HL7 Testing

Andreas Hoffmann

Fraunhofer FOKUS
Competence Center for Modeling and Testing (MOTION)

Motivation

Telematic
technolog
important
healthcar

Health
are em

➢a range of s
of medicine/
➢consistent creation of healthcare services

ents
alization
systems
ing standards

HE, DICOM, etc.
t

Interoperability *is becoming* a concern

John Dalli, European Commissioner for Health and Consumer Policy:

The key issue for the progress in the eHealth domain is the lack of interoperability.

http://www.euractiv.de/soziales-europa/artikel/dalli-003826

eHealth Interoperability

Registration
Scheduling

Nurse

Interoperability check?

„The goal of the eHealth Lab at FOKUS is to address the challenges of interoperability testing of Healthcare Information Systems (HIS) by introducing a testing methodology and its realization framework based on TTCN-3 Test Language"

@Home

eHealth services and systems are ubiquitous

"eHealth paradigm shift"

Healthcare Information Systems (HIS)

"Data-intensive Systems"

- Complex
- Heterogeneous Architectures

tive Office

ealthcare Information Systems (HISs)

Patient

EHR

...

CPOE

...

ePrescriptio

Exchange Electronic Health Records (EHRs)

- Globalization
- Habitat Dynamics

Integration Profiles

IHE Continua HEALTH ALLIANCE HITSP

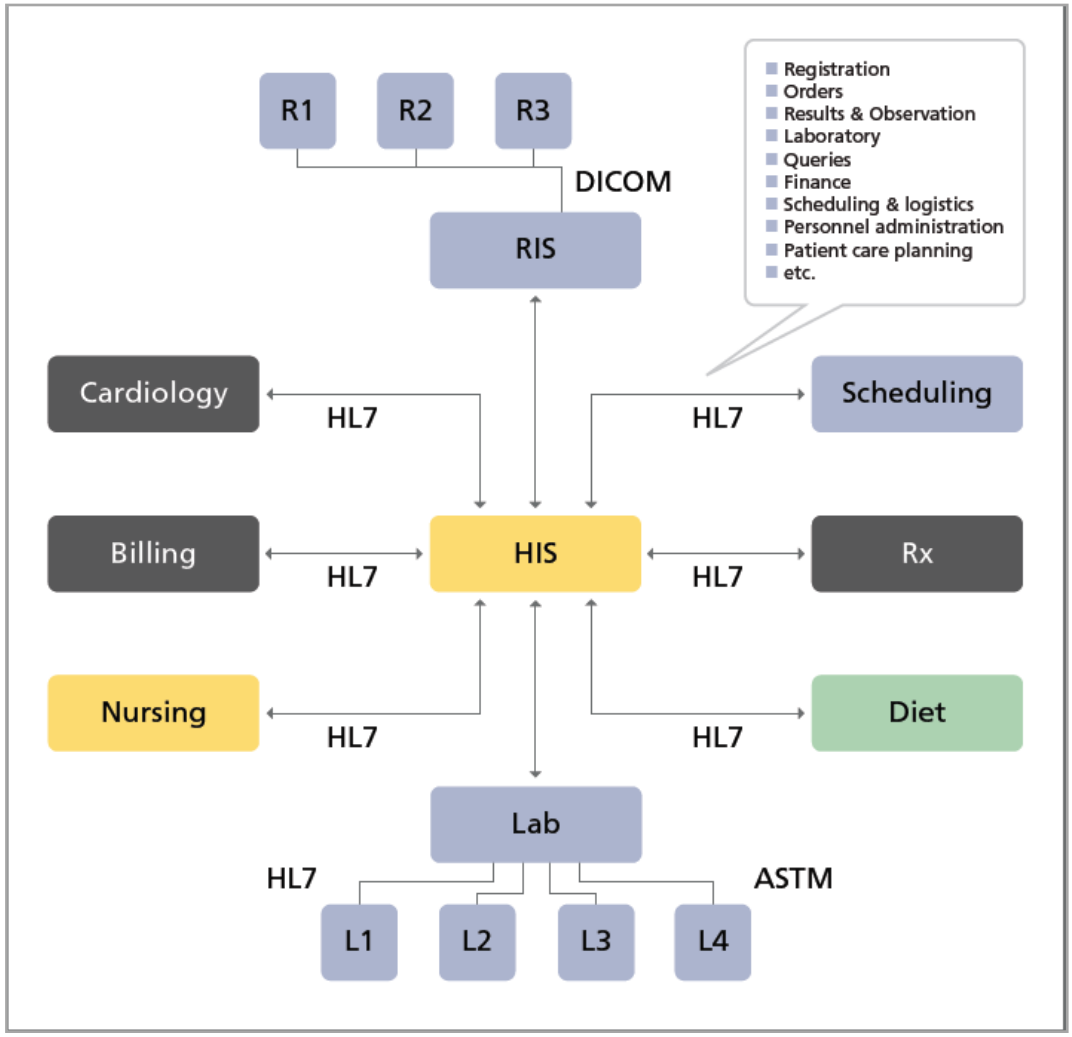
IEEE Advancing Technology for Humanity · ASC X12 The Accredited Standards Committee · LOINC® · ... · CDISC · HL7 TRANSITION · DICOM Digital Imaging and Communications in Medicine · CEN · OASIS · ASTM INTERNATIONAL Standards Worldwide

Large landscape of eHealth SDOs & Standards

sician

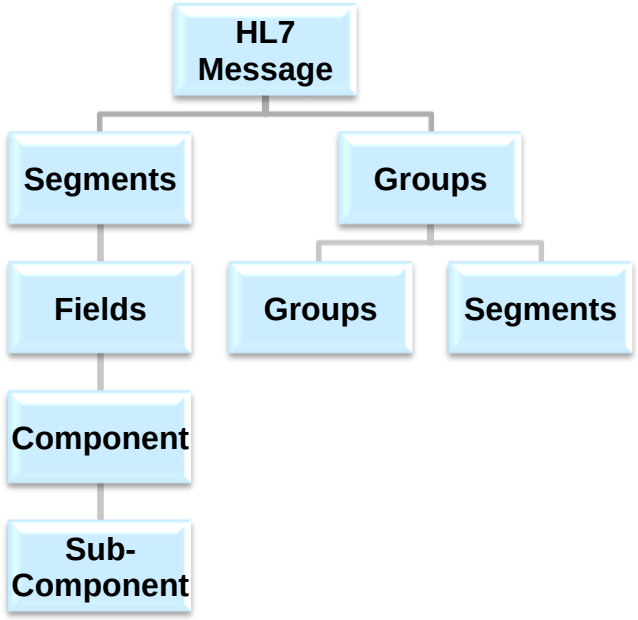
Interoperability (IOP) of HISs is a major concern!

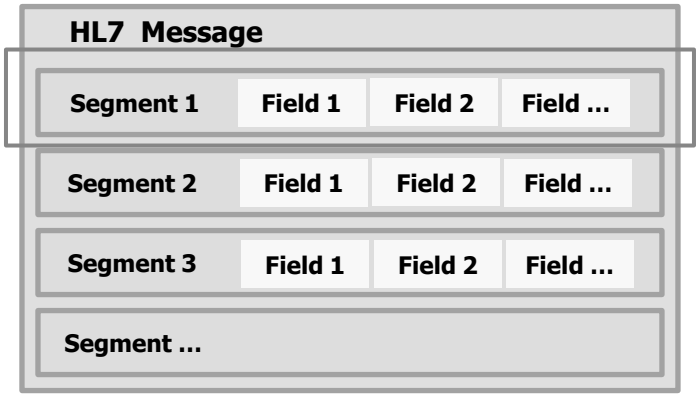
HL7 and HIS Integration

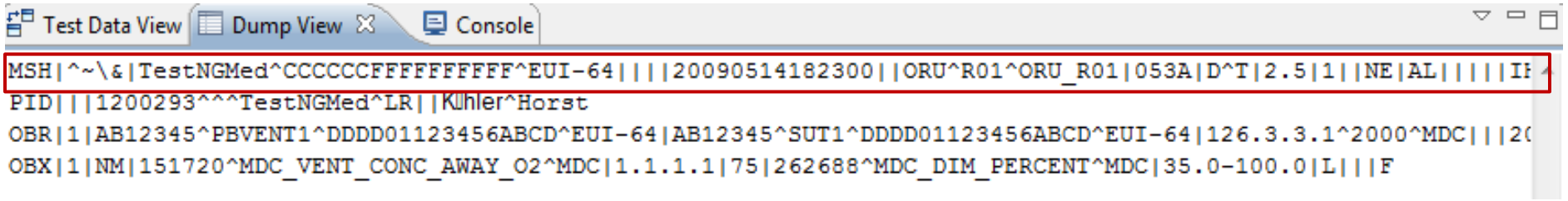


- **HL7 (Health Level Seven)** Messaging Standard (Application level)
- Standards for the exchange, management and integration of data for medical devices
  - Messages model real world events
  - e.g., Messages for registering a patient or requesting a lab order
- HL7 standard
- Organization: www.hl7.org
- HL7 Versions: v2.x, currently v3

