Dynamically Generating Conformance Tests for Messaging Systems

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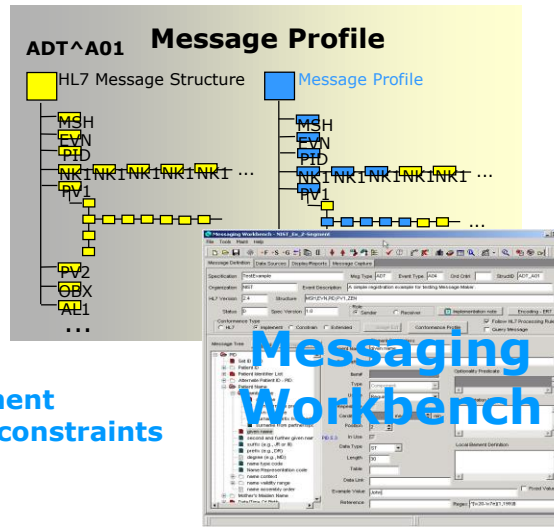rsnelick@nist.gov
http://www.nist.gov/messagemaker

HL7 and Conformance: The Big Picture

HL7 Standard

✓Universal design
✓Riddled with optionality
✓Implementation chaos
✓Interoperability difficult

ADT^A01 **Message Profile**

🟨 HL7 Message Structure   🟦 Message Profile

MSH
EVN
PID
NK1 NK1 NK1 NK1 NK1 …
PV1
…
PV2
OBX
AL1
…

✓Tools to build profiles
✓e.g., MWB (VA)
✓XML representation

✓Agreement
✓Define constraints

Messaging Workbench

```
<?xml version="1.0"?>
<HL7v2xConformanceProfile H
<MetaData Name="CALINX" Or
<Encodings>
<Encoding>ER7</Encoding>
</Encodings>
<DynamicDef AccAck="NE" Ap
<HL7MsgType="ADT"
EventType="A01"
<MetaData Name="CALINX" >
<Segment Name="MSH" LongN
<Field Name="Field Separator" Us
</Field>
<Field Name="Encoding Characters"
<Reference>2.16.9.2</Reference
</Field>
<Field Name="Sending Application"
```
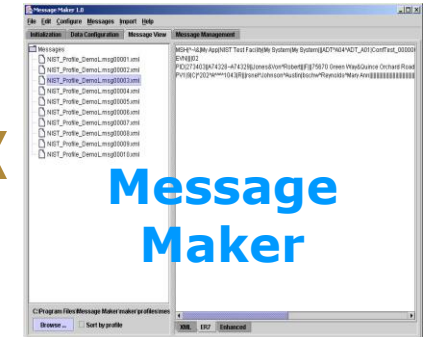
✓Need for test messages

Message Maker

✓Tools to build messages
✓Message Maker (NIST)
✓Automated and adaptable

Test System

HL7 System

Profile

Test Harness
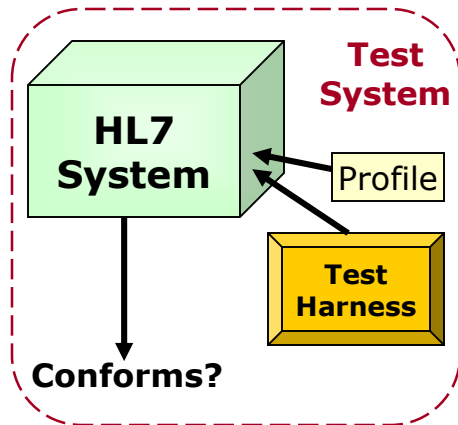
Conforms?

✓Conformance testing needed
✓Improves reliability and interoperability
✓Testing Framework

```
MSH|^~\&|REGA
EVN|A05|199901
PID|1||191919^
NK1|1|MASSIE^E
NK1|2|MASSIE^I
…
```

