The Role of Interoperability in Critical Care Information Systems

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Objectives

- Describe the key components of Critical Care Information System (CCIS) interoperability.
- Describe how interoperability is supported between CCIS and other information systems.
- Describe how interoperability is supported between CCIS receives and devices.
Characteristics of Critical Care Clinical Information System (CCIS)

- Used in the care of the patients in critical care units
- Used to at the bedside to support and document patient care
- Used by all members of the multi-disciplinary team
Interoperability

The ability of two or more systems or components to exchange information and to use the information that has been exchanged (IEEE)

In healthcare, interoperability is the ability of different information technology systems and software applications to communicate, to exchange data accurately, effectively, and consistently, and to use the information that has been exchanged

(The National Alliance for Health Information Technology)
Why Interoperability is Important for CCIS

- To provide a higher level of usability by
  - Supporting patient care workflow in seamless manner
  - Reducing redundant entry

- To reduce patient care errors and improve the quality of care by
  - Reducing errors due to manual entry
  - Providing a more complete picture of the patient’s status and care at the point of care
  - Providing a complete pool of patient and administrative data for quality analysis
Levels of Interoperability

### Open Systems Interconnection Reference Model

- **Physical**: hardware related, wires, etc.
- **Data Link**: flow of data from device to device.
- **Network**: transmits address to address.
- **Transport**: insures transport of packets.
- **Session**: connections between systems.
- **Presentation**: formats the data for transport.
- **Application**: semantics meaning, how used by users.

By the ISO (International Organization of Standardization)
Key Components of CCIS Interoperability

- **Messaging**
  - Syntax – format/grammar of the message
  - Semantics – Meaning of the contents Supported by the structure of the message and terminologies

- **Mappings** – Mapping between items in the message and CCIS data dictionary using CCIS tools

- **CCIS role** – What is the role of the CCIS system?
Interoperability - Inbound

Sender

- Follows syntax rules
- Providers semantic meaning with terminologies

Receiver

- Uses mapping to interpret meaning
- Processes the message and performs the appropriate action according to role
CCIS Role

- CCIS may receive or send messages, depending on the situation

- Role
  - Performs a requested action
  - Tells others an unrequested action was performed
  - Ask others to perform actions
  - Tracks actions performed and requested by others
  - Or any combination thereof in a workflow scenario
Interoperability with Other Healthcare Information Systems

- **Messaging:**
  - **Syntax:** HL7 (Health Level 7) is the standard
  - **Semantic:** provided by HL7 message definitions and terminologies

- **Mappings:** tools in the CCIS map terminologies to data dictionary items

- **CCIS Role:** depends on the workflow scenario and the type of message
Intersystem Communication
Topology

LAB

ADT

Interface Engine

External Data Server

Applications

CCIS
External Device Server (EDS)

- A complex system, like a CCIS, is often broken down into subcomponents to reduce complexity and risk.
- EDS is a subcomponent of the CCIS that handles system and device communications in a common way for all external systems and devices.
- EDS and its configuration tools handle the interoperability below level 7.
- Contains a patient and bed index to match data to the correct patient.
What does HL7 provide?

- HL7 messages define the syntax and semantics for intersystem communication and identify the acceptable terminologies.
- HL7 standards are updated (versioned) on a periodic basis. The most common versions in use are 2.3, 2.4, and 2.5.
- See [www.hl7.org](http://www.hl7.org) for more information.
HL7 Standards – Areas (2.4)

- Patient Administration (ADT)
- Orders (and their implementation)
- Financial
- Observations/Results (like laboratory results)
- Medical Records/Document Management
- Scheduling
- Patient Referral
- Patient Care (goals, problems, pathways)
HL7 Message Components

Message -> Segments -> Fields -> Data Types

- Messages
  - An atomic unit with a single thought
  - Made up of segments
  - Has an number identifier and label such as A01
  - Belongs to an HL7 area

- Segments
  - Is a grouping of data fields
  - May be required or optional
  - May be repeating
  - Short identifiers such as PV1
  - Reused by multiple messages
  - Contains Fields
HL7 Message Components cont

- **Fields**
  - Has a certain position in a segment
  - Has a data type
  - May be required or optional
  - May be repeating

- **Data Type (examples)**
  - String
  - Number
  - Date
  - Coded Element
  - Person name, Address, Telephone number, etc.
## HL7 Table Example

### Table 0127 Allergen Type

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
<td>Drug allergy</td>
</tr>
<tr>
<td>FA</td>
<td>Food allergy</td>
</tr>
<tr>
<td>MA</td>
<td>Miscellaneous allergy</td>
</tr>
<tr>
<td>MC</td>
<td>Miscellaneous contraindication</td>
</tr>
<tr>
<td>EA</td>
<td>Environmental Allergy</td>
</tr>
<tr>
<td>AA</td>
<td>Animal Allergy</td>
</tr>
<tr>
<td>PA</td>
<td>Plant Allergy</td>
</tr>
<tr>
<td>LA</td>
<td>Pollen Allergy</td>
</tr>
</tbody>
</table>

