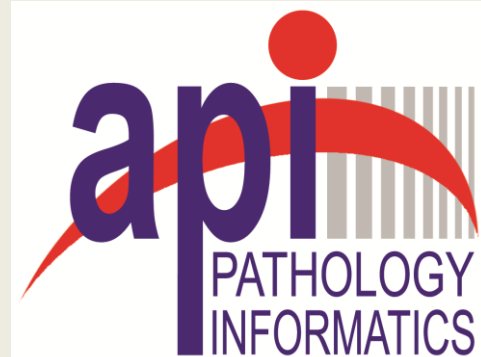


# LIS Interfaces: Basics, Implementation, and Pitfalls

Mark Routbort, MD, PhD  
UT MD Anderson Cancer Center

Pathology Informatics Review – Pathology Informatics 2014



Grateful acknowledgements to John Sinard, MD, PhD

# Laboratory System Interfaces

- No laboratory/pathology information system is an island ....
- Information from lab/path systems underlies patient treatment and diagnosis, at multiple levels:
  - Transactional
    - Hematocrit
    - Do I need to transfuse this patient with anemia?
  - Problem list
    - Coombs test positive
    - Hemolytic anemia, will require careful monitoring and possibly therapy
  - Persistent
    - Diagnosis: CLL
    - This patient has chronic lymphocytic leukemia, with subsequent paraneoplastic autoimmune hemolytic anemia
- Understanding how this information is transmitted (and represented) is core the to practice of clinical informatics for the laboratorian

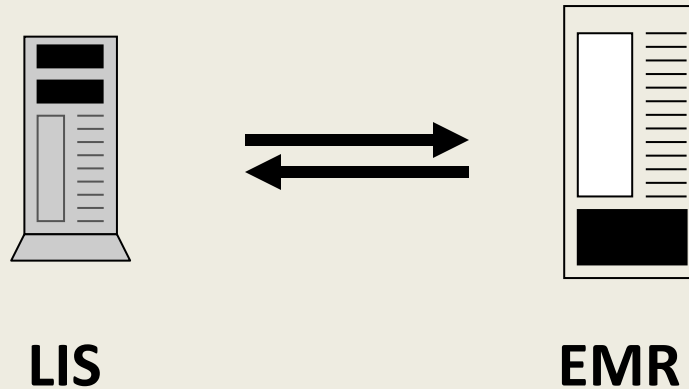
# Electronic Interfaces

- Hardware/software used to get data into and out of an information system electronically, usually for communication with another computer system
- Most common input interfaces:
  - ADT (admission/discharge/transfer – patient demographics)
  - Instrument
  - Orders
- Most common output interfaces:
  - Billing
  - Results
  - Orders

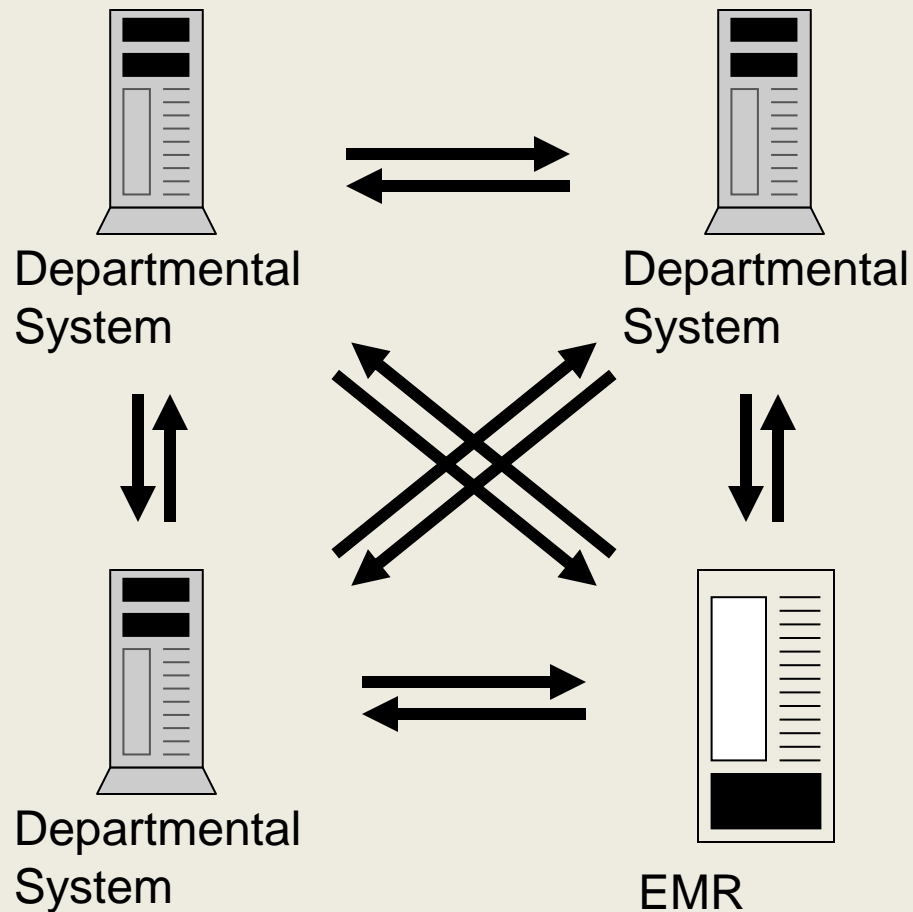
# Foundational Issues

- Connectivity
  - How does the electronic data get from one computer system to another?
- Comprehension
  - Syntax
    - How is the message structured?
    - How do I know when one message ends and another begins?
    - Where do I look in the message to find a particular data element?
  - Semantics
    - What does the data mean?