✓Profile based
✓Suite of test messages
✓Suitable for conformance testing

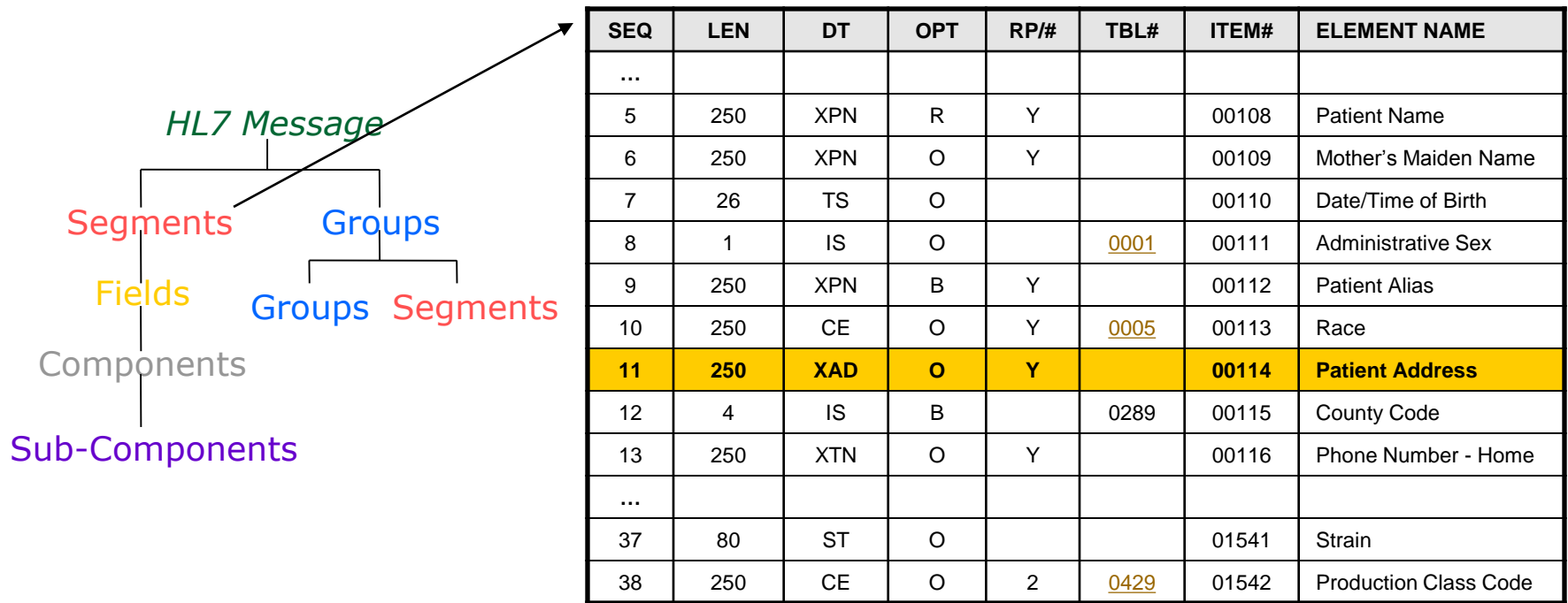# HL7 and Healthcare Integration
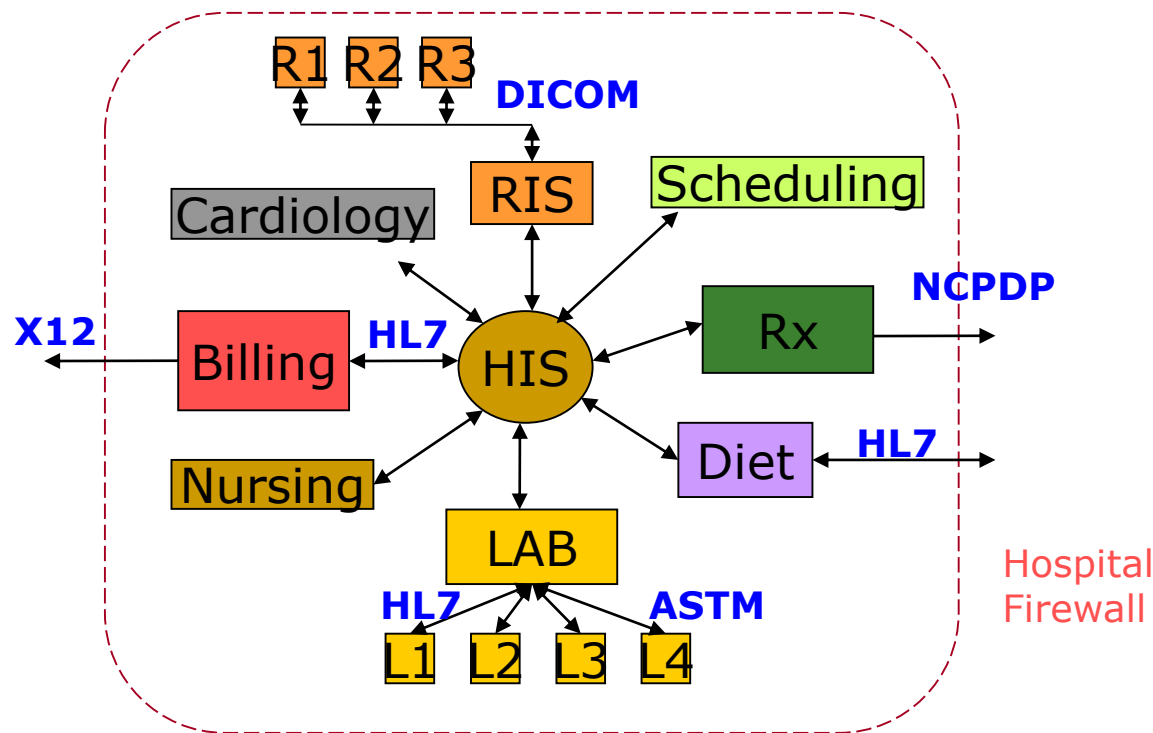
- HL7 (Health Level Seven) Messaging Standard (Application level)
- Standards for the exchange, management, and integration of data for clinical care
  - Messages model real world events
  - e.g., Messages for registering a patient or requesting a lab order
- HL7 provides a flexible framework to build messages
- Widely used; 90% of hospitals

The Problem: Too Flexible

- Overwhelmingly large with many optional features
- Little agreement on how to define an interface
- Applications didn't know what to expect
- No two interfaces were alike