HL7 Messaging Standard





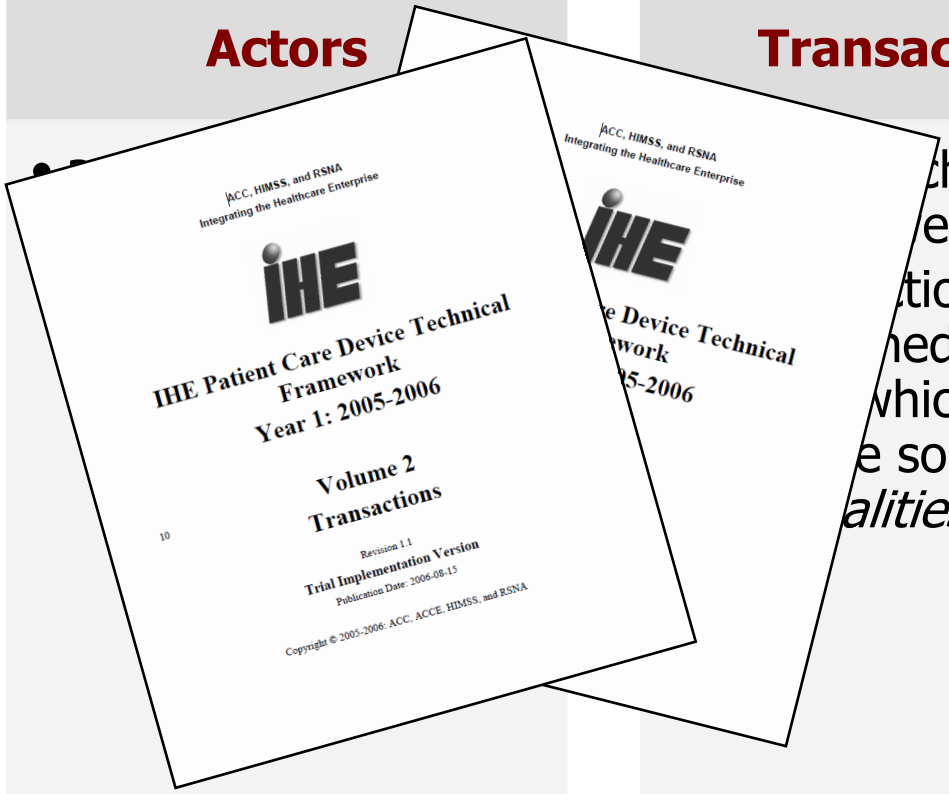


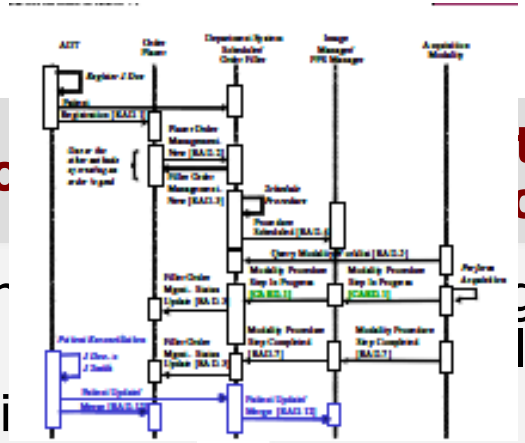
The IHE Technical Framework

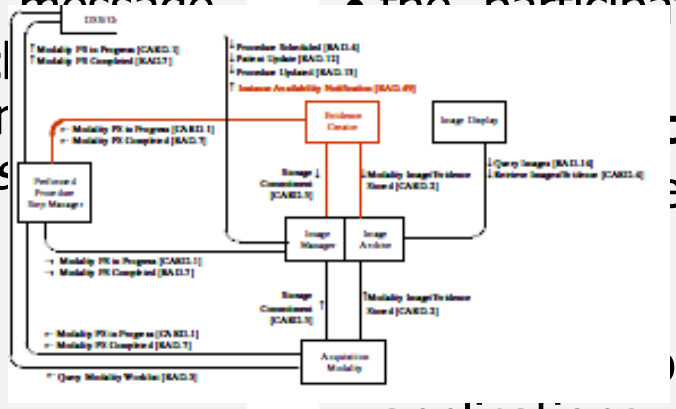
Actors

Transactic

tegration ofiles







gration
linical use

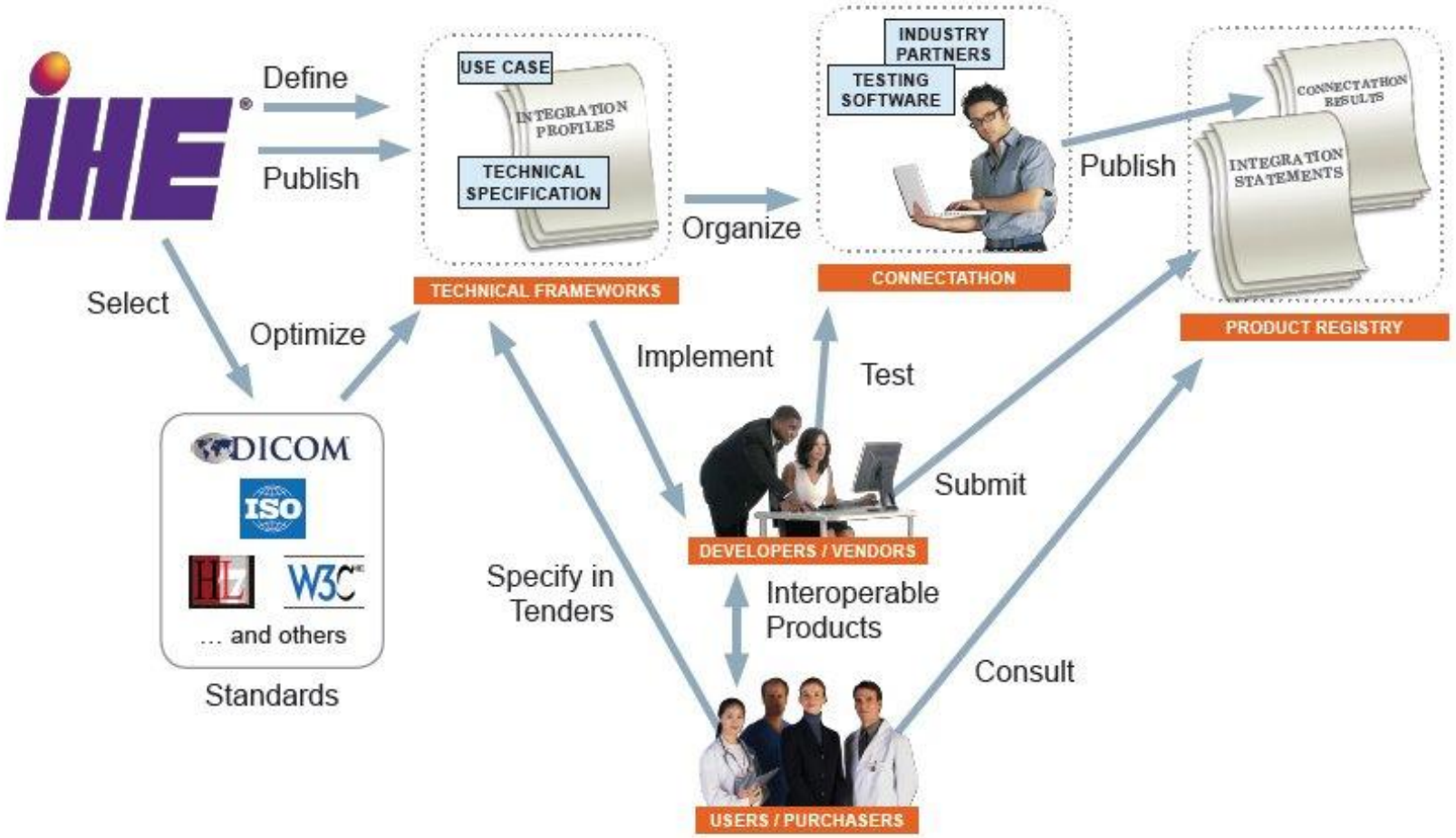
ting

tions
e of

y

applications

IHE Testing Process



Source: www.ihe.net

Approaches to Interoperability Testing (IOT)

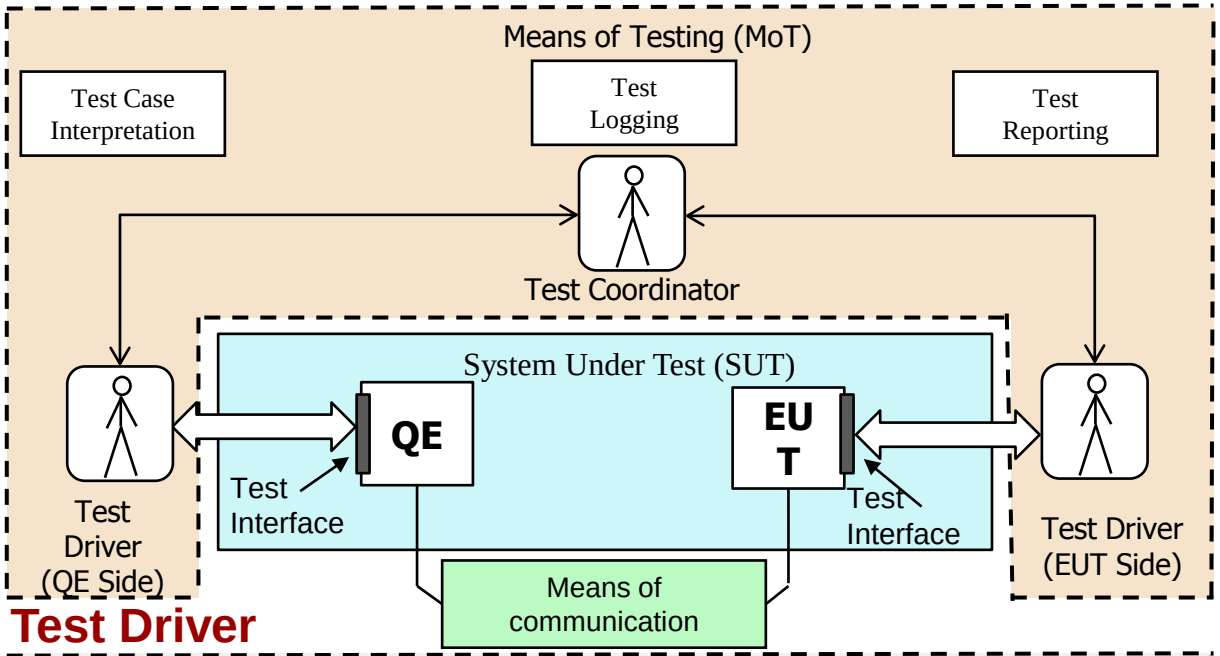
1. Test Driver - QE - SUT2 - Test Driver

→ *ETSI*

→*Generic Approach to Interoperability Testing (GAIT) v1.2.1* ***(2010)***

GAIT was defined for software interoperability testing, without focusing on a specific software domain.