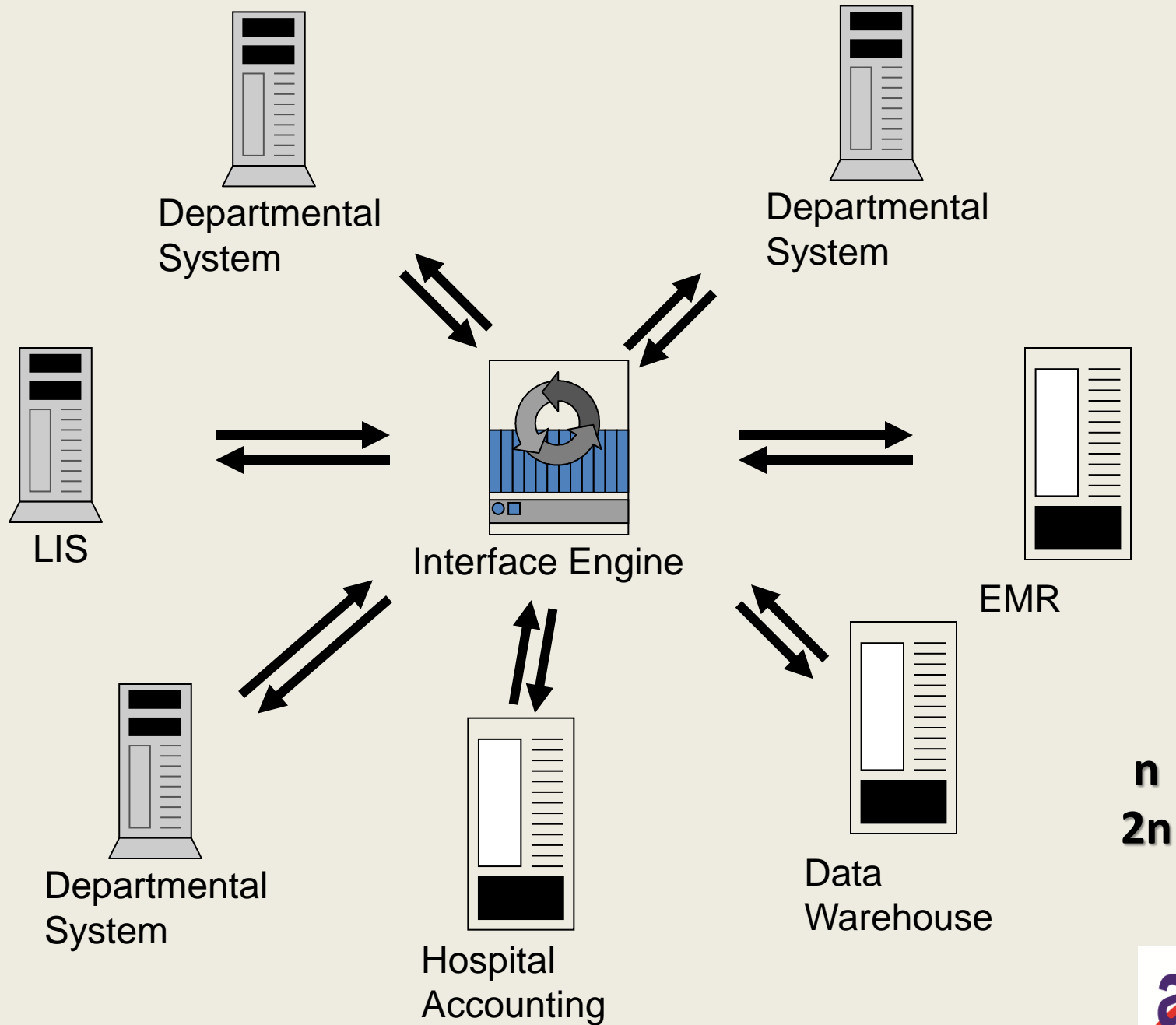
# Connectivity



**# Systems: 2**  
**# Interfaces: 2**



# Systems: 2 → 3 → 4       $n$   
 # Interfaces: 2 → 6 → 12       $n(n-1)$



# Elements of an interface engine

## I/O Handler

- Receives data from and outside system and stores it in an input table OR takes data from an output table and sends it to an outside system
- Communication Modes:
  - TCP/IP (direct “real time” communication)
  - Multiple Files (each “message” is put into its own file)
  - Single File (appends new data on to end of file)
  - Serial
  - Custom
- The I/O Handler knows nothing about the content of the message, only how to communicate it (and what format will be used to process it)



# Elements of an interface engine

## I/O Processor

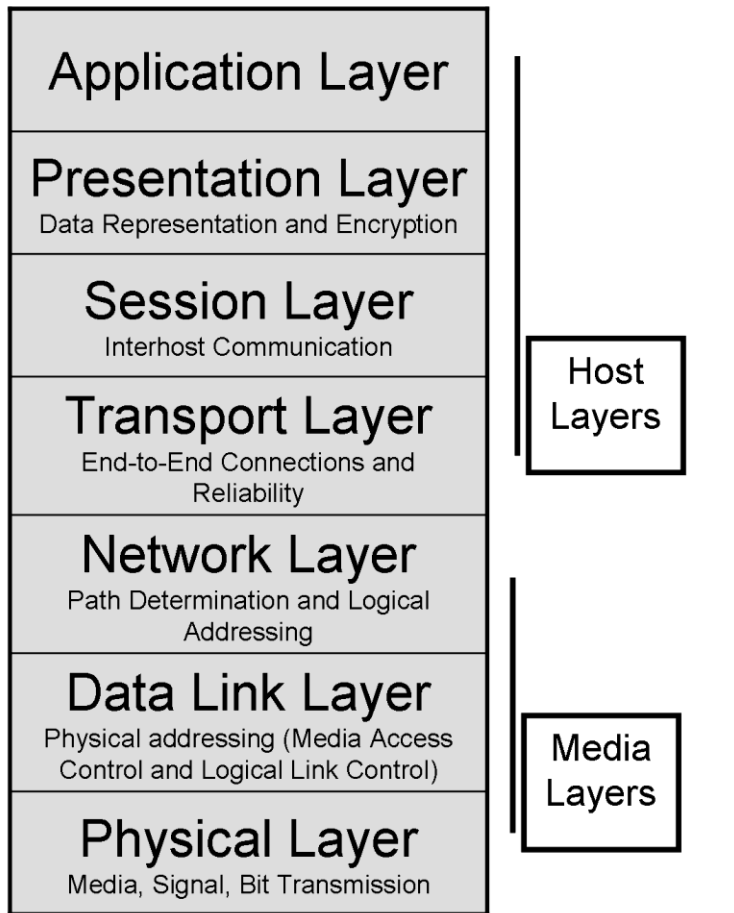
- Breaks down the message into its component data and stores it in the database OR gets data from the database and builds an output message
- Message Segmentation Methods (format types):
  - Delimited
    - Comma or tab separated values
    - In HL7: | ^ & ~
  - Fixed Length Fields (typically used for conversion)
  - More complex segmentation types
    - XML – eXtended Markup Language
    - JSON – Javascript serial object notation
- The I/O Processor is responsible for dealing with the CONTENT of the message, but is not at all involved in communicating it

# HL7

- Health Level Seven standard for the electronic exchange of data in healthcare environments, with specific emphasis on inpatient acute care facilities
- Represents a “common syntax” which software from different vendors can use to communicate with each other
- Based on the theory that although each healthcare system stores data in different ways, both with respect to the database structure and data encoding, the data elements stored and the concepts they represent are essentially the same

# The “7” in HL7 refers to the Seventh Level of the OSI Model

*The “Open Systems Interconnect” (OSI) Model:  
Layer-based reference model for computer  
networking developed by the International  
Standards Organization (ISO)*



All client applications. Internet browsers, email, telnet

Character-code translation, data conversion, data compression

Controls when applications/users can send or receive data; synchronization

Monitors the quality of the connection (data integrity)