Example: PID Segment

HL7 Message

Segments Groups

Fields

Groups Segments

Components

Sub-Components

SEQ	LEN	DT	OPT	RP/#	TBL#	ITEM#	ELEMENT NAME
...							
5	250	XPN	R	Y		00108	Patient Name
6	250	XPN	O	Y		00109	Mother's Maiden Name
7	26	TS	O			00110	Date/Time of Birth
8	1	IS	O		0001	00111	Administrative Sex
9	250	XPN	B	Y		00112	Patient Alias
10	250	CE	O	Y	0005	00113	Race
11	**250**	**XAD**	**O**	**Y**		**00114**	**Patient Address**
12	4	IS	B		0289	00115	County Code
13	250	XTN	O	Y		00116	Phone Number - Home
...							
37	80	ST	O			01541	Strain
38	250	CE	O	2	0429	01542	Production Class Code

The Solution: Message Profiles

- Refinement of the HL7 Standard (Eliminates Optional Items)
- Agreement between Trading Partners
- Represented as an XML document (HL7 defined schema)
- Tools to build message profiles

Building a Message Profile

ADT^A01

HL7 Message Structure → **Message Profile**

MSH
EVN
PID
NK1 — NK1 — NK1 — NK1 — NK1 — …
PV1

…

PV2
OBX
AL1
…

MSH
EVN
PID
NK1 — NK1 — NK1 — NK1 — NK1 — …
PV1

…

PV2
OBX
AL1
…

Segments/Segment Groups:
Usage (optionality)
Cardinality (min, max)

Fields/Components:
- Field Usage (Optinality: R, RE, C, CE, X)
- Cardinality (min, max)
- Value Sets/Coding system
- Descriptions
- Length
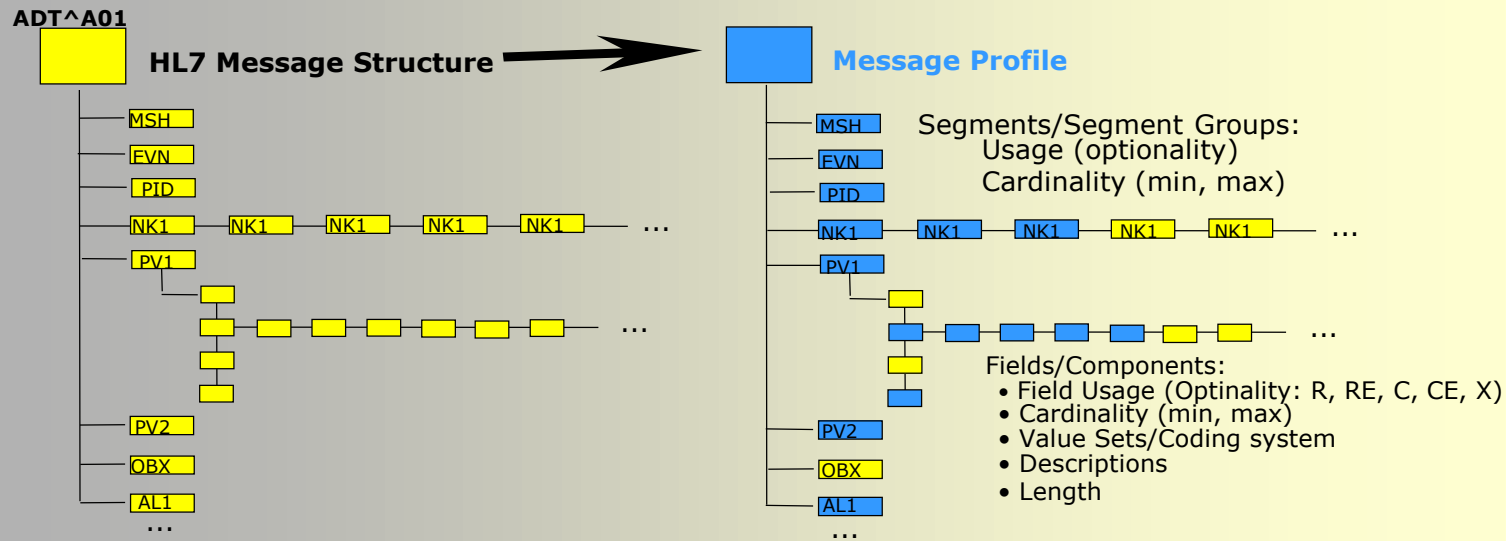
Message Profile Example (XML)

Snippet from PID segment

SSN not supported

License is required and must appear exactly one time

Value needs to be in table 0333

Value must be a valid date

```xml
<Field Name="SSN Number - Patient" Usage="X" Min="0" Max="*" Datatype="ST" Length="16" ItemNo="00122">
          <Reference>3.4.2.19</Reference>
</Field>
<Field Name="Driver's License Number - Patient" Usage="R" Min="1" Max="1" Datatype="DLN" Length="250" ItemNo="00123">
          <Reference>3.4.2.20</Reference>
          <Component Name="Driver's License Number" Usage="R" Datatype="ST" Length="100">
          </Component>
          <Component Name="Issuing State, province, country" Usage="R" Datatype="IS" Length="" Table="0333">
          </Component>
          <Component Name="expiration date" Usage="R" Datatype="DT" Length="30">
          </Component>
</Field>
<Field Name="Mother's Identifier" Usage="X" Min="0" Max="*" Datatype="CX" Length="250" ItemNo="00124">
          <Reference>3.4.2.21</Reference>
          <Component Name="ID" Usage="X" Datatype="ST" Length="3">
          </Component>
          <Component Name="Check digit" Usage="X" Datatype="ST">
          </Component>
          <Component Name="code identifying the check digit scheme employed" Usage="X" Datatype="ID" Length="3" Table="0061">
          </Component>
```