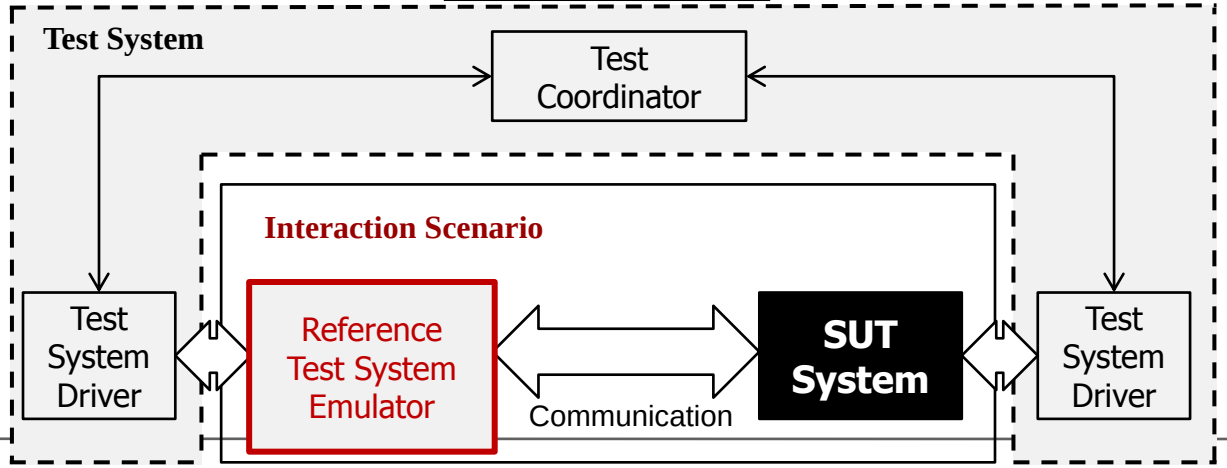
QE - Qualified Equipment



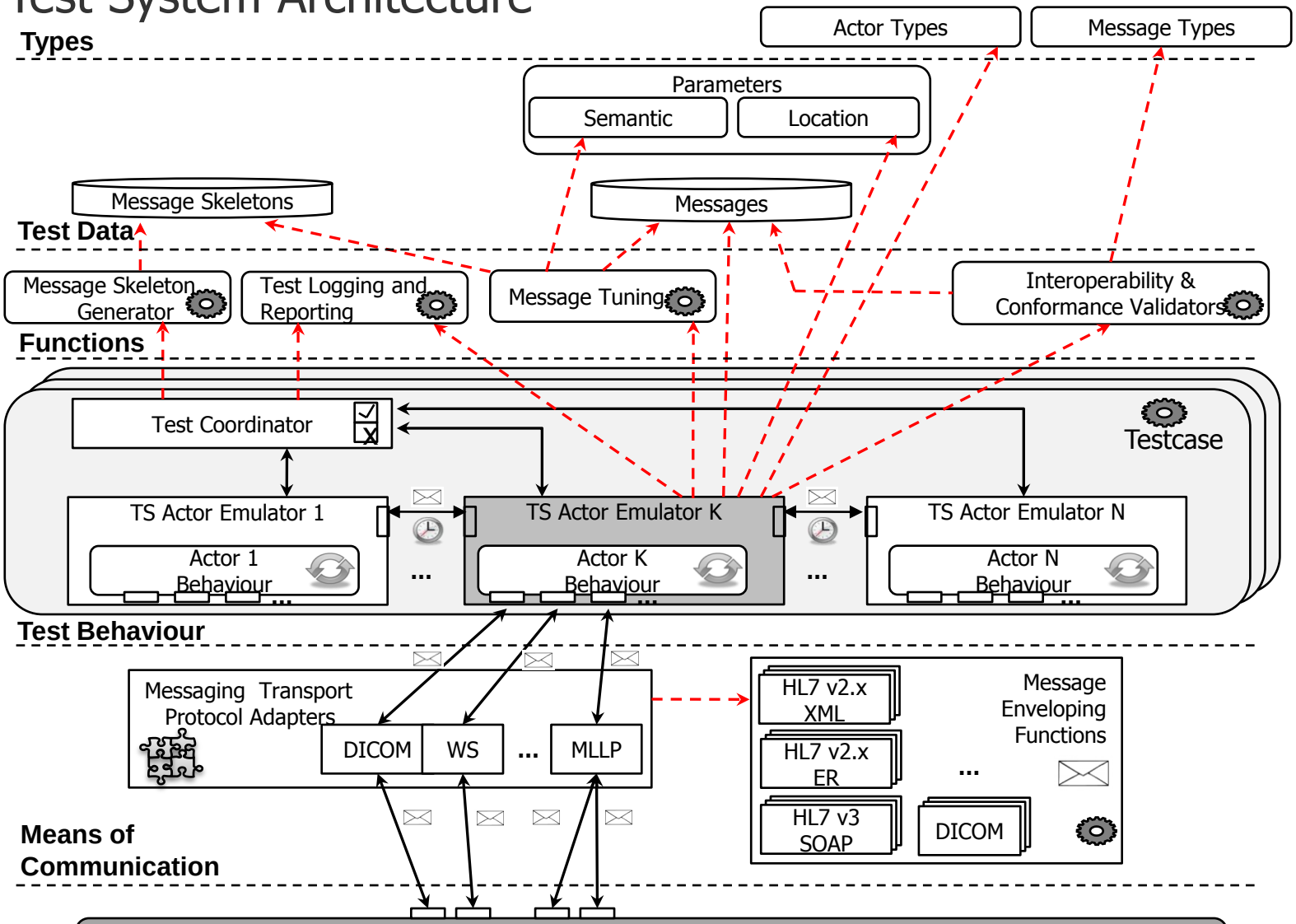
1. Test Driver - RTSE - SUT2 - Test Driver

→ this approach is adopted in eHealth Lab

IOT by using Reference Test System Emulator (RTSE) instead of QE **within interaction scenarios**