Fragmentation/re-assembly; routing data among nodes

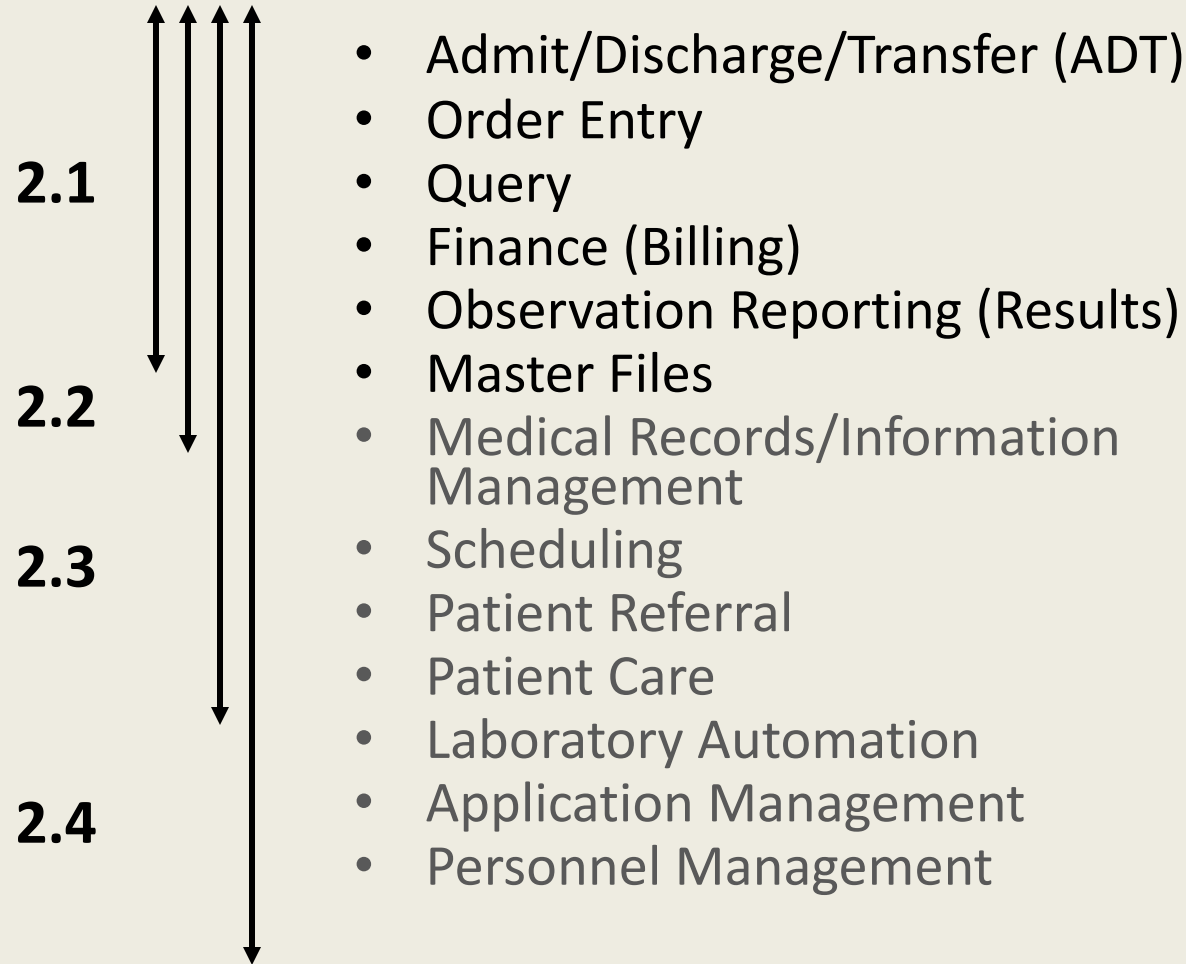
Provides for the error free transmission of data frames

Specifics of voltages, cabling, connectors

# History of HL7

- Initially developed by 12 volunteers (the “HL7 working group”)
  - Version 1 released in 1987
  - Version 2 released in 1988
- 1994: HL7 working group became an American National Standards Institute (ANSI) accredited standards organization
- Version 2
  - Uses a delimited message format
  - Version 2.5 released in 2003
  - Version 2.7 released in 2009
- Version 3
  - Uses XML (eXtensible Markup Language)
  - Initial release published 2005
  - Very limited penetrance in the US

# HL7 Supported Message Specifications



# HL7 Message Construction Rules

- Messages are composed of varying length segments, each terminated by a carriage return (ASCII 13).
- Segments may be defined as required or optional, and may be allowed to repeat
- Each segment is a series of variable length fields, separated by field separator characters (delimiters)
- Each segment begins with a 3 character identifier
  - Custom (site specific) segment identifiers must start with a “Z”
- Individual data fields are identified solely by their position within the segment

# HL7 Message Construction Rules (cont)

- Each message begins with a message header (MSH)
- Every message has a “type” – which corresponds to its real-world purpose and further specifies what segments it must/can contain
  - Contained in MSH-9 (ninth field of MSH segment)
  - Examples
    - Patient registration
    - Laboratory order
    - Laboratory result

# Sample HL7 Segments

Segment Identifier  
Field 1  
Field 3 is empty  
Segment Terminator

**EVN|A31|20010312155756|||20010312155756<13>**

Field Delimiter  
Field 2  
(Date/Time as YYYYMMDDHHMMSS) 3/12/2001 3:57:56 PM

Segment Identifier  
Field 5  
Component (sub-field) delimiter

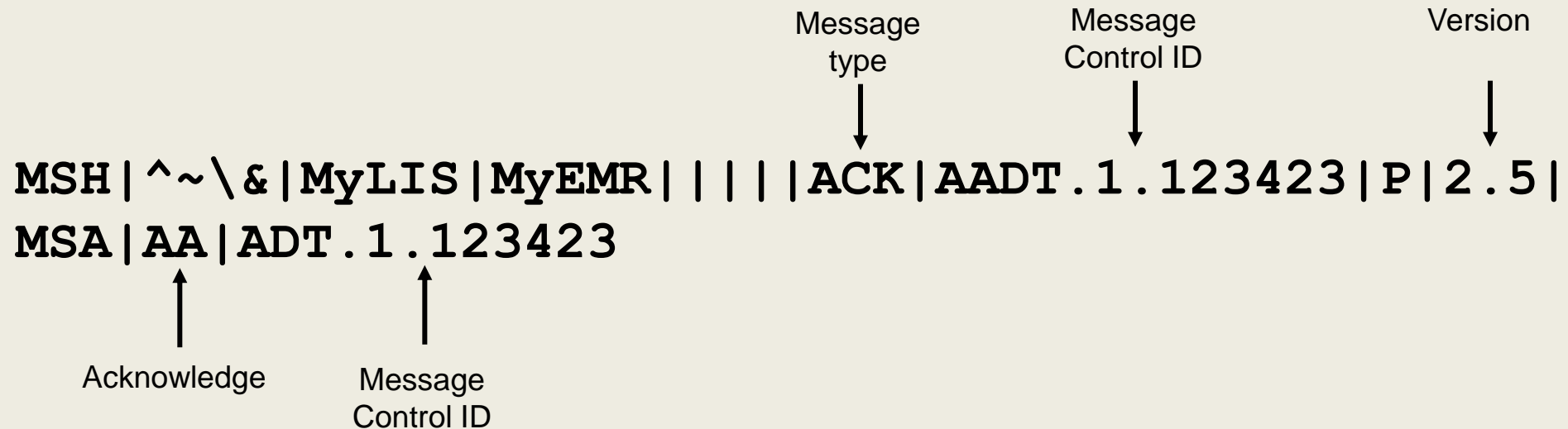
**PID|1||0001234567||DOE^JANE^E^^MS^||19651006|...**

Set ID  
(for potentially repeating segments)

Field 5 Component 1  
Field 5 Component 2  
Field 5 Component 3  
Field 5 Component 5



# The simplest message ACK (nowledgment)



Acknowledge Status	Meaning
AA	Positive acknowledgment: the message was successfully processed.
AE	Application error
AR	Application reject

# Cracks in the ACK ...

- Does an acknowledgement mean:
  - Message received?
  - Message received and processed?
  - Message received and processed without error?
- Relatively few systems/interfaces use the AE/AR rejection/error codes
  - What does a sending system **DO** with a rejection?
- There are marked differences between what the HL7 message interfaces allows and what vendors have implemented
- Much of the limitations of HL7 are associated with the “lowest common denominator” phenomenon

# Some important message types

ADT^A04 Register a patient

ADT^A08 Update patient information

ADT^A01 Admit/visit notification

ORM^O01 Order message

ORU^R01 Observation message (results)

# Sample ORU message

```
MSH|^~\`|674|GHC|SISRL|PAML|20060922162830|L674-  
200609221628310220|ORU^R01|ORU000016168|P|2.3|||AL|AL  
PID|1||1478895^4^M10^PA|XTEST^PATIENT^||19591123|F||||||||||||||  
ORC|RE|F4334|51013174200601||||^||||||||||  
OBR|1|F4334|51013174200601|80048^BASIC METABOLIC  
PANEL|||20060922152300|||||||023901^PACLAB|||||||CH|F||20060922162659^^GHA  
||||||||||  
OBX|1|NM|84295^SODIUM^GH|1|145|mmol/L||||F|||20060922152300|GH  
OBX|2|NM|84132^POTASSIUM^GH|2|5.2|mmol/L||||F|||20060922152300|GH  
OBX|3|NM|82435^CHLORIDE^GH|3|108|mmol/L||||F|||20060922152300|GH  
OBX|4|NM|82374^CARBON DIOXIDE^GH|4|31|mmol/L||||F|||20060922152300|GH  
OBX|5|NM|82947^GLUCOSE^GH|5|76|MG/DL||||F|||20060922152300|GH  
OBX|6|NM|84520^BUN^GH|6|22|MG/DL||||F|||20060922152300|GH
```