1. Provides a roadmap for creating messages
2. Input into Message Maker

The Need for Dynamic Message Creation

• **Need many test messages for each profile and a testing framework to ensure that applications implement what was agreed upon in the message profiles**

Automated and Adaptable Message Creation

Profile N

```
<?xml version="1.0"?>
<HL7v2xConformanceProfile H
<MetaData Name="CALINX" Or
<Encodings>
<Encoding>ER7</Encoding>
</Encodings>
<DynamicDef AccAck="NE" Ap
<HL7MsgType="ADT"
EventType="A01
<MetaData Name="CALINX" >
<Segment Name="MSH" LongN
<Field Name="Field Separator" Us
</Field>
```

Build your own

Manual Test Suite
- tests needed for each profile
- written individually
- meticulous work
- error prone
- high cost $$$$$
- often tests not performed

Message Maker Test Suite
- tests needed for each profile
- automatically generated easy
- lower cost $$
- increases likelihood tests will be performed
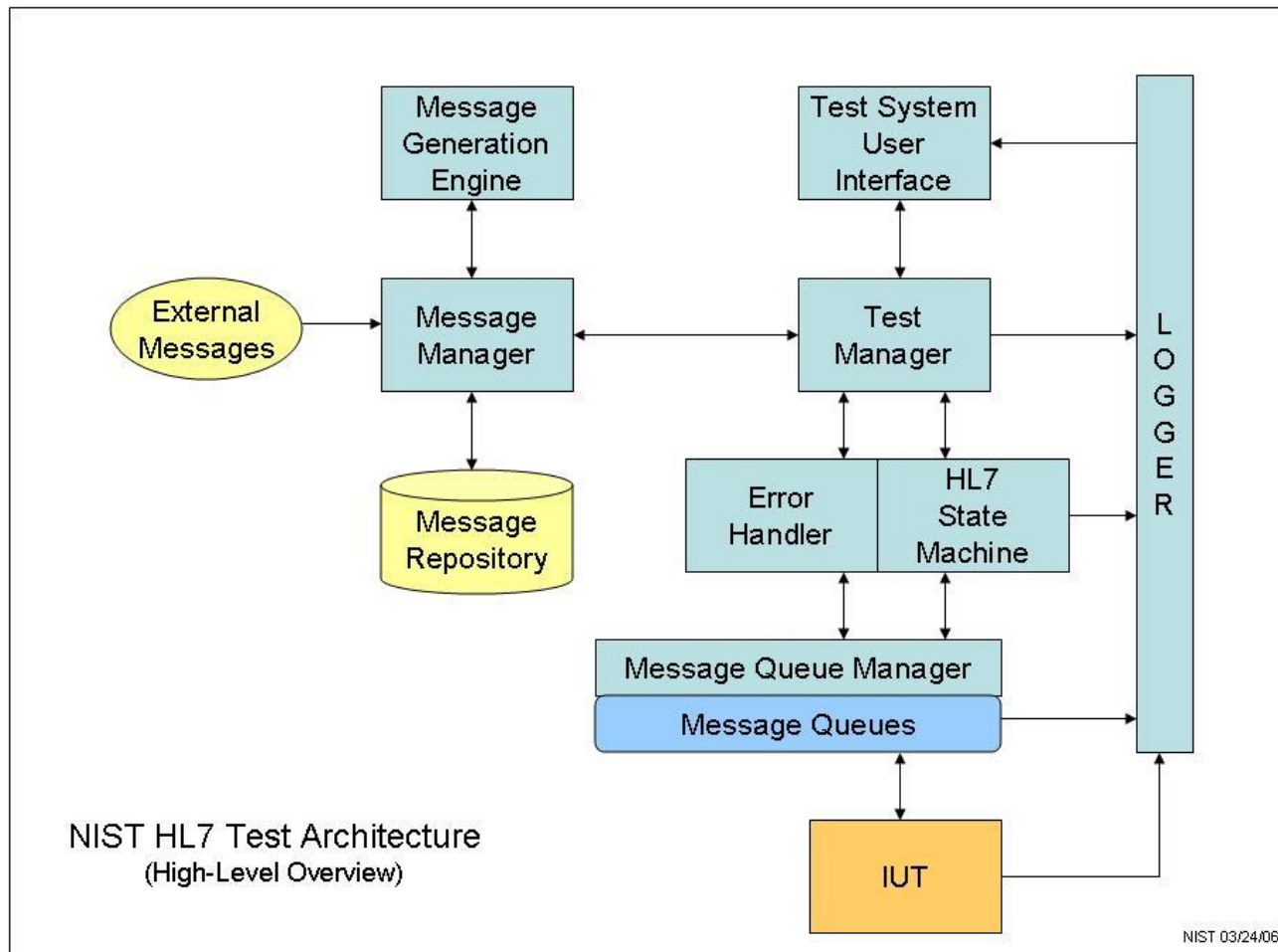
Use Message Maker