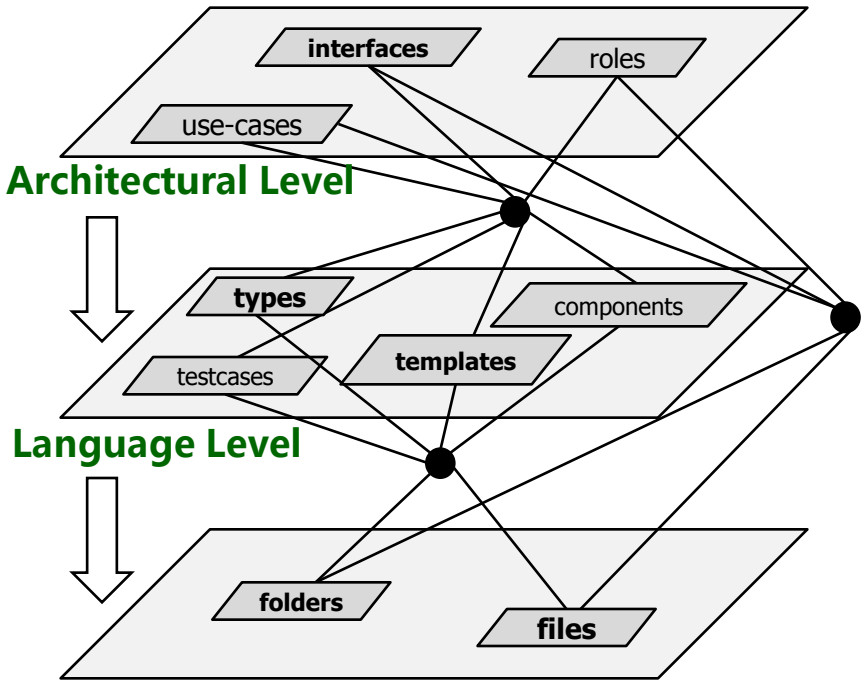


IOT Test System Architecture



Concepts for Semantic and Guidelines based Mapping

Concept of Guidelines for Test Specifications



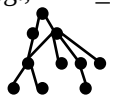
v2.x Specs

Semantic-based Mapping Rules

Functional Group

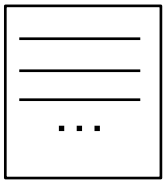
Record Types

Message Structures e.g., ADT_A01



ADT_A01_Message_Type

Tables/Codes



Types Restrictions

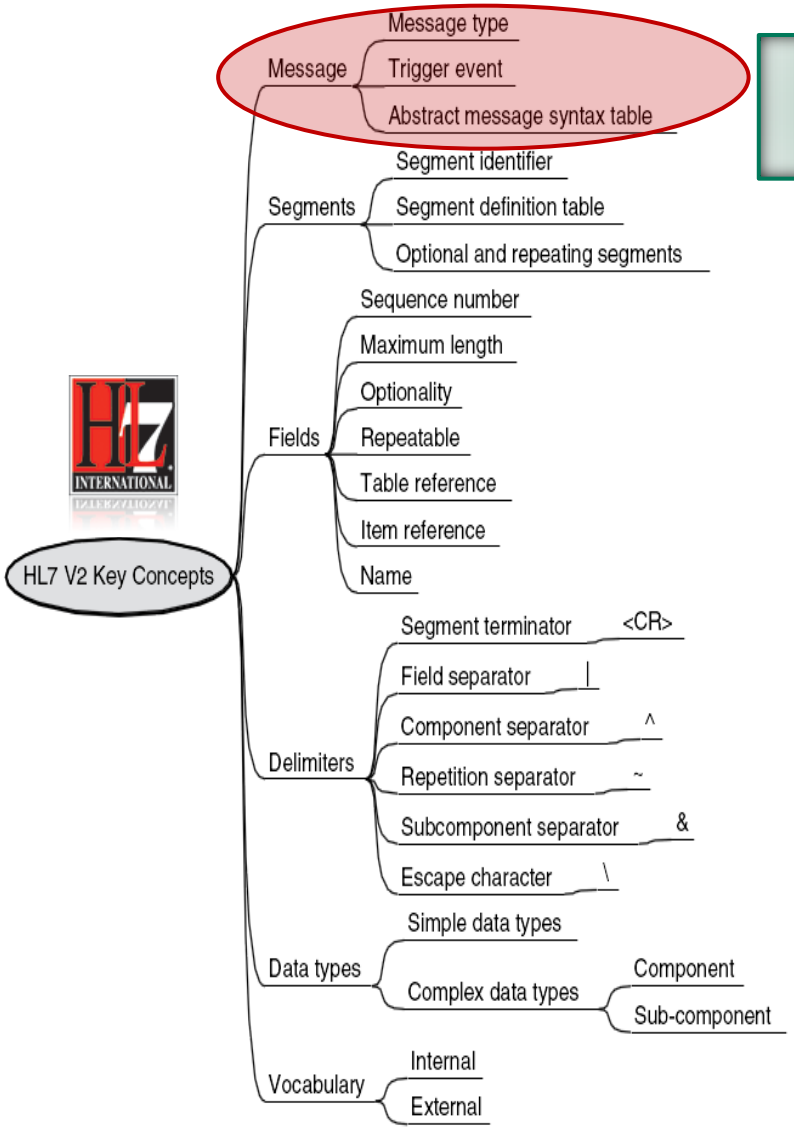
```
/*Table 0399: Country Code*/
type ID Country_Code_Table(
  "ALA", //AALAND ISLANDS
  "AFG", //AFGHANISTAN
  "ALB", //ALBANIA
  "DZA", //ALGERIA
  "ASM", //AMERICAN SAMOA
  "AND", //ANDORRA
  "AGO", //ANGOLA
  "AIA",  //ANGUILLA
  ...
);
```

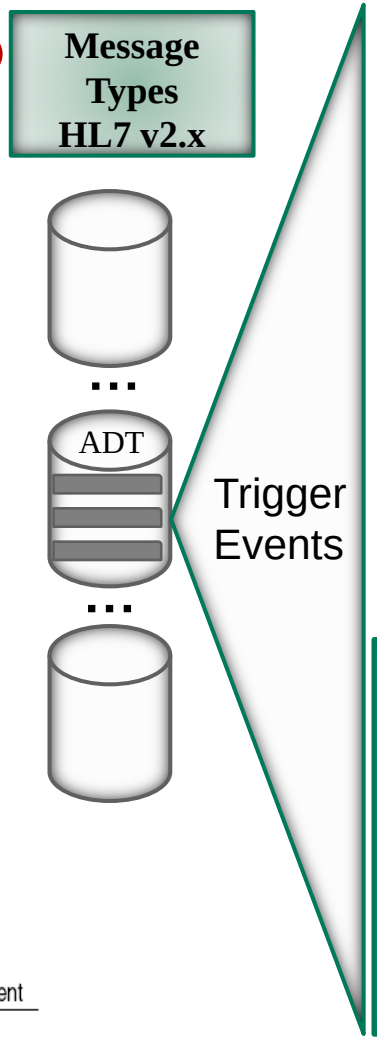
...

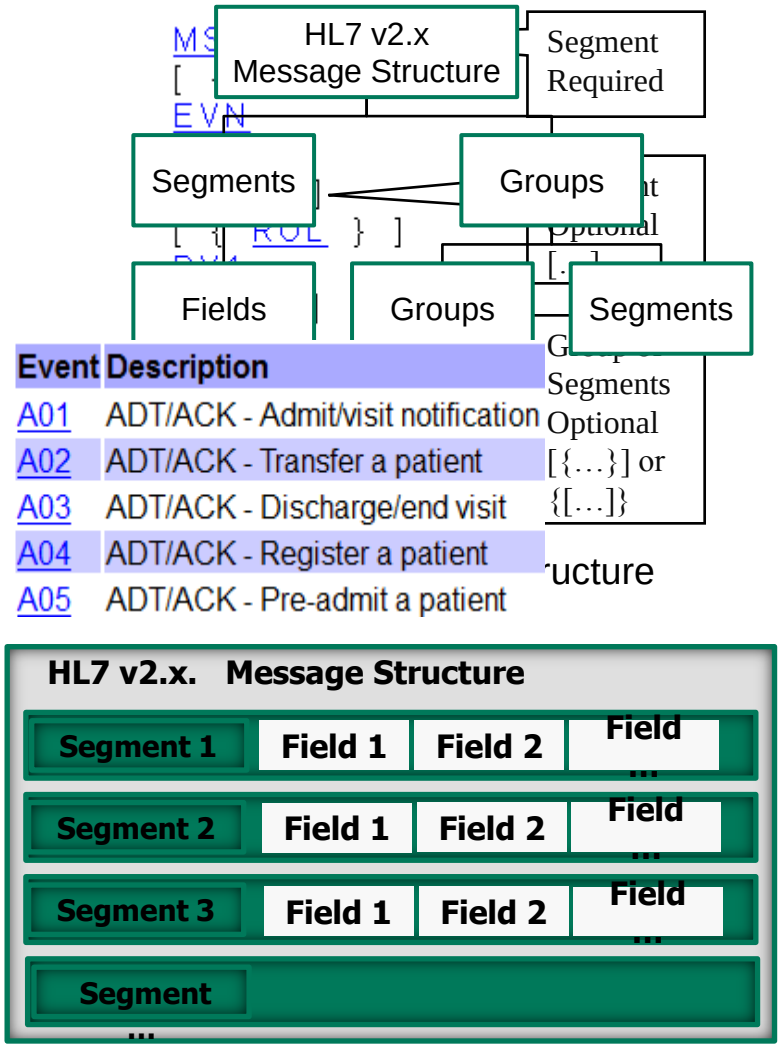
Rules for Pre/Post - fixing, Cardinality, Length Restrictions, ...

ADT_*_**Message_Type**
(*) --> Trigger Event
e.g.:
ADT_A01_Message_Type

TTCN 3 Testing & Test Control Notation **Type System**


HL7 V2 Key Concepts
Message
Message type
Trigger event
Abstract message syntax table
Segments
Segment identifier
Segment definition table
Optional and repeating segments
Fields
Sequence number
Maximum length
Optionality
Repeatable
Table reference
Item reference
Name
Delimiters
Segment terminator <CR>
Field separator |
Component separator ^
Repetition separator ~
Subcomponent separator &
Escape character \
Data types
Simple data types
Complex data types
Component
Sub-component
Vocabulary
Internal
External


Message Types HL7 v2.x
ADT
Trigger Events


HL7 v2.x Message Structure
Segment Required
Segments
Groups
Fields
Groups
Segments
Segments Optional [{…}] or {[…]}
Event Description
A01 ADT/ACK - Admit/visit notification
A02 ADT/ACK - Transfer a patient
A03 ADT/ACK - Discharge/end visit
A04 ADT/ACK - Register a patient
A05 ADT/ACK - Pre-admit a patient
HL7 v2.x. Message Structure
Segment 1
Field 1
Field 2
Field …
Segment 2
Field 1
Field 2
Field …
Segment 3
Field 1
Field 2
Field …
Segment …

ADT_A01 Message Structure in HL7 v2.5.1

```
MSH
[ { SFT } ]
EVN
PID
[ PD1 ]
[ { RO
[ { NK
PV1
[ PV2
[ { RO
[ { DB
[ { OB
[ { AL
[ { DG
[ DRG
[{
  PR1
  [ {
}]
[ { GT
[{
  IN1
  [ IN2
  [ {
  [ {
}]
[ ACC ]
[ UB1 ]
[ UB2 ]
[ PDA ]
```

ADT_A01 Message Type in TTCN-3

```
type record ADT_A01_M
{
};
```

```
type record MSH_Segment_Type
{
};
```