# OBX – observation segment

- OBX-1: Set ID - OBX (SI) **optional**
- OBX-2: Value Type (ID)
- OBX-3: Observation Identifier (CE)
- OBX-4: Observation Sub-ID (ST) **optional**
- OBX-5: Observation Value (Varies) **optional repeating**
- OBX-6: Units (CE) **optional**
- OBX-7: References Range (ST) **optional**
- OBX-8: Abnormal Flags (ID) **optional repeating**
- OBX-9: Probability (NM) **optional**
- OBX-10: Nature of Abnormal Test (ID) **optional**
- OBX-11: Observ Result Status (ID)
- OBX-12: Date Last Obs Normal Values (TS) **optional**
- OBX-13: User Defined Access Checks (ST) **optional**
- OBX-14: Date/Time of the Observation (TS) **optional**
- OBX-15: Producer's ID (CE) **optional**
- OBX-16: Responsible Observer (XCN) **optional**
- OBX-17: Observation Method (CE) **optional repeating**

# LIS/OBX model limitations

- Observables needs to be tightly defined and adhere to the basic lab test model:
  - Test
  - Result value
  - Result units
  - Result flags
  - Reference range
- More complex data can primary be represented by either
  - Going “free text” – embedding a bunch of sequential OBX segments containing “sentences” to transmit a free text report
  - Embedding or linking to a PDF or other binary data form

# Increasing amounts of laboratory data do not fit the rigid observable/OBX model

OncoSeek - UT MD Anderson Molecular Diagnostics Laboratory

File Configuration Test/Debug

Analysis Browser Query Browser Sample Annotation Server Analyses Test and Maintenance Code Debug Table Management Log Local Annotations

Re-annotate Print Refresh Enable draggable panes

Select analysis sample

Results

\*\*\* TEST 282273 MDL:303204 \*\*\*

Variants Gemline Coverage Snapshots Sample Ordered Genes Report

Copy Export Rebuild

☒ Sort genes into ordered/additional ☒ Include sample header?  
☐ Clinicopathologic review statement ☐ Include links?

**MUTATION SCREENING SUMMARY:**

ABL1	CSF1R	FGFR2	IDH1	MLH1	PTPN11	<b>TP53</b>
AKT1	CTNNB1	FGFR3	IDH2	MPL	RB1	VHL
ALK	EGFR	FLT3	JAK2	NOTCH1	RET	
APC	ERBB2	GNA11	JAK3	NPM1	SMAD4	
ATM	ERBB4	GNAQ	KDR	NRAS	SMARCB1	
BRAF	EZH2	GNAS	KIT	PDGFRA	SMO	
CDH1	FBXW7	HNF1A	<b>KRAS</b>	<b>PIK3CA</b>	SRC	
CDKN2A	FGFR1	HRAS	MET	PTEN	<b>STK11</b>	

**I. Mutations in ordered genes**

Gene	Standardized Nomenclature (HGVS)	Location	DNA change	Protein change	dbSNP ID	COSMIC ID
KRAS	NM_004985.3(KRAS):c.183A>T p.Q61H	Exon 3	SNV	Missense	rs17851045	COSM555

**II. Mutations in non-ordered genes**

Gene	Standardized Nomenclature (HGVS)	Location	DNA change	Protein change	dbSNP ID	COSMIC ID
PIK3CA	NM_006218.2(PIK3CA):c.1633G>A p.E545K	Exon 10	SNV	Missense	rs104886003	COSM763
STK11	NM_000455.4(STK11):c.109C>T p.Q37*	Exon 1	SNV	Nonsense	rs121913324	COSM12925
TP53	NM_000546.5(TP53):c.722C>T p.S241F	Exon 7	SNV	Missense	rs28934573	COSM10812

PRODUCTION MJRoutbort CMS50 Production

# LIS/OBX model limitations

- More complex data can primary be represented by either
  - Going “free text” – embedding a bunch of sequential OBX segments containing “sentences” to transmit a free text report
  - Embedding or linking to a PDF or other binary data form
- Either of these approaches obviate much of the benefit of HL7 and reduce it to a message transport syntax
- A hybrid model is possible and probably the best option
  - PDF or well-defined representational format for complex, uncommon reports
  - HL7 OBX model for numeric values that need to be trendable or drive clinical decision support



## Billing Batch Interfaces

- Usually operate in “Batch” mode
  - Don’t send a bill as each case is signed out
  - On a daily basis, compile a list of charges, verify the batch for errors
  - “Send” the batch: create an HL7 message with the patient information and charging information
  - The message can either be transmitted electronically or saved in a text file and then transferred to the billing system
- Usually have additional “housekeeping” segments (batch header and trailer segments) to verify that the entire batch is complete
- Details of segment contents varies a lot with different billing systems

# Summary of HL7

- Nearly ubiquitous standard
- But there is no standard implementation
- Two vendor systems which say they “support” HL7 may not necessarily connect with each other
  - More important is the domain of information interchanged
  - And the mapping of the underlying data models
- One way to ask how efficient/scalable HL7 is is to ask the question:
  - For integrated EMR systems, e.g. Epic, CERNER – how many use HL7 as their internal communication framework between Lab and Clinician?
  - Answer: None
  - These systems either use direct database access or a services architecture
  - This is frequently advanced as a reason for the different functionality which may be available between Lab and Clinician when using an “interfaced” versus “integrated” solution

# Other segmentation/data representation models of importance in pathology informatics

- Simple delimited
- ODBC
- XML
- JSON

# Simple delimited

- Delimiter separated values
  - CSV – comma separated values
  - TSV – tab separated values
- Usually lines separated by carriage returns
- Commonly, the first line (header) contains column names
- Generic mechanism for sharing 2-dimensional data (Excel-like)
- Ubiquitous “lingua franca” for device/result interfacing outside the LIS instrument interface pathway
  - List of samples to run
  - Output data for those samples

# Caveats for simple delimited data

- Handling delimiter characters within the data

Name	MRN	Sample	Concentration
Smith	1234	M-14-123	2.45
Doe, John	2345	M-14-124	1.94
Frank	3456	M-14-125	1.74



Name,MRN,Sample,Concentration  
Smith,1234,M-14-123,2.45  
Doe, John,2,2345,M-14-124,1.94  
Frank,3456,M-14-125,1.74

Name	MRN	Sample	Concentration	
Smith	1234	M-14-123	2.45	
Doe, John	2345	M-14-124	1.94	1.94
Frank	3456	M-14-125	1.74	

# Caveats for simple delimited data

- Content is unstructured
  - Any validation is left to the specific implementation
  - Subject to disruptive change
    - On software versioning
    - At boundary states
- Data is untyped
  - No differentiation between numeric, string, date data types

# ODBC

- Open Database Connectivity
- Standard middleware API (application programming interface) for accessing database management systems
- Database and operating system independent
- Independence is accomplished by using ODBC drivers as a translation layer between applications and the DBMS
- ODBC-compliant applications can access any DBMS for which a driver is installed
- Drivers exist for
  - all major DBMS
  - other data sources (Excel)
  - Text/flat delimited files

# ODBC use cases

- Reports
  - Many LISs use a third party report generation tool like Crystal Reports
  - These tools uniformly use ODBC to access the data
- Data extraction
  - Nearly all LISs have a DBMS back-end
  - Many support direct ODBC read access to the underlying data for extraction for more complex off-line analysis or reporting



# XML

- “Extensible Markup Language (XML)”
- A markup language that defines a set of rules for encoding documents and data in a format that is both human-readable and machine-readable
- Defined in specification produced by the W3C as a set of open standards
- Widely used for the representation of arbitrary data structures
- Many application programming interfaces (APIs) have been developed to aid software developers with processing XML data, and several schema systems exist to aid in the definition of XML-based languages.

