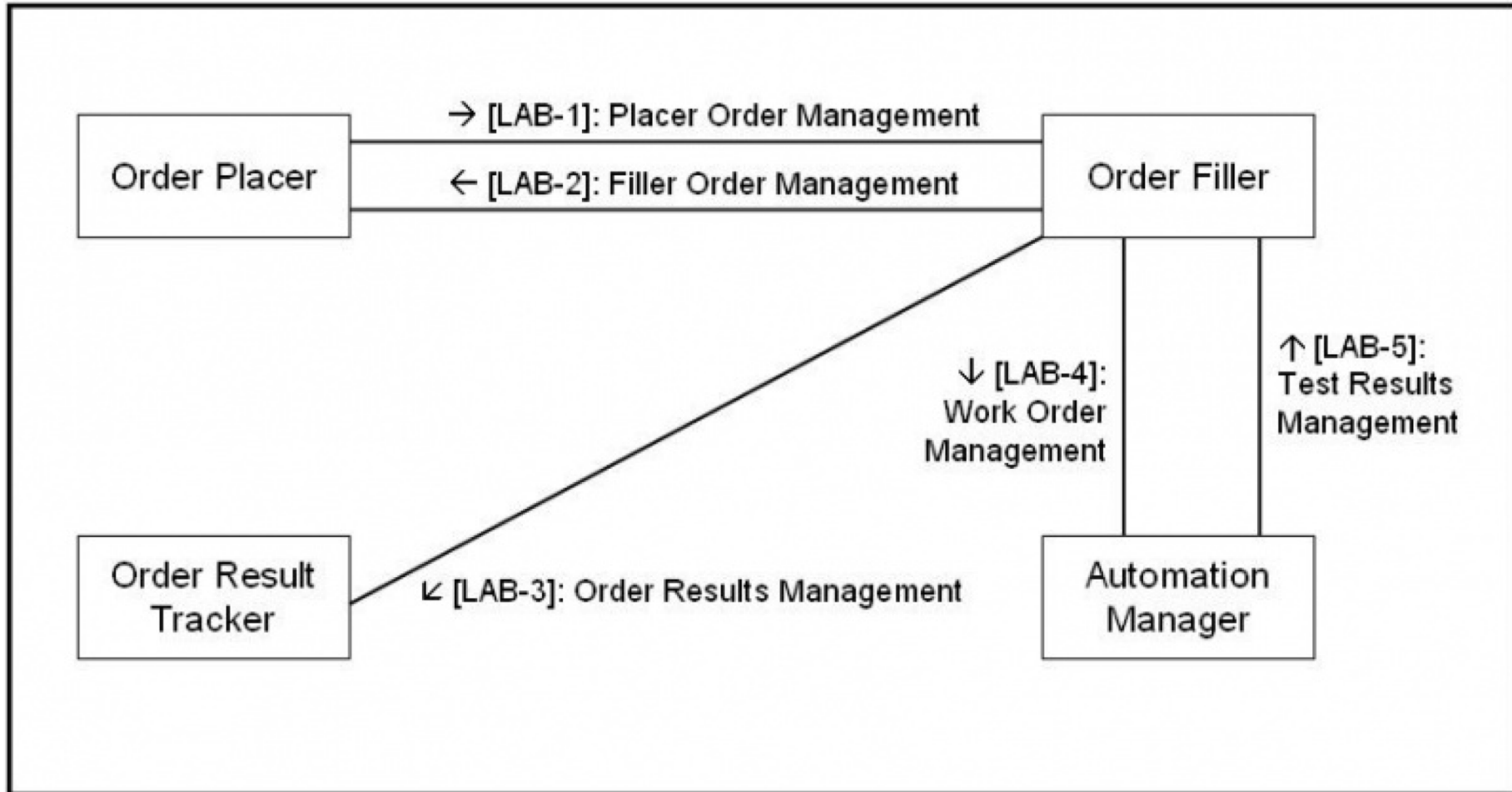
Example: LTW actors and transactions reference messages

Actors	Transactions	Optionality	Section in Vol. 2
Order Placer	Placer Order management [LAB-1]	R	LAB TF-2a: 3.1
	Filler Order Management [LAB-2]	R	LAB TF-2a: 3.2
Order Filler	Placer Order management [LAB-1]	R	LAB TF-2a: 3.1
	Filler Order Management [LAB-2]	R	LAB TF-2a: 3.2
	Order Results management [LAB-3]	R	LAB TF-2a: 3.3
	Work Order Management [LAB-4]	R	LAB TF-2a: 3.4
	Test Results Management [LAB-5]	R	LAB TF-2a: 3.5
Automation Manager	Work Order Management [LAB-4]	R	LAB TF-2a: 3.4
	Test Results Management [LAB-5]	R	LAB TF-2a: 3.5