Example: HL7 v2.5.1 Messages in Numbers

122 Message Types

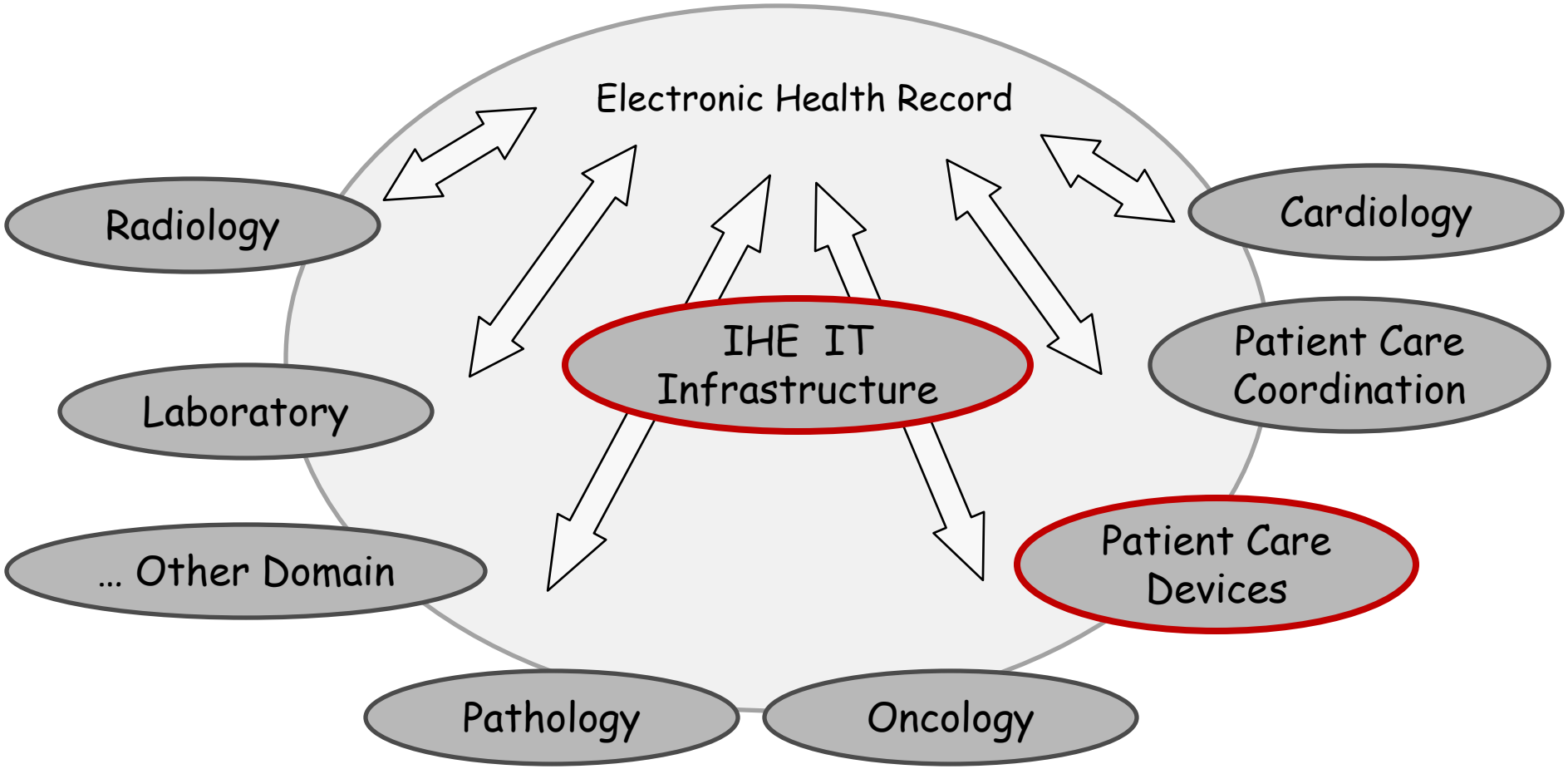
313 Trigger Events

153 Segment Types

189 Msg. Structures

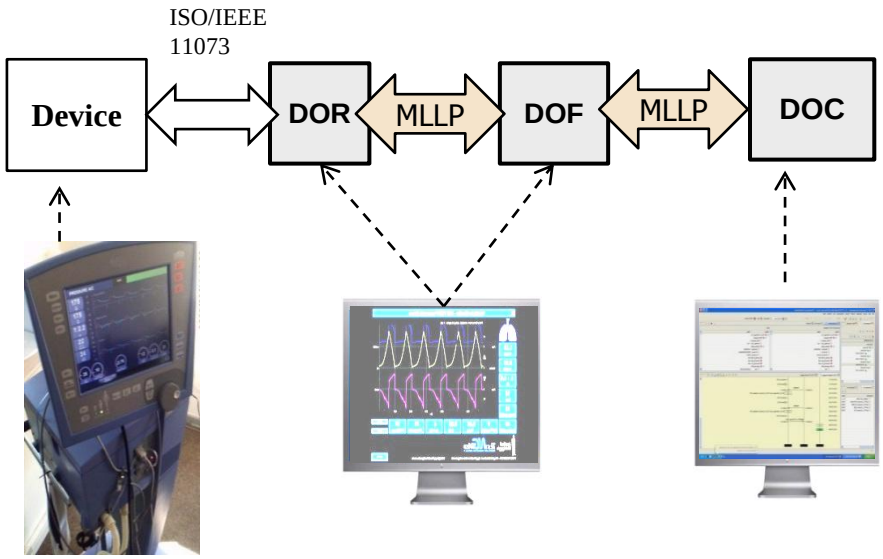
Msg. Structures	Description
ADR_A19	Patient Query
ADT_A01	Admit/Visit Notification
ADT_A02	Transfer a Patient
ADT_A03	Discharge/End Visit
ADT_A05	Pre-Admit a Patient
ADT_A06	Change an Outpatient to an Inpatient
ADT_A09	Patient Departing - Tracking
ADT_A12	Cancel Transfer
ADT_A15	Pending Transfer
ADT_A16	Pending Discharge
...	

Case Studies -- Integrating the Healthcare Enterprise (IHE) Integration Profiles



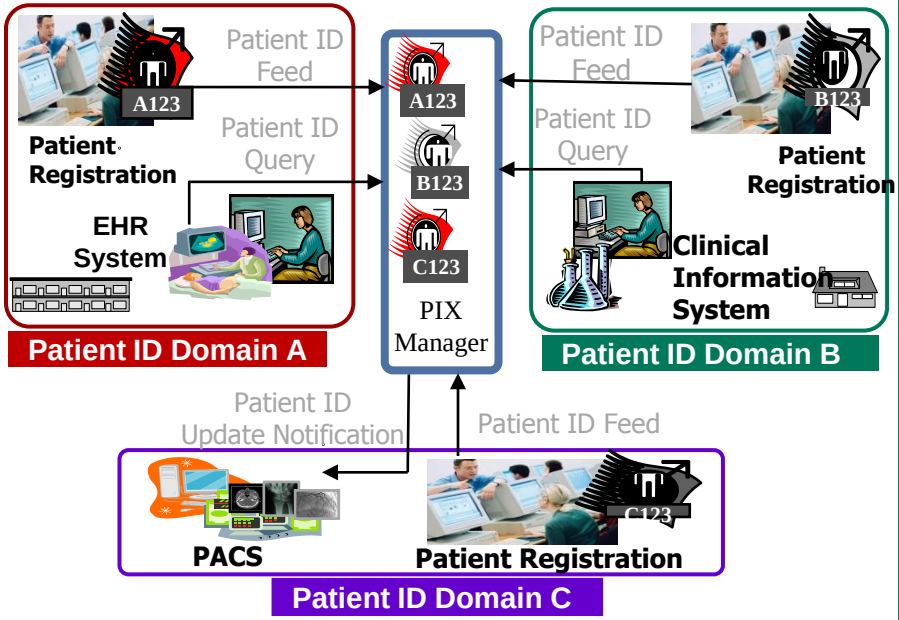
IHE Patient Care Device (PCD)
Device Enterprise Communication (DEC)

- **Research projects**
  - Goal: A test methodology (incl. IOT) based on TTCN-3 for automated testing of HL7 based medical systems



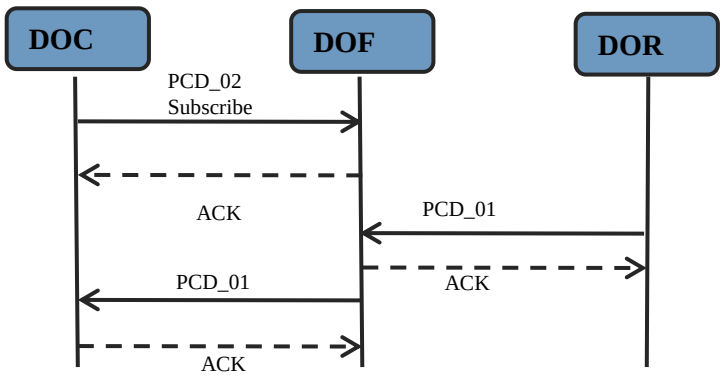
IHE IT Infrastructure (ITI)
Patient Identifier Cross-Referencing (PIX)

- **PIX and PDQ IOT Connectathon Test Suite**
  - Connectathon 2010, 2011, 2012, 2013
  - Fraunhofer FOKUS for ETSI
  - Goal: demonstrate the use of TTCN-3 technology for interoperability of HISs compliance with IHE profiles