# XML

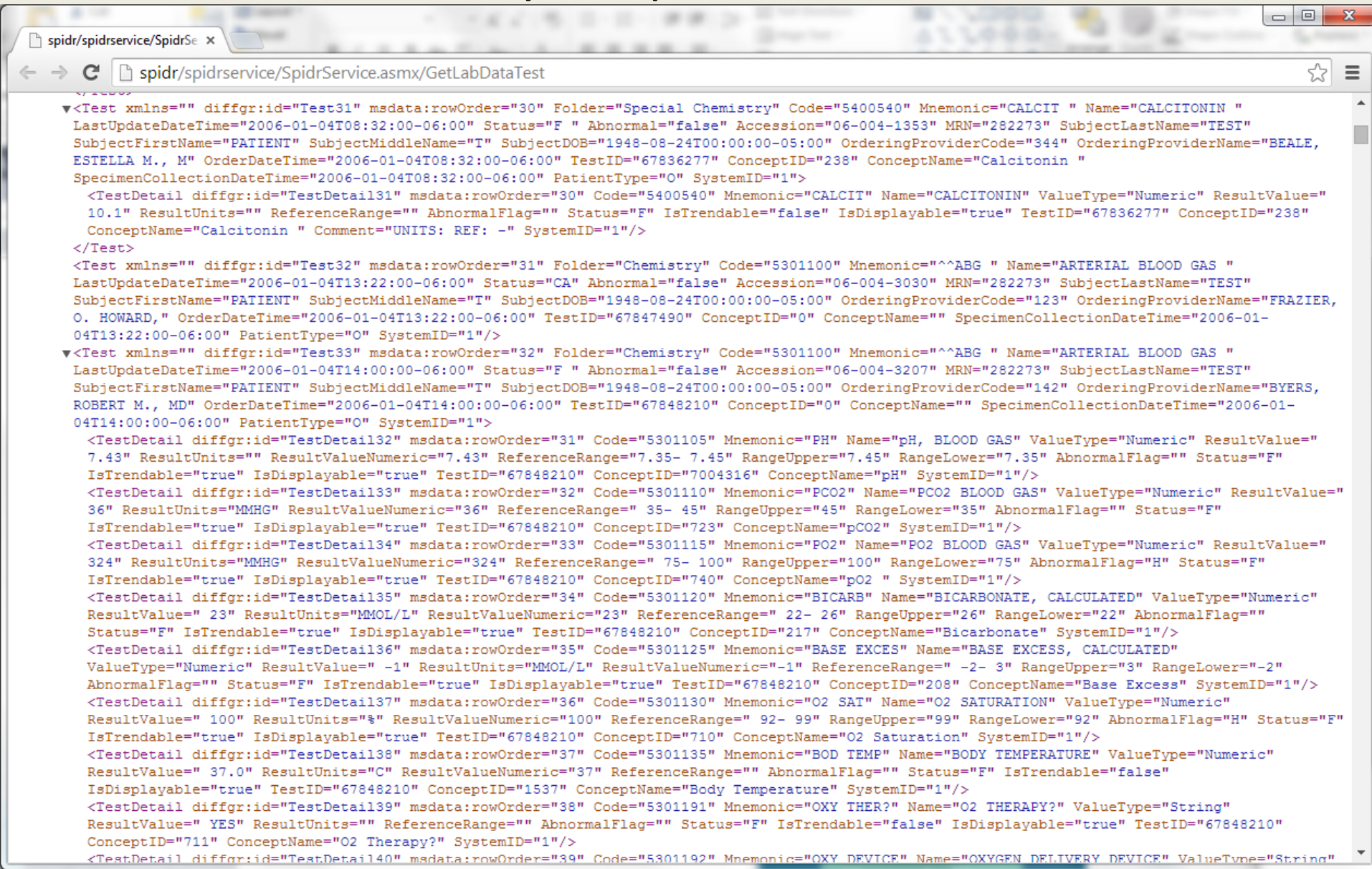
```
<?xml version="1.0"?>
<quiz>
  <qanda seq="1">
    <question>
      Who was the forty-second
      president of the U.S.A.?
    </question>
    <answer>
      William Jefferson Clinton
    </answer>
  </qanda>
  <!-- Note: We need to add
  more questions later.-->
</quiz>
```

**XML**

# XML details

- Tag
  - A markup construct that begins with < and ends with >.
    - *start-tags*; for example: <section>
    - *end-tags*; for example: </section>
    - *empty-element tags*; for example: <empty\_section />
- Element
  - A logical document component which either begins with a start-tag and ends with a matching end-tag or consists only of an empty-element tag.
  - The characters between the start- and end-tags, if any, are the element's *content*, and may contain markup, including other elements, which are called *child elements*.
  - <Greeting>Hello, world.</Greeting>
- Attribute
  - A markup construct consisting of a name/value pair that exists within a start-tag or empty-element tag.
    - 
    - Attributes are "src" and "alt"