Example: LTW process flow for placer ordering
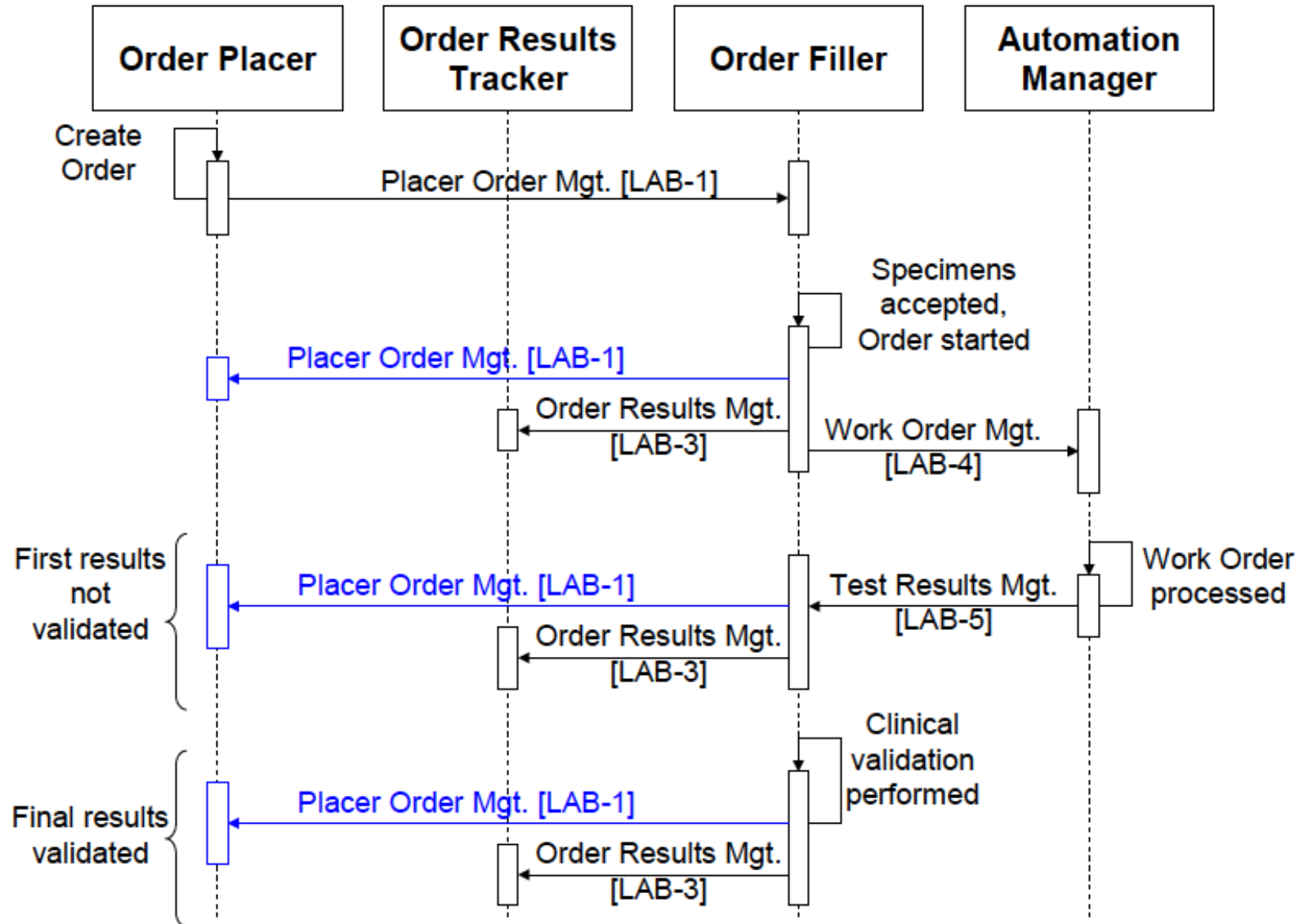
Example: OML^O21 message for the LAB-1 transaction in LTW

Table 3.1.5.3-1: OML^O21 static definition for transaction LAB-1

Segment	Meaning	Usage	Card.	HL7 chapter
MSH	Message Header	R	[1..1]	2
[	--- PATIENT begin	RE	[0..1]	
PID	Patient Identification	R	[1..1]	3
[PV1]	Patient Visit	RE	[0..1]	3
]	--- PATIENT end			
{	--- ORDER begin	R	[1..*]	
ORC	Common Order (for one battery)	R	[1..1]	4
[TQ1]	Timing Quantity	RE	[0..1]	4
	--- OBSERVATION REQUEST begin	R	[1..1]	
OBR	Observation Request	R	[1..1]	4
{[NTE]}	Notes and Comments	O	[0..*]	2
[{	--- OBSERVATION begin	O	[0..*]	
OBX	Observation Result	R	[1..1]	7
[{NTE}]	Comment of the result	C	[0..*]	2
}]	--- OBSERVATION end			
[{	--- SPECIMEN begin	O	[0..*]	
SPM	Specimen	R	[1..1]	7
[{SAC}]	Container	C	[0..*]	13
}]	--- SPECIMEN end			
[{	--- PRIOR_RESULT begin	O	[0..*]	
PV1	Patient Visit – previous result	R	[1..1]	3
{	--- ORDER_PRIOR begin	R	[1..*]	

Connectathon

Annual plenary session among all the vendors and clinical and operational experts that test the profile implementations to define the integration level