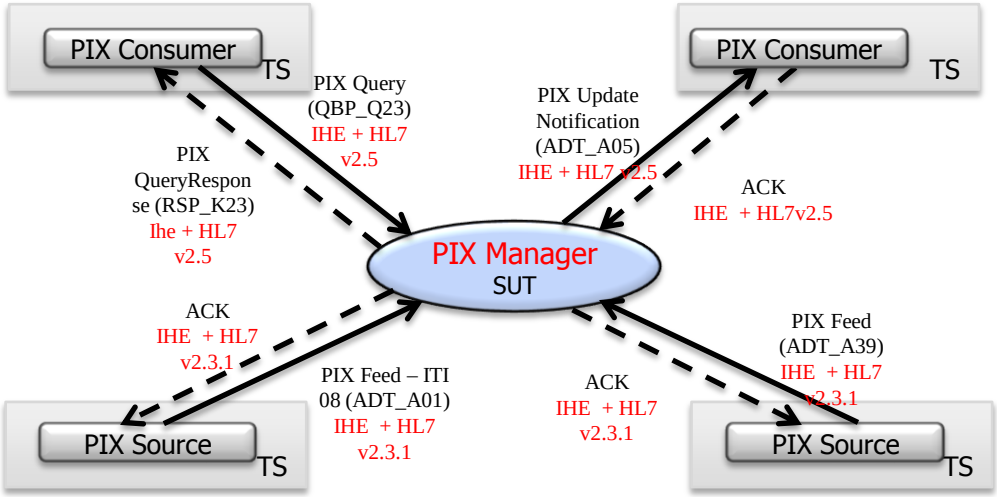
PCD and ITI Domains

Case Study 1: IHE PCD (Patient Care Device) Domain- DEC Profile



- Some examples of the tests:
  - Consumer subscription/unsubscription
  - Use of valid/invalid IDs
  - Consumer receives data
  - Validation of received data
  - Reported data sending frequency

Case Study 2: IHE ITI (IT Infrastructure) Domain – PIX Profile



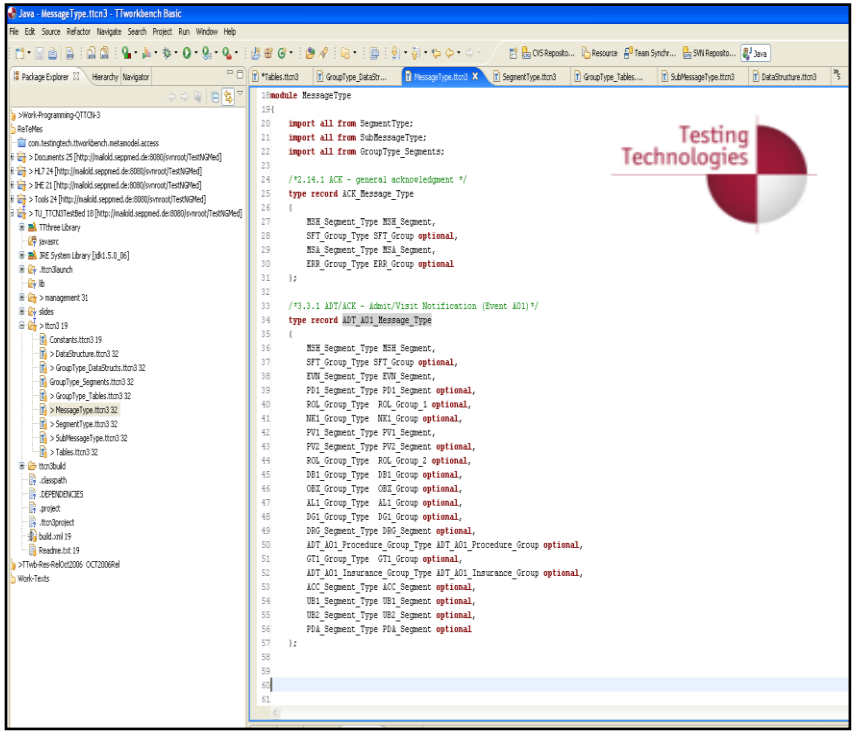
- Some examples of the tests:
  - Source patient registration/update/merge
  - Manager answers correctly to the Consumer Queries for patients
  - Use of valid/invalid patient IDs
  - Validation of received data ACK

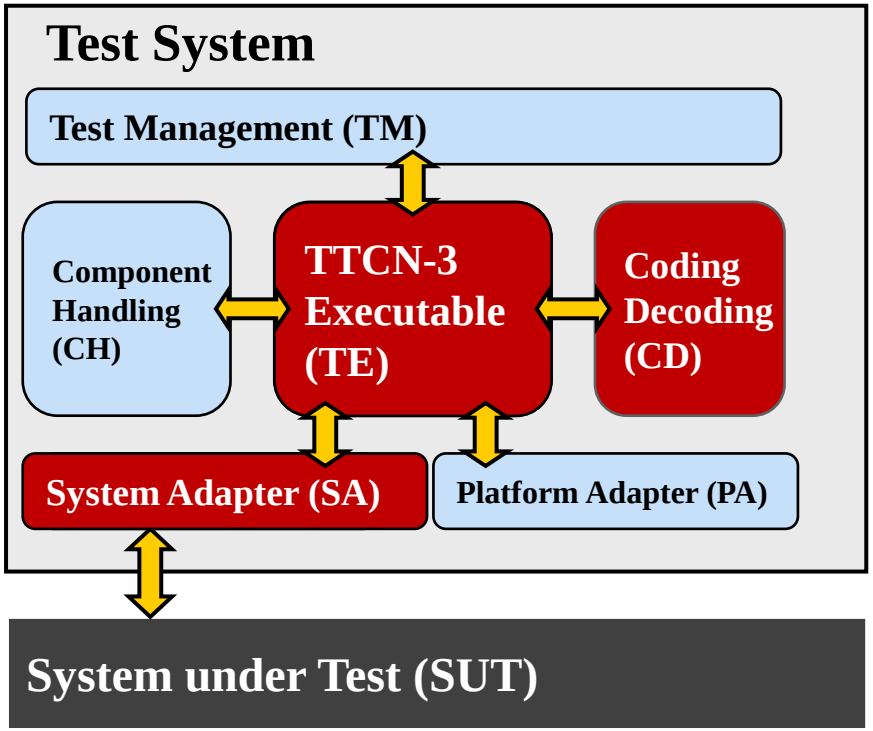
Types of Tests Related to Interoperability

- HL7 interface unit testing – testing that HL7 messages sent and/or received from a medical application conform to the HL7 interface specification
- HL7 interface integration testing – testing of business scenarios to ensure that information is able to flow correctly between medical applications
- HL7 system testing – end-to-end scenario testing focused on ensuring all relevant components of all relevant medical applications are able to interoperate correctly

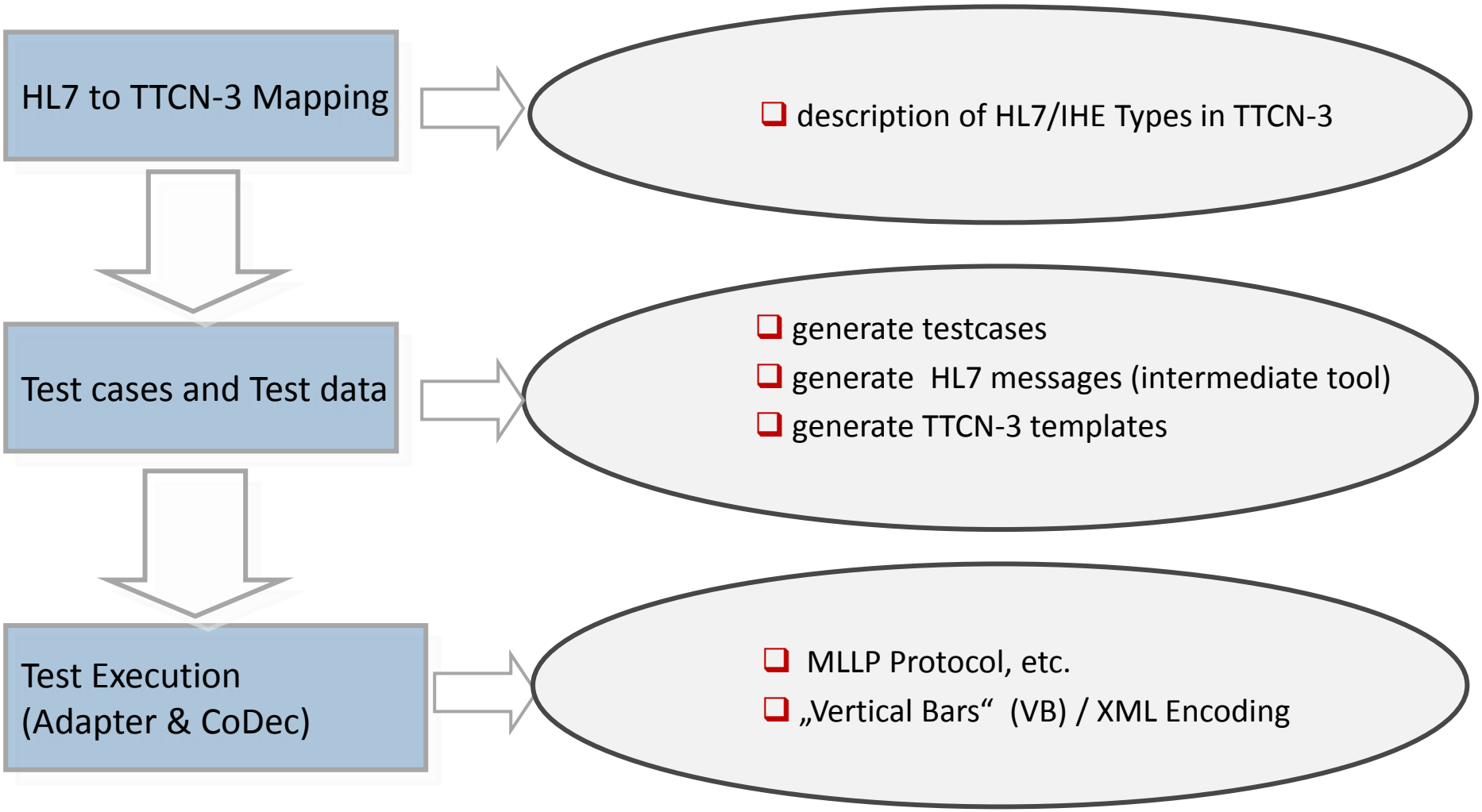
TTCN-3 - The Testing and Test Control Notation