# XML is fully relational and capable of supporting arbitrarily complex data structures



The screenshot shows a web browser window with the address bar displaying `spidr/spidrservice/SpidrService.asmx/GetLabDataTest`. The main content area displays an XML response. The XML structure is as follows:

```
<?xml version="1.0" encoding="utf-8" ?>
<Test xmlns="" diffgr:id="Test31" msdata:rowOrder="30" Folder="Special Chemistry" Code="5400540" Mnemonic="CALCIT " Name="CALCITONIN "
LastUpdateDateTime="2006-01-04T08:32:00-06:00" Status="F " Abnormal="false" Accession="06-004-1353" MRN="282273" SubjectLastName="TEST"
SubjectFirstName="PATIENT" SubjectMiddleName="T" SubjectDOB="1948-08-24T00:00:00-05:00" OrderingProviderCode="344" OrderingProviderName="BEALE,
ESTELLA M., M" OrderDateTime="2006-01-04T08:32:00-06:00" TestID="67836277" ConceptID="238" ConceptName="Calcitonin "
SpecimenCollectionDateTime="2006-01-04T08:32:00-06:00" PatientType="O" SystemID="1">
  <TestDetail diffgr:id="TestDetail31" msdata:rowOrder="30" Code="5400540" Mnemonic="CALCIT " Name="CALCITONIN" ValueType="Numeric" ResultValue="
  10.1" ResultUnits="" ReferenceRange="" AbnormalFlag="" Status="F" IsTrendable="false" IsDisplayable="true" TestID="67836277" ConceptID="238"
  ConceptName="Calcitonin " Comment="UNITS: REF: -" SystemID="1"/>
</Test>
<Test xmlns="" diffgr:id="Test32" msdata:rowOrder="31" Folder="Chemistry" Code="5301100" Mnemonic="^^ABG " Name="ARTERIAL BLOOD GAS "
LastUpdateDateTime="2006-01-04T13:22:00-06:00" Status="CA" Abnormal="false" Accession="06-004-3030" MRN="282273" SubjectLastName="TEST"
SubjectFirstName="PATIENT" SubjectMiddleName="T" SubjectDOB="1948-08-24T00:00:00-05:00" OrderingProviderCode="123" OrderingProviderName="FRAZIER,
O. HOWARD," OrderDateTime="2006-01-04T13:22:00-06:00" TestID="67847490" ConceptID="0" ConceptName="" SpecimenCollectionDateTime="2006-01-
04T13:22:00-06:00" PatientType="O" SystemID="1"/>
<Test xmlns="" diffgr:id="Test33" msdata:rowOrder="32" Folder="Chemistry" Code="5301100" Mnemonic="^^ABG " Name="ARTERIAL BLOOD GAS "
LastUpdateDateTime="2006-01-04T14:00:00-06:00" Status="F " Abnormal="false" Accession="06-004-3207" MRN="282273" SubjectLastName="TEST"
SubjectFirstName="PATIENT" SubjectMiddleName="T" SubjectDOB="1948-08-24T00:00:00-05:00" OrderingProviderCode="142" OrderingProviderName="BYERS,
ROBERT M., MD" OrderDateTime="2006-01-04T14:00:00-06:00" TestID="67848210" ConceptID="0" ConceptName="" SpecimenCollectionDateTime="2006-01-
04T14:00:00-06:00" PatientType="O" SystemID="1">
  <TestDetail diffgr:id="TestDetail32" msdata:rowOrder="31" Code="5301105" Mnemonic="PH" Name="pH, BLOOD GAS" ValueType="Numeric" ResultValue="
  7.43" ResultUnits="" ResultValueNumeric="7.43" ReferenceRange="7.35- 7.45" RangeUpper="7.45" RangeLower="7.35" AbnormalFlag="" Status="F"
  IsTrendable="true" IsDisplayable="true" TestID="67848210" ConceptID="7004316" ConceptName="pH" SystemID="1"/>
  <TestDetail diffgr:id="TestDetail33" msdata:rowOrder="32" Code="5301110" Mnemonic="PCO2" Name="PCO2 BLOOD GAS" ValueType="Numeric" ResultValue="
  36" ResultUnits="MMHG" ResultValueNumeric="36" ReferenceRange="35- 45" RangeUpper="45" RangeLower="35" AbnormalFlag="" Status="F"
  IsTrendable="true" IsDisplayable="true" TestID="67848210" ConceptID="723" ConceptName="pCO2" SystemID="1"/>
  <TestDetail diffgr:id="TestDetail34" msdata:rowOrder="33" Code="5301115" Mnemonic="PO2" Name="PO2 BLOOD GAS" ValueType="Numeric" ResultValue="
  324" ResultUnits="MMHG" ResultValueNumeric="324" ReferenceRange="75- 100" RangeUpper="100" RangeLower="75" AbnormalFlag="H" Status="F"
  IsTrendable="true" IsDisplayable="true" TestID="67848210" ConceptID="740" ConceptName="pO2 " SystemID="1"/>
  <TestDetail diffgr:id="TestDetail35" msdata:rowOrder="34" Code="5301120" Mnemonic="BICARB" Name="BICARBONATE, CALCULATED" ValueType="Numeric"
  ResultValue=" 23" ResultUnits="MMOL/L" ResultValueNumeric="23" ReferenceRange="22- 26" RangeUpper="26" RangeLower="22" AbnormalFlag=""
  Status="F" IsTrendable="true" IsDisplayable="true" TestID="67848210" ConceptID="217" ConceptName="Bicarbonate" SystemID="1"/>
  <TestDetail diffgr:id="TestDetail36" msdata:rowOrder="35" Code="5301125" Mnemonic="BASE EXCES" Name="BASE EXCESS, CALCULATED"
  ValueType="Numeric" ResultValue=" -1" ResultUnits="MMOL/L" ResultValueNumeric="-1" ReferenceRange=" -2- 3" RangeUpper="3" RangeLower="-2"
  AbnormalFlag="" Status="F" IsTrendable="true" IsDisplayable="true" TestID="67848210" ConceptID="208" ConceptName="Base Excess" SystemID="1"/>
  <TestDetail diffgr:id="TestDetail37" msdata:rowOrder="36" Code="5301130" Mnemonic="O2 SAT" Name="O2 SATURATION" ValueType="Numeric"
  ResultValue=" 100" ResultUnits="%" ResultValueNumeric="100" ReferenceRange="92- 99" RangeUpper="99" RangeLower="92" AbnormalFlag="H" Status="F"
  IsTrendable="true" IsDisplayable="true" TestID="67848210" ConceptID="710" ConceptName="O2 Saturation" SystemID="1"/>
  <TestDetail diffgr:id="TestDetail38" msdata:rowOrder="37" Code="5301135" Mnemonic="BOD TEMP" Name="BODY TEMPERATURE" ValueType="Numeric"
  ResultValue=" 37.0" ResultUnits="C" ResultValueNumeric="37" ReferenceRange="" AbnormalFlag="" Status="F" IsTrendable="false"
  IsDisplayable="true" TestID="67848210" ConceptID="1537" ConceptName="Body Temperature" SystemID="1"/>
  <TestDetail diffgr:id="TestDetail39" msdata:rowOrder="38" Code="5301191" Mnemonic="OXY THER?" Name="O2 THERAPY?" ValueType="String"
  ResultValue=" YES" ResultUnits="" ReferenceRange="" AbnormalFlag="" Status="F" IsTrendable="false" IsDisplayable="true" TestID="67848210"
  ConceptID="711" ConceptName="O2 Therapy?" SystemID="1"/>
  <TestDetail diffgr:id="TestDetail40" msdata:rowOrder="39" Code="5301192" Mnemonic="OXY DEVICE" Name="OXYGEN DELIVERY DEVICE" ValueType="String"
```

# Power of XML for data interchange comes from two sets of extensions

- XML Schema
  - Brings an enforceable “data contract” to XML
  - Defines the expected/required/optional elements of a particular class of XML documents
  - XML can be automatically verified for compliance by many frameworks/tools prior to application processing
- Web services using WSDL and SOAP

# XML Schema

- A description of a type of XML document
  - Provides a data “contract” for implementation
  - Rules governing
    - Order
    - Data types
    - Required versus optional
    - Cardinality
    - Uniqueness
    - Referential integrity

# XML Schema

## Schema (prototype)

```
<?xml version="1.0"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">

<xs:element name="note">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="to" type="xs:string"/>
      <xs:element name="from" type="xs:string"/>
      <xs:element name="heading" type="xs:string"/>
      <xs:element name="body" type="xs:string"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>

</xs:schema>
```

## Document (instance)

```
<?xml version="1.0"?>
<note
  xmlns="http://www.w3schools.com"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.w3schools.com
  note.xsd">
  <to>Homer</to>
  <from>Marge</from>
  <heading>Reminder</heading>
  <body>Please remember to
  take out the garbage</body>
</note>
```

# JSON

- Javascript serial object notation
- Open standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs
- Used primarily to transmit data between a server and web application, as an alternative to XML
- More parsimonious than XML (no closing tags)

```
{  
  "firstName": "John",  
  "lastName": "Smith",  
  "isAlive": true,  
  "age": 25,  
  "height_cm": 167.64,  
  "address": {  
    "streetAddress": "21 2nd Street",  
    "city": "New York",  
    "state": "NY",  
    "postalCode": "10021-3100"  
  },  
  "phoneNumbers": [  
    { "type": "home", "number": "212 555-1234" },  
    { "type": "fax", "number": "646 555-4567" }  
  ]  
}
```



# Web services/WSDL

- Software implementations designed to support interoperable machine-to-machine interaction over a network
- Interfaces described in a machine-processable format (specifically WSDL)
- Permit use of complex functionality by downstream applications, with little development effort

# Summary of additional data formats

- None of these solve the problem of complex data being complex, or needing to map between different applications which may have different relational views of the world
- Provide a toolset to approach problems with
- Successful solutions come from integrations of toolsets with domain expertise/feedback

# Implementation

- Resources
  - <http://HL7.org>
    - HL7 organization
    - Standards available for review/download
  - Mirth Connect
    - An open source, highly capable messaging framework with deep HL7 support
    - <http://www.mirthcorp.com/products/mirth-connect>
  - Interfaceware
    - <http://www.interfaceware.com/>
    - Tutorials & information
    - Extensive (non-free) toolset for HL7

# Top Pitfalls for Interfacing

- Semantic corruption
  - A major risk with conversions for anatomic pathology reports

# HL7-based delivery of pathology reports converted from Microsoft Word to ASCII

Pathologist

Self, transcriptionist,  
resident entry



“Native”  
pathology  
report

Format conversion to  
ASCII text

DIAGNOSIS

Metastatic adenocarcinoma.