HL7 tables with terms specific to their messages…
**HL7 Message Definition Example**

- **A01**: Admission to hospital
- **PV1**: segment name
- `{ }` can repeat
- `[]` optional

---

<table>
<thead>
<tr>
<th>ADT^A01^ADT_A01</th>
<th>MSH</th>
<th>Message Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVN</td>
<td>PID</td>
<td>Patient Identification</td>
</tr>
<tr>
<td>[ PD1 ]</td>
<td>[ ]</td>
<td>Additional Demographics</td>
</tr>
<tr>
<td>[ ROL ]</td>
<td>[ ]</td>
<td>Role</td>
</tr>
<tr>
<td>[ NK1 ]</td>
<td>[ ]</td>
<td>Next of Kin / Associated Parties</td>
</tr>
<tr>
<td>PV1</td>
<td>[ ]</td>
<td>Patient Visit</td>
</tr>
<tr>
<td>[ PV2 ]</td>
<td>[ ]</td>
<td>Patient Visit - Additional Info.</td>
</tr>
<tr>
<td>[ ROL ]</td>
<td>[ ]</td>
<td>Role</td>
</tr>
<tr>
<td>[ DB1 ]</td>
<td>[ ]</td>
<td>Disability Information</td>
</tr>
<tr>
<td>[ OBX ]</td>
<td>[ ]</td>
<td>Observation/Result</td>
</tr>
<tr>
<td>[ AL1 ]</td>
<td>[ ]</td>
<td>Allergy Information</td>
</tr>
<tr>
<td>[ DG1 ]</td>
<td>[ ]</td>
<td>Diagnosis Information</td>
</tr>
<tr>
<td>[ DRG ]</td>
<td>[ ]</td>
<td>Diagnosis Related Group</td>
</tr>
<tr>
<td>[ ]</td>
<td>PR1</td>
<td>Procedures</td>
</tr>
<tr>
<td>[ ROL ]</td>
<td>[ ]</td>
<td>Role</td>
</tr>
<tr>
<td>[ GT1 ]</td>
<td></td>
<td>Guarantor</td>
</tr>
</tbody>
</table>
## PV1 Segment Definition

<table>
<thead>
<tr>
<th>SEQ</th>
<th>LEN</th>
<th>DT</th>
<th>OPT</th>
<th>RP/#</th>
<th>TBL#</th>
<th>ITEM#</th>
<th>ELEMENT NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>SI</td>
<td>O</td>
<td></td>
<td></td>
<td>00131</td>
<td>Set ID - PV1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>IS</td>
<td>R</td>
<td></td>
<td></td>
<td>00132</td>
<td>Patient Class</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
<td>PL</td>
<td>O</td>
<td></td>
<td></td>
<td>00133</td>
<td>Assigned Patient Location</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>IS</td>
<td>O</td>
<td></td>
<td></td>
<td>00134</td>
<td>Admission Type</td>
</tr>
<tr>
<td>5</td>
<td>250</td>
<td>CX</td>
<td>O</td>
<td></td>
<td></td>
<td>00135</td>
<td>Pre-admit Number</td>
</tr>
<tr>
<td>6</td>
<td>80</td>
<td>PL</td>
<td>O</td>
<td></td>
<td></td>
<td>00136</td>
<td>Prior Patient Location</td>
</tr>
<tr>
<td>7</td>
<td>250</td>
<td>XCN</td>
<td>O</td>
<td>Y</td>
<td>0010</td>
<td>00137</td>
<td>Attending Doctor</td>
</tr>
<tr>
<td>8</td>
<td>250</td>
<td>XCN</td>
<td>O</td>
<td>Y</td>
<td>0010</td>
<td>00138</td>
<td>Referring Doctor</td>
</tr>
<tr>
<td>9</td>
<td>250</td>
<td>XCN</td>
<td>B</td>
<td>Y</td>
<td>0010</td>
<td>00139</td>
<td>Consulting Doctor</td>
</tr>
</tbody>
</table>
Example of ADT Message

MSH|^~\&|ADT1|MCM|LABADT|MCM|198808181126|SECURITY|ADT^A01|MSG00001|P|2.4|
EVN|A01|1988081811123||
PID|1||PATID1234^5^M11^ADT1^MR^MCM~123456789^~~USSSA^SS||JONES^WILLIAM^A^III||19610615|M-
||C|1200 N ELM STREET^^GREENSBORO^NC^27401-1020|GL|(91-9)379-1212|(919)271-3434||S||
PATID12345001^2^M10^ADT1^AN^A|123456789|9-87654^NC|
NK1|1|JONES^BARBARA^K|WI^WIFE|||NK^NEXT OF KIN
Example of Message Exchange – ADT messages