- **ETSI: European Telecommunication Standardization Institute**
- Official web page: www.ttcn-3.org
- Standard: www.ttcn-3.org/StandardSuite.htm
- Tool: TTworkbench: www.testingtech.com/





Components of the TTCN-3 HL7 Test System



Example Mapping: TTCN-3 Message

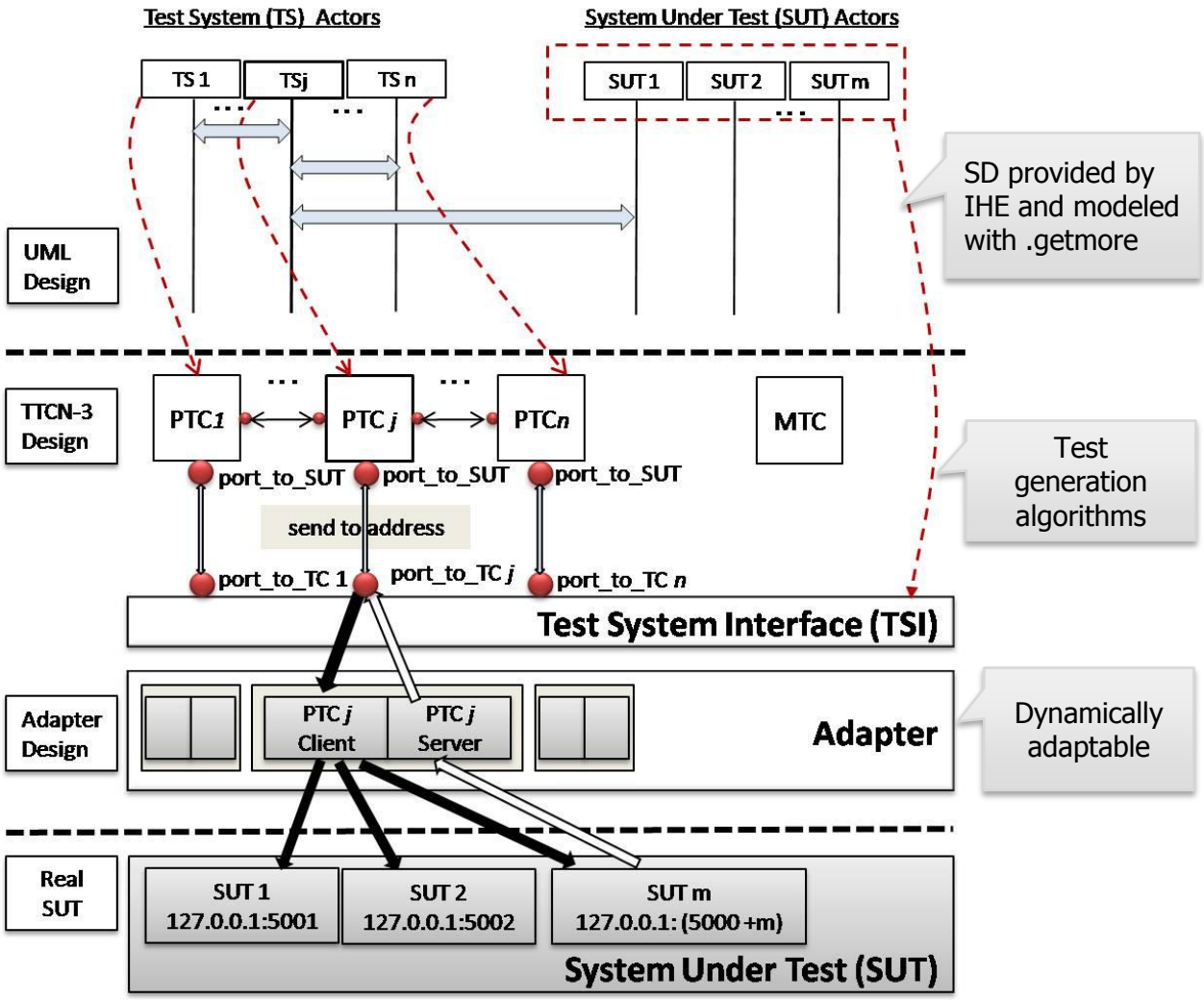
```
/*QSB^Z02^QSB^Q16*/
type record PCD_02_Message
{
  MSH_Segment_Type MSH_Seg
  QPD_Segment_Type QPD_Seg
  RCP_Segment_Type RCP_Seg
  DSC_Segment_Type DSC_Seg
};

type record QPD_Segment_Ty
  CE_HL70471  Message_Quer
  ST32 Query_Tag optional,
  CX_20Group_Type MRN opti
  Pharmacy_Order_Types_Tab
  PL_20Group_Type Patient_
  CE_6Group_Type Device_Cl
  CE_6Group_Type Parameter
  TS Start_Date_Time optio
  TS End_Date_Time optiona
  CQ Interval optional
};

  ...

type record length (1..20)
```

```
type record MSH_Segment_Type
{
 MSH_Segment_ID_Type MSH_
 ST1 Field_Separator,
 ST4 Encoding_Characters,
 HD Sending_Application optiona
 HD Sending_Facility optional,
 HD Receiving_Application optional,
 HD Receiving_Facility optional,
 TS TimeOfMessage,
 ST40 Security optional,
 MSG Message_Type,
 ST20 Message_Control_ID,
 PT  Processing_ID,
 VID Version_ID,
 NM Sequence_Number optional,
 ST180 Continuation_Pointer opti
 Acc_App_Acknowledgement_Ta
 Acc_App_Acknowledgement_Ta
 Country_Code_Table Country_C
 Character_Set_Group_Type Char
 CE Principal_Language_Of_Mes
 Character_Set_Handling_Scheme
 EI_Group_Type Message_Profile_
};
```

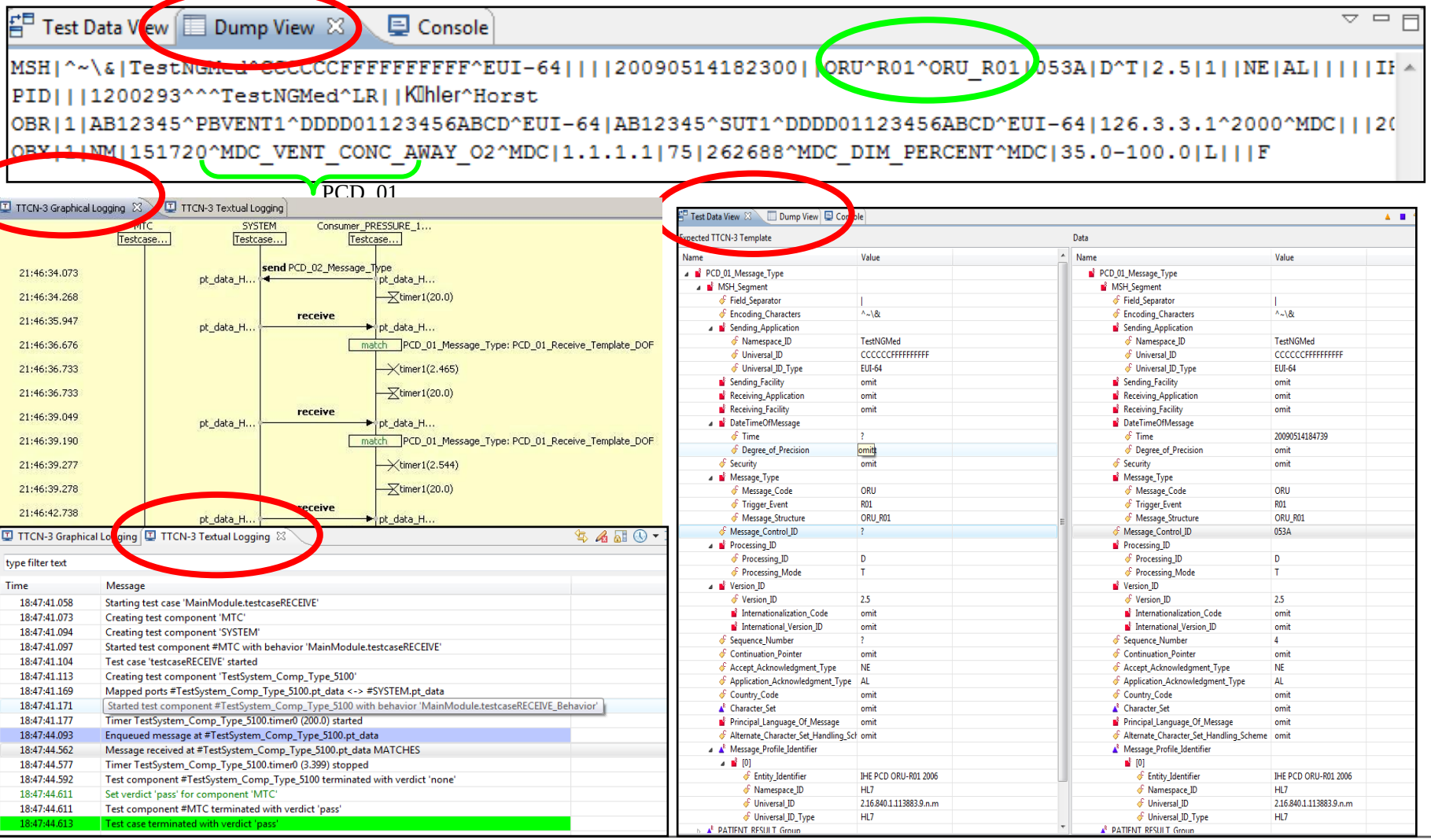
```
/*2.A.1.74 ST - string data -- LEN 40*/
type charstring ST40 length (0..40);
```

```
/*Table 0399: Country code*/
type ID Country_Code_Table(
"ALA", //AALAND ISLANDS   AX    248
"AFG", //AFGHANISTAN  AF    004
"ALB", //ALBANIA     AL    008
"DZA", //ALGERIA     DZ    012
"ASM", //AMERICAN SAMOA AS    016
"AND", //ANDORRA     AD    020
"AGO", //ANGOLA      AO    024
"AIA", //ANGUILLA    AI    660
...
);
```