HL7

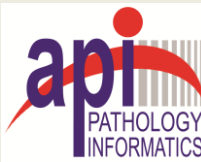
Interface  
engine

HL7

HIS Viewer

Clinician

Custom  
display  
logic



# Some issues with this approach

- No “what you see is what you get”
- Advantages of HL7 standard (“standardization”) balanced with inflexibility
  - Every interface is custom
- Pathologists not directly involved in HIS viewer display logic
- One standard for quality reporting (of many!):  
Concordance between pathologist and clinician view of the report

# Pathologist view

**Case Finder**

Criteria Set: (None)

Search Criteria

Advanced Criteria

Results by Patient

**Results by Case**

Accession no.	Patient name (current)	Primary referring physician	Primary specimen	Receive date	Case status	Case type
---------------	------------------------	-----------------------------	------------------	--------------	-------------	-----------

100%

**DIAGNOSIS**

(A) STOMACH (BIOPSY OF NODULARITY AT INCISURA AFTER CHEMORADIATION):

MICROSCOPIC FOCI OF RESIDUAL INFILTRATING POORLY DIFFERENTIATED CARCINOMA WITH TREATMENT EFFECTS INVOLVING LAMINA PROPRIA OF ATROPHIC ANTRAL MUCOSA WITH EROSION, LUMINAL FIBRINO-INFLAMMATORY EXUDATE, FOVEOLAR HYPERPLASIA, FIBROSIS, EDEMA, AND DEGENERATIVE AND REACTIVE EPITHELIAL CHANGES.

See Comment section below.

Entire report and diagnosis completed by [REDACTED]

**COMMENT**

Immunohistochemistry for cytokeratin confirms the presence of carcinoma cells in the lamina propria.

[REDACTED]

DD: 07/06/05  
7/6/2004 1:17 PM

**GROSS DESCRIPTION**

200 cases were found. ☒ Show results

SelectCancelHelp

# Clinician view in EMR

UT M.D. Anderson Cancer Center's ClinicStation 2.9 - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Reload Home Search Favorites Media

Address http://utmplm101nt/tamtron/prod/old/ Go

Patient Clinical Schedule Census Hide Queries 11133 Logged in at 06/17/05 04:51 Print Copy Help

Select by Patient MRN: Query

Pathology Reports: 10

Folder Items	Procedure	Procedure ...	Received ...	Stat...	Accession	Pathologist
Allergies/Reactions: Click to (	Surgical Biopsy					
Unread Radiology Exams: 0	Surgical Biopsy					
Radiology Reports: 38	Surgical Biopsy					
Diagnostic Images: 29	Surgical Case					
Laboratory: 45	Non-Gyn					
Pathology Reports: 10	Surgical Biopsy					
Transcribed Documents: 58	Surgical Biopsy					
Anesthesia Preop: 5	Non-Gyn					
Anesthesia/PACU Record: 1						
Scanned Documents: 461						
Cardiology: 1						
Pulmonary Function Tests: 0						
Pulmonary Function (Xenon-1						
Vital Signs: 0						
Treatment Plans: 0						
Outpatient Pharmacy: 0						
Pharmacy (IP & ATC)						
Historical IP Pharmacy: 0						
FlowSheet: 0						
Schedule: 11						
Scheduled Surgeries: 1						
Involved Providers: 4						
Protocols: 3						
Tumor Registry: 1						
Durable Medical Equipment:						
Respiratory Care: 36						
Medical Photographs: 0						
Orders						
Recent Patients: 15						
My Patients						
Clinical Schedule						

**DIAGNOSIS**

(A) STOMACH (BIOPSY OF NODULARITY AT INCISURA AFTER CHEMORADIATION):

MICROSCOPIC FOCI OF RESIDUAL INFILTRATING POORLY DIFFERENTIATED CARCINOMA WITH TREATMENT EFFECTS INVOLVING LAMINA PROPRIA OF ATROPHIC ANTRAL MUCOSA WITH EROSION, LUMINAL FIBRINO-INFLAMMATORY EXUDATE, FOVEOLAR HYPERPLASIA, FIBROSIS, EDEMA, AND DEGENERATIVE AND REACTIVE EPITHELIAL CHANGES.

See Comment section below.

Entire report and diagnosis completed by

**COMMENT**

Immunohistochemistry for cytokeratin confirms the presence of carcinoma cells in the lamina propria.

SRH:ejh  
DD:07/06/05  
7/6/2004 1:17 PM

Issues noted in the ASCII conversion of formatted pathology reports included a necessary loss of font & style information, as well as variable line breaking which in some cases led to confusing reports



Integrity of  
semantic  
content is at  
stake in *any*  
transformation

In rare cases we  
saw the  
potential for  
semantic  
corruption:

PowerPath - [Case Information - S-05-000050]

File Edit View Record Image Tools Window Help

Accession no: S-05-000050 Case type: Surgical Case Patient name: TEST, PATIENT T Age: 56 Medical rec no: 282273 Case status: Addendum Final

General Req Data Specimens Charges Patient History Concurrent Results Images Notes

Sex: Female Total blocks: 1 Total slides: 2

100%

\*\*\*\*\* MODIFIED REPORT - REVIEW ADDENDUM SECTION \*\*\*\*\*

**DIAGNOSIS**

(A) Specimen A, biopsy:  
Diagnosis A

(B) Specimen B, biopsy:  
Diagnosis B

**GROSS DESCRIPTION**

This is the original gross description

**CLINICAL HISTORY**

None given.

**SNOMED CODES**

Snomed codes here.

\*Some tests reported here may have been developed and performance characteristics determined by UT MD Anderson Pathology and Laboratory Medicine. These tests have not been specifically cleared or approved by the U.S. Food and Drug Administration.\*

Released by: Mark J Routbort MD, PhD Feb 08, 2005

**ADDENDUM**

Addendum completed by Mark Routbort, MD PhD 11133.  
Feb 08, 2005 at 04:33 PM

This addendum is issued to revise a diagnosis erroneously rendered due to specimen mislabeling. The corrected diagnosis follows.

**DIAGNOSIS**

(A) Specimen A, biopsy:  
Diagnosis B.

(B) Specimen B, biopsy:  
Diagnosis A.

Case Flags... Results... Correlate... SNOMED... Results Log... Signout...

1 item(s) selected 148577 [SA] (utmpwrpath4nt.Powerpath)

Can you  
spot the  
problem?