Message Maker Design

Approach to Message Generation

- ## XSLT Engine
  - Create *base* message
  - Combines XML Profile, Rules, Data
- ## Modify the profile
  - Message Structure
  - Element attributes (e.g., cardinality, usage)
- ## Modify existing message content
  - XPath expression and data value
  - Element content (length, data, value set)
- ## Used in combination

NIST HL7 Test Framework

NIST HL7 Test Architecture
(High-Level Overview)

NIST 03/24/06

Initial Setup

Load a valid HL7 XML Message Profile

Message Maker 1.3

File Configure Messages Tools Help

| Initialization | Data Configuration | Message View | Message Management |

Test Message Set Initialization

Location to save the messages

Profile: `C:\Program Files\Message Maker\maker\testing\Simple\NIST_SampleA`   Browse ...   Clear

Message Path: `C:\Program Files\Message Maker\maker\testing\Simple\messages`   Browse ...   Clear

Test Message Options

Select the type of messages you want to create

Volume: `5`

Set number of messages to be created

○ Create a set of valid test messages   ○ Create a sample message (randomly populated)

○ Create a set of invalid test messages   ○ Create a sample message (minimally populated)

○ Create a set of both valid and invalid test messages   ○ Create a sample message (maximally populated)

When generating messages

● Ignore length constraints   ○ Enforce length constraints

○ Customize Settings: More Options >>>   ○ Manual test selection: Set

Options to create sample messages

Define Specific Test Location and Type

Description: The Manual Test Selection allows you to pick a specific location in the profile and the type of test you'd like. Tests can be valid or invalid. A number of error messages have been requested above.

Browse and Edit Repository Data

Description: The Data Repository is a collection of data items for each HL7 primitive element. Users can browse and edit the values in the repository.

Table Data

Message Maker 1.3

File   Configure   Messages   Tools   Help

Initialization | **Data Configuration** | Message View | Message Management

- PID
  - Set ID - PID
  - Patient ID
  - Patient Identifier List
  - Alternate Patient ID - PID
  - Patient Name
  - Mother's Maiden Name
  - Date/Time Of Birth
  - **Administrative Sex**
  - Patient Alias
  - Race
  - Patient Address
  - County Code
  - Phone Number - Home
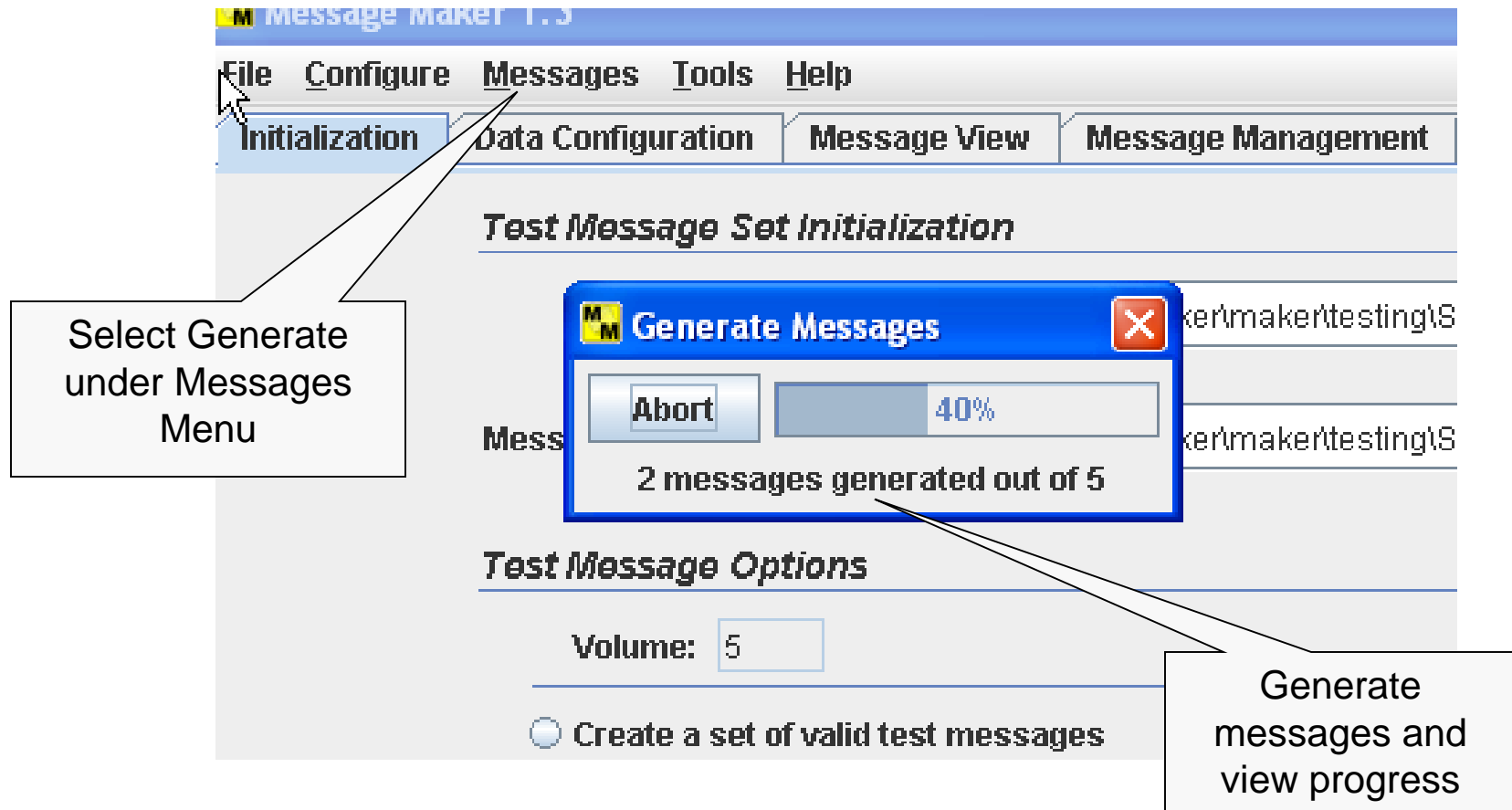 - Phone Number - Business
  - Primary Language
  - Marital Status
  - Religion
  - Patient Account Number
  - SSN Number - Patient
  - Driver's License Number - Patient
  - Mother's Identifier
  - Ethnic Group
  - Birth Place
  - Multiple Birth Indicator
  - Birth Order
  - Citizenship
  - Veterans Military Status
  - Nationality
  - Patient Death Date and Time
  - Patient Death Indicator
  - Identity Unknown Indicator
  - Identity Reliability Code
  - Last Update Date/Time