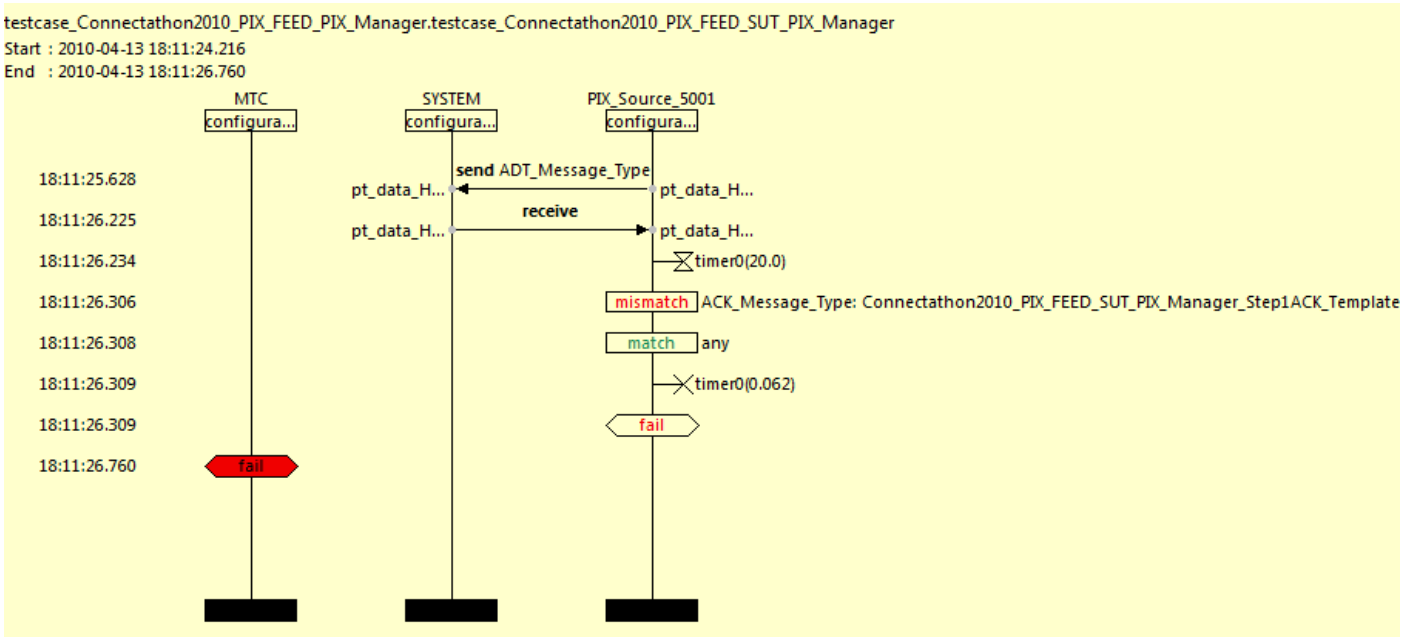

Test Behaviour Generation for Automated Execution



TTCN-3 Test Execution (with TTworkbench Tool)



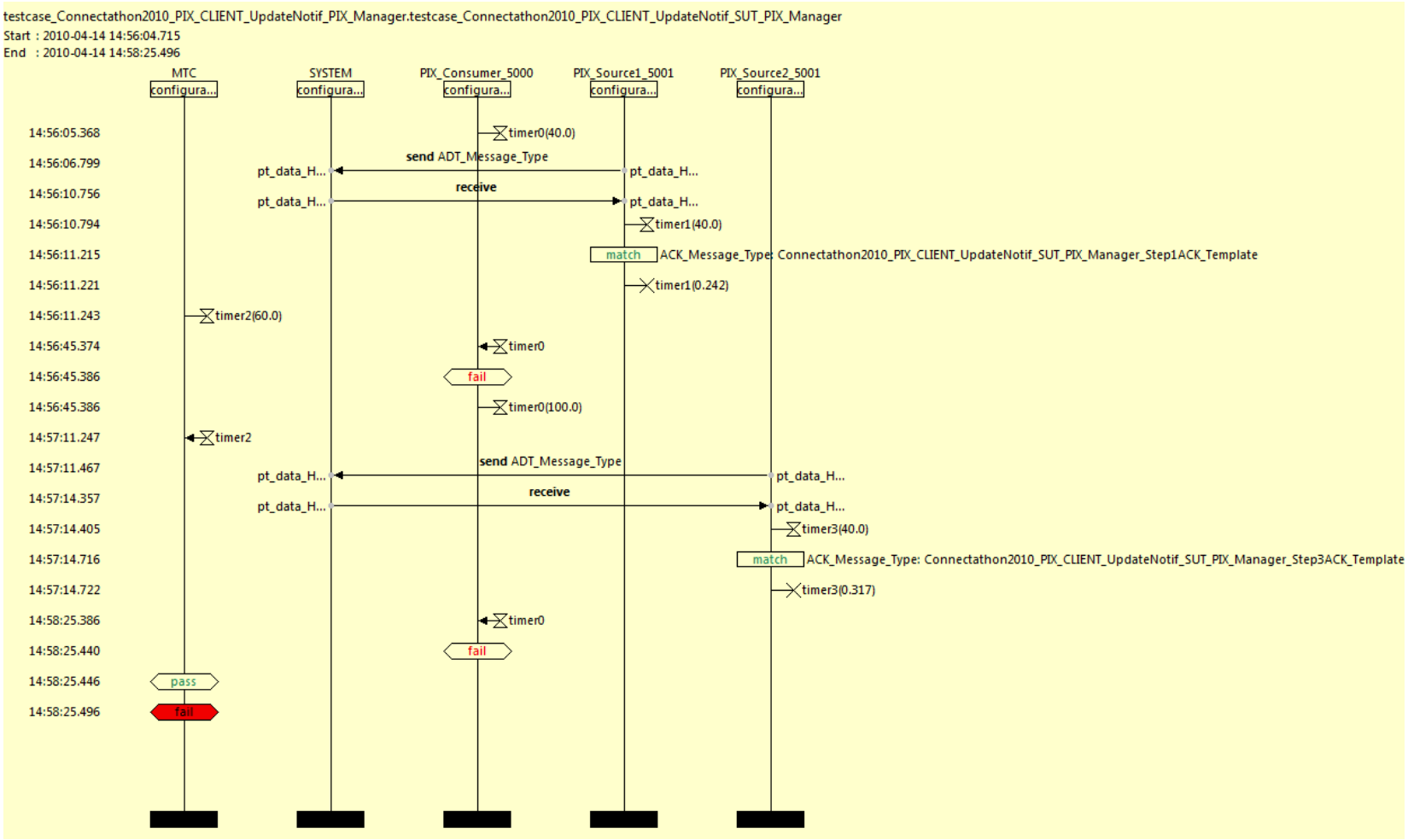
PIX_FEED Interaction Scenario - Run Example: ACK with Different Version




```
MSH|^~\&|OTHER_ETSI|ETSI|ETAH|ETAH|20100413061526||ADT^A04^ADT_A01|ETSI-5216076|P|2.3.1
EVN||20090224104145-0600
PID|||101^^^ETOT&1.3.6.1.4.1.21367.2010.2.1.419&ISO||FARNSWORTH^STEVE||19781208|M
PV1||O
```

```
MSH|^~\&|ETAH|ETAH|OTHER_ETSI|ETSI|20100413181536||ACK^A04|127117533649618||2.5
MSA|AA|ETSI-5216076
```

PIX_CLIENT_Upd_Notif_Option Interaction Scenario – Run Example: No Update Notifications



Summary: Conceptual Results

Mapping Concept	- *TTCN-3 test data types* derived from the HL7 messaging standard and IHE profiles across HL7 versions 2.x
TTCN-3 Templates Generation	- Mechanism for *generating TTCN-3 templates* out of specified types and existing data pools of HL7 messages
Test Configuration and Design Principles	- The design of test configurations enables: ❑communication with different SUTs by using *multiple protocols* ❑*emulation of different actors* from IHE profiles ❑possibility to adress symulteniously *multiple SUT components*
Multi-Adapter Concept	- to handle the communication over *multiple protocols* and to *dynamically adapt* to a particular test configuration, e.g. varing number of consumers in the PCD scenario

Summary: Technical Results

TTCN-3 Core Test Framework

- TTCN-3 test system framework for HL7 systems with an architecture targeting a higher degree of automation

TTCN-3 Test System For PCD and PIX IHE Profiles

- Implementation of *test systems for two IHE profiles* (case studies):
  PCD and ITI IHE profiles:
  - Type System
  - CoDec Layer
  - Adapter Layer

- Automated conformance check for messages
- Supports VB and XML HL7 Message Serialization
- Deals with different HL7 versions in the same interaction flow
- Emulates various /missing Actors
- Dynamicaly adapts to each given test configuration

Contact

Andreas Hoffmann
Fraunhofer Institute for Open Communication Systems

Kaiserin-Augusta-Allee 31
10589 Berlin, Germany

www.fokus.fraunhofer.de