**Tamtron Test**

Medical Record Number  ☒ Test Print

**Tamtron: 409** MRN: 282273

Folder Items	Procedure	Procedure Date	Received Date	Status	Accession	Pathologist	Ordering Physician
Tamtron: 409	Surgical Case	2/7/2005	2/8/2005	Incomplete	S-05-000050	Mark J Routbort, MD, PhD	Physician, Tamtron MD
	Surgical Case	1/31/2005	2/1/2005	Final	S-05-000042	Mark J Routbort, MD, PhD	Physician, Tamtron MD
	Surgical Case	1/25/2005	1/26/2005	Addendum	S-05-000040	Mark J Routbort, MD, PhD	Physician, Referring MD
	Bone Marrow	1/13/2005	1/14/2005	Incomplete	S-05-000003	Pathologist Test, MD	Physician, Tamtron MD
	Bone Marrow	1/13/2005	1/14/2005	Incomplete	S-05-000004	Pathologist Test, MD	Physician, Tamtron MD
	Bone Marrow	1/13/2005	1/14/2005	Incomplete	S-05-000006	Pathologist Test, MD	Physician, Tamtron MD
	Bone Marrow	1/13/2005	1/14/2005	Incomplete	S-05-000007	Pathologist Test, MD	Physician, Tamtron MD
	Surgical Case	1/2/2005	1/3/2005	Addendum	S-05-000002	Mark J Routbort, MD, PhD	Physician, Tamtron MD
	Bone Marrow	12/29/2004	12/30/2004	Incomplete	S-04-051509	Mark J Routbort, MD, PhD	Physician, Tamtron MD
	Surgical Case	12/29/2004	12/30/2004	Final	S-04-051510	Mark J Routbort, MD, PhD	Physician, Tamtron MD

**\*\*\*\*\* MODIFIED REPORT - REVIEW ADDENDUM SECTION \*\*\*\*\***  
**Patient Name:** TEST, PATIENT T  
**Case Number:** S-05-000050

**ADDENDUM**  
 Addendum completed by Mark Routbort, MD PhD 11133.  
 Feb 08, 2005 at 04:33 PM

This addendum is issued to revise a diagnosis erroneously rendered due to specimen mislabeling. The corrected diagnosis follows.

**DIAGNOSIS**  
 (A) Specimen A, biopsy:  
     Diagnosis B.  
 (B) Specimen B, biopsy:  
     Diagnosis A.  
 (A) Specimen A, biopsy:  
     Diagnosis A  
 (B). Specimen B, biopsy:  
     Diagnosis B

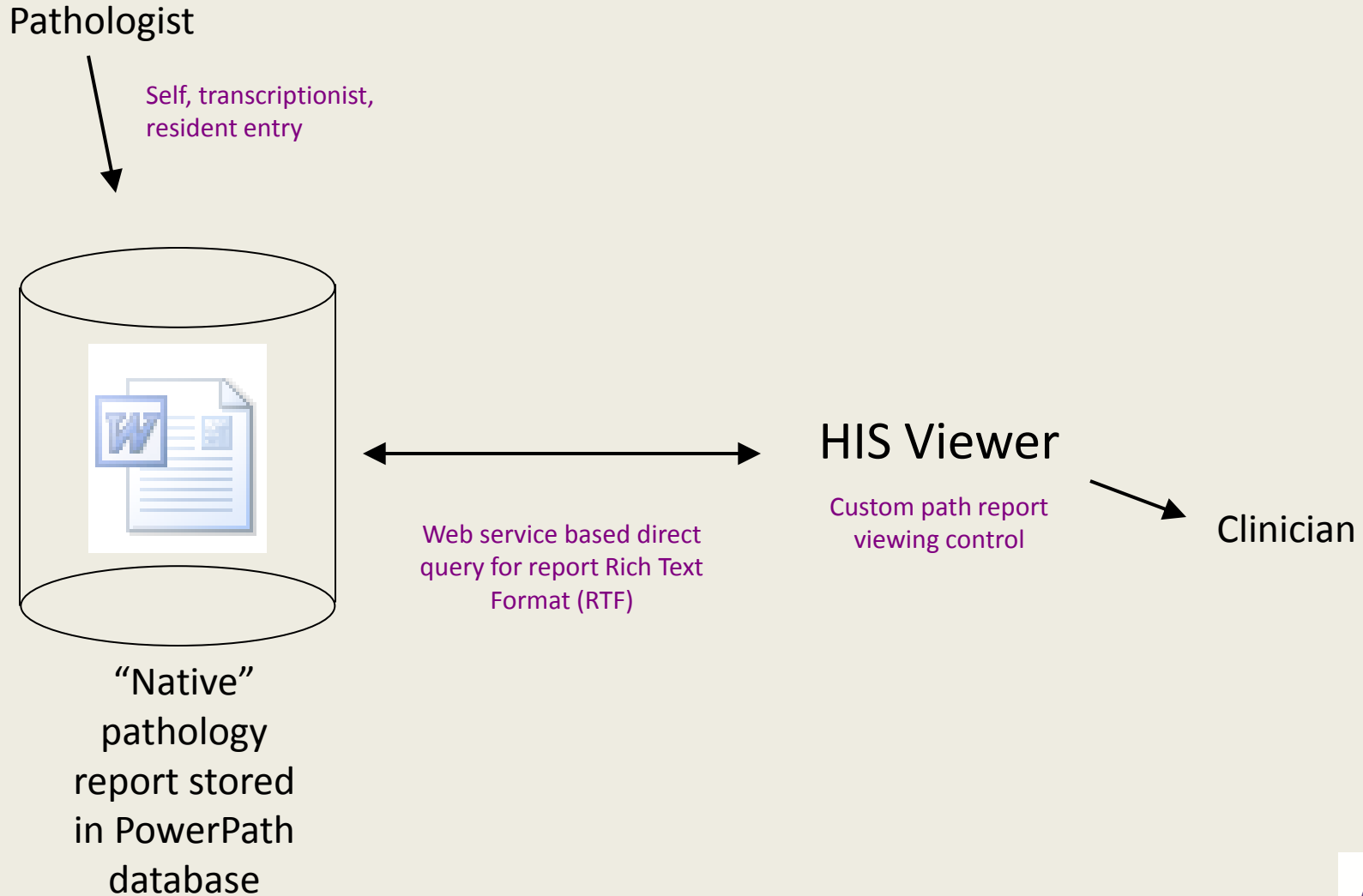
**GROSS DESCRIPTION**  
 This is the original gross description

**CLINICAL HISTORY**  
 None given.

**SNOMED CODES**  
 Snomed codes here.

"Some tests reported here may have been developed and performance characteristics determined by UT MD Anderson Pathology and Laboratory Medicine. These tests have not been specifically cleared or approved by the U.S. Food and Drug Administration."

# “Direct” electronic delivery of pathology reports



# Top Pitfalls for Interfacing

- Allowing multiple views of reality
  - For instance, enabling an ADT feed for patient demographics but also also manual patient entry for outreach
  - Multiple systems will always get out of synch – particularly if some allow manual data entry
  - Patient merges tend to be a band-aid solution for systemic problems

# Top Pitfalls for Interfacing

- Vendor promises
  - “Sure we can do that”
  - “We have an interface/flat file transfer system/API that can solve that issue”
  - Any promises should be
    - Taken with a grain of salt
    - Detailed in the contract (pre-nup)
    - Verified with references where possible
    - Verified with real world demonstration where possible

# Top Pitfalls for Interfacing

- Square pegs and round holes
  - Poor mapping between the relational database design or workflow requirements between two different systems can't be solved independently with interfacing technologies
    - Example. System A uses an 8 character mnemonic/code for lab tests. System B is not constrained.
  - Mapping issues require good old fashioned common sense, workflow/impact analysis, and harmonization between systems

# Summary

- There are many tools for LIS interfacing
- If you have a hammer, everything looks like a nail
- The specific tool is less important than
  - having a general understanding of the toolkit
  - asking questions and learning
  - seeking to merge domain expertise with technical implementation work