☐ Show elements with missing values

Table Number: 0001 - Table Name: Administrative sex - Version: 2.4

Code	Value
A	Ambiguous
F	Female
M	Male
N	Not applicable
O	Other
U	Unknown

Select the table

Add values to the table

Edit existing values

New | Add | Remove | Edit | Cancel

S | Special

Save the HL7 Table | Save As ...

Suggested Data Link: | Copy Values

Description: Table data can be browsed and edited. Tables can also be viewed from a table centric view by selecting Table Viewer item under the Configure menu.
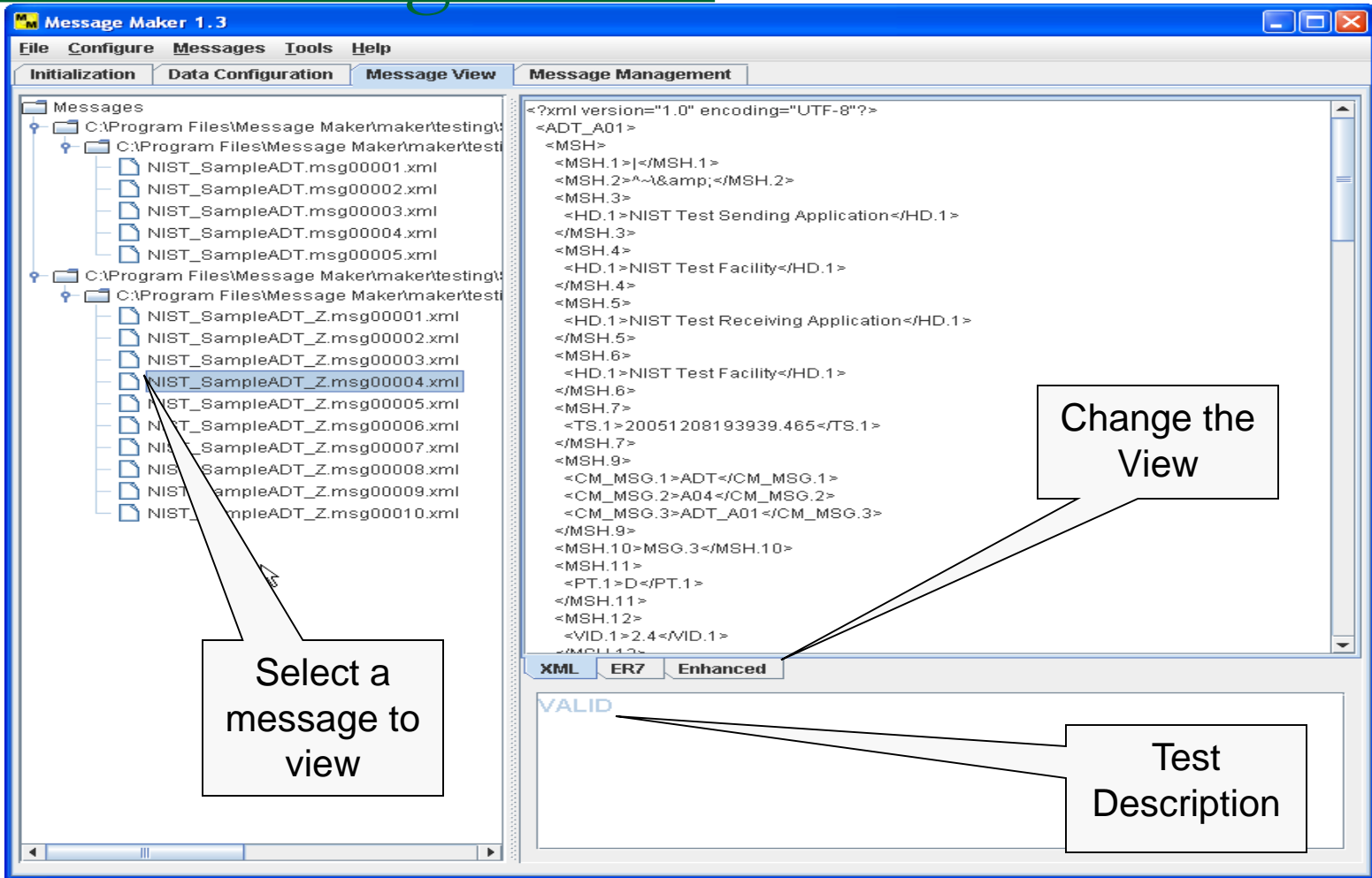
Generate Messages

Message Maker 1.3

File   Configure   Messages   Tools   Help

Initialization | Data Configuration | Message View | Message Management

Test Message Set Initialization

Select Generate under Messages Menu

Generate Messages

Abort   40%

2 messages generated out of 5

ker\maker\testing\S

ker\maker\testing\S

Test Message Options

Volume: 5

○ Create a set of valid test messages

Generate messages and view progress

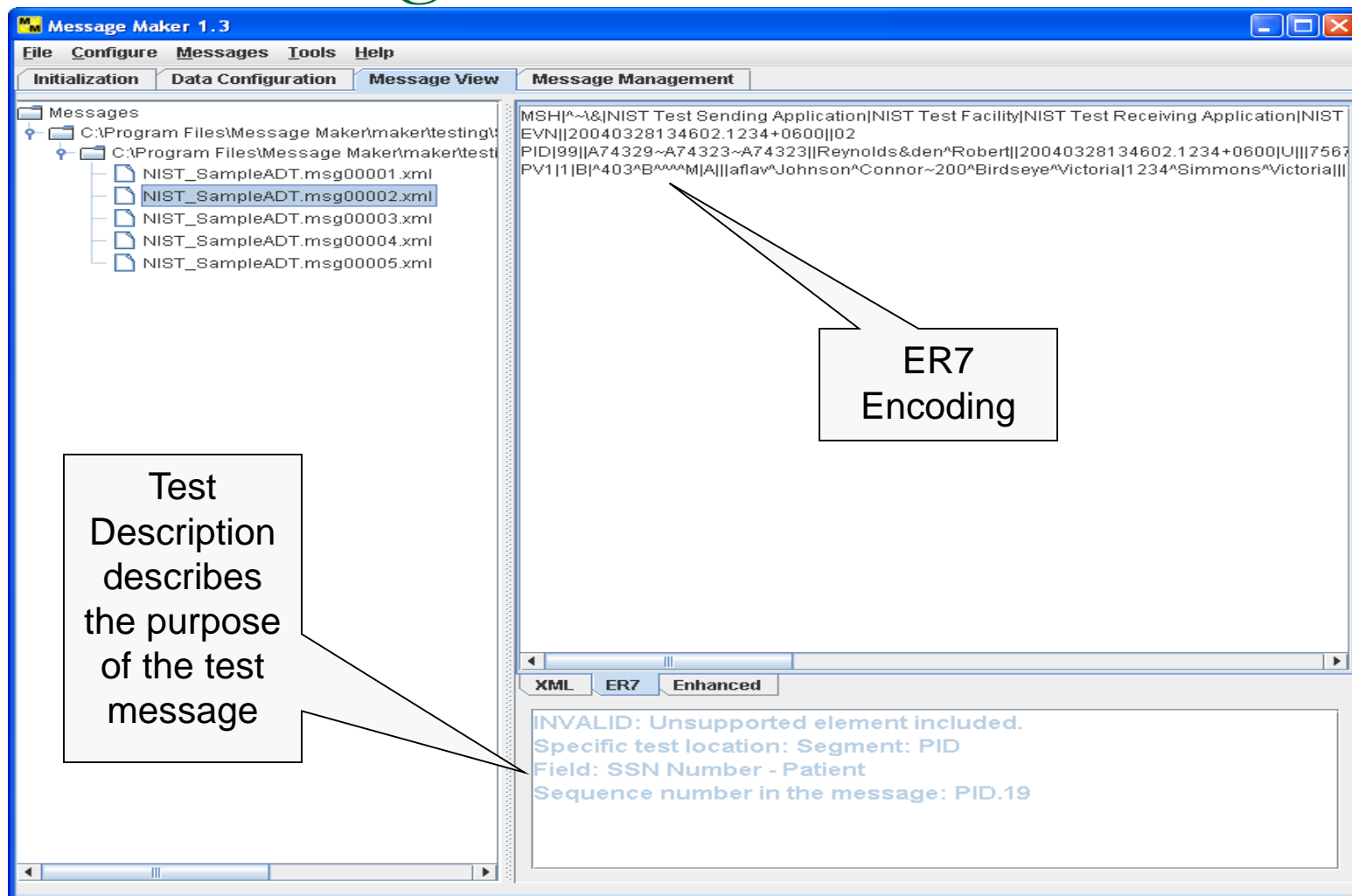**Description:** Once initialization has been completed messages can be generated.

XML Message View

Description: Message Maker provides three views of the messages (XML, ER7 and Enhanced ER7). For each message a Test Description is given that describes the purpose of the test message.

ER7 Message View

Description: ER7 view with a detailed test description.

Enhanced Message View

Description: The enhanced ER7 view presents the message in a tree structure that can be navigated. The above call outs shows the injected error description and the location in the message.

Post Edit Message
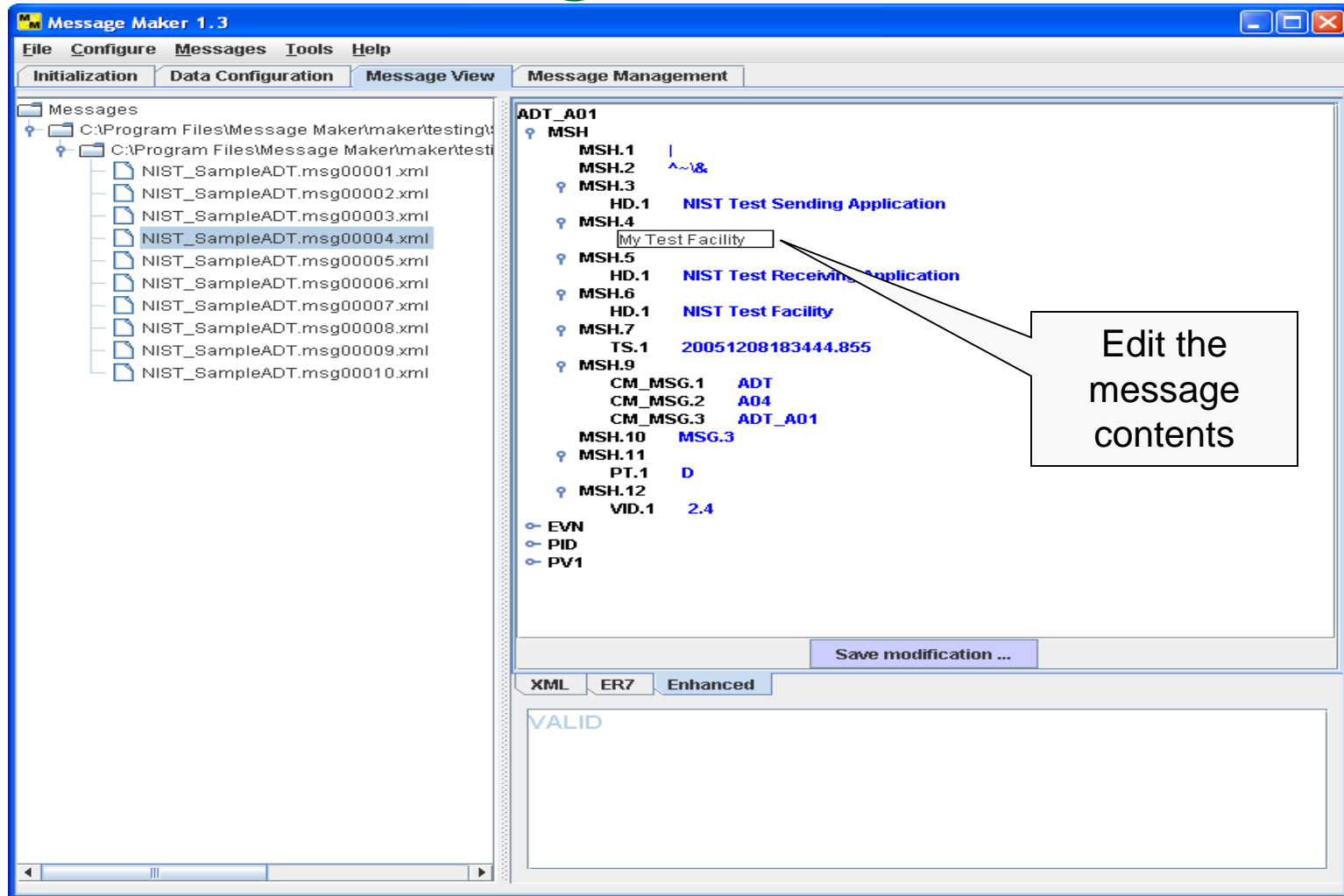
Description: The enhanced ER7 view allows messages to be edited and saved.

Summary

- Methodology and tool to create test messages
- Automatically and dynamically generate messages for any given profile
  - Account for site-specific characteristics and options
  - Can be used to produce self-adapting test suites
- Capabilities:
  - Message Variation
  - Data Configuration
  - Methods to automatically determine test message set
  - Multiple encodings (XML, ER7)
  - Test Descriptions (metadata)
- http://www.nist.gov/messagemaker
  - Public domain
  - Source code available