A01: Pt Admission

Patient Admitted

Admit Patient to Unit

A08: Update Demographics

Update demographics

Demographics updated
Example of Message Exchange
Medication Orders

1. O09 OMP
2. O11 RDE

1. O09 OMP
2. O11 RDE

2. O11 RDE
3. O15 RGV
4. O17 RAS

3. O15 RGV
4. O17 RAS
Common Exchanges with a CCIS

<table>
<thead>
<tr>
<th>System</th>
<th>CCIS Direction</th>
<th>CCIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADT</td>
<td>In</td>
<td>Admit and discharge patients. Update demographics</td>
</tr>
<tr>
<td>ADT</td>
<td>Out</td>
<td>Demographic updates. ADT actions</td>
</tr>
<tr>
<td>Lab and other results systems</td>
<td>In</td>
<td>Lab results stored and displayed on flowsheet</td>
</tr>
<tr>
<td>Pharmacy/CPOE</td>
<td>In</td>
<td>Orders and pending interventions are displayed on administration records and worklists</td>
</tr>
<tr>
<td>Billing, Pharmacy, CPOE</td>
<td>Out</td>
<td>Medications given and tasks completed.</td>
</tr>
<tr>
<td>Data Repository</td>
<td>Out</td>
<td>Patient data like vital signs, notes, and others</td>
</tr>
<tr>
<td>Document Repository</td>
<td>Out</td>
<td>Documents such as discharge summary</td>
</tr>
<tr>
<td>Systems generating documents</td>
<td>In</td>
<td>Such as pre-anesthesia evaluations</td>
</tr>
</tbody>
</table>

All HL7 communications involve acknowledgement (hand shake)
Example of Mapping Items

Configuration tool for mapping lab items to data dictionary items

Data Dictionary Item

Item property to receive the data

Identifier sent by other system

This example is using the LOINC ® code to identify the lab result
Example of Mapping HL7 Tables
Challenges

- Different versions of HL7 and different interpretations of standards

- What patient identifier to use? Patient’s have multiple identifiers

- What if the patient is not here yet – the need for an orphan pool in the EDS

- Expertise required for implementation

- Testing the interface
Devices

- Infusion pumps, cardiac monitors, ventilators, etc.
- Organization: IEEE developing standards - MIB (Medical Information Bus)
- Problems with devices – standards have not been developed as far along as HL7
Device Communication Topology

Device Linker: outputs data from different devices into a standard format
Syntax and Semantics

- Until it reaches the External Data Server (EDS), syntax and semantics can vary.
- MIB provides some terminology to identify parameters, but is incomplete and not used consistently among devices.
- Often vendors have to expand the terminology to cover all of the parameters it deals with. This terminology is used and enforced by the EDS.
The Role of Interoperability in Critical Care Information Systems

Mapping Example

Data Dictionary item

Item Attribute to Capture Data

Device Data Terminology

[Diagram showing a window for mapping and capturing data]
CCIS Role

- **Data is**
  - Periodic (chart every hour)
  - Aperiodic (chart cardiac output when done)
  - Charted on change (chart when setting is changed on ventilator)

- **Depending on the type of data:**
  - Auto-charting – such as charting a heart rate every hour.
  - As default data – click on a cell and get data from the device as a default which is approved and accepted by the clinician.
## Use of Device Data

<table>
<thead>
<tr>
<th>Flowsheet (Adult)</th>
<th>5/14/2008 8:00 AM</th>
<th>9:00 AM</th>
<th>10:00 AM</th>
<th>11:00 AM</th>
<th>12:00 PM</th>
<th>1:00 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg) (Daily)</td>
<td>44.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp (°C)</td>
<td>37.0</td>
<td></td>
<td>37.0</td>
<td></td>
<td>37.0</td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>66</td>
<td>77</td>
<td>80</td>
<td>98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac Rhythm</td>
<td>NSR</td>
<td>NSR</td>
<td>NSR</td>
<td>NSR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac Ectopy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NBP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Art BP</td>
<td>120 / 66 (84)</td>
<td>130 / 80 (97)</td>
<td>135 / 84 (101)</td>
<td>136 / 88 (104)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiration Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SpO2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart Sounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5W</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adm Volume</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adm Rate</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adm Site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PO Intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foley Insert Date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stool Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Auto Charted**

**Default Data**
Challenges

- Insufficient standards and adoption.
- Large volume of data: data received every 30 seconds
- Need for back charting – need to keep old data for a period of time
- Data is not always valid
- Patient identification: sometimes by bed, sometimes by MRN
- Multiple devices give the same clinical value like heart rate
- Large terminology: > 10,000 items
- Multiple types of devices in the hospital
- Not sure what parameters are provided by what devices for particular bed
- Patient may not be identified for a period of time – need an orphan pool
Infusion Pumps
Challenges of Interfacing to Pumps

- **Pumps**
  - One pump may handle multiple infusions at the same time
  - Provide boluses and secondary infusions
  - Not identified by friendly names
  - May move from bed to bed or be wireless

- **Patients**: on multiple infusions at the same time with multiple pumps

- **Smart Pumps**: drug and infusion names are short

- **Overall**: the CCIS flowsheet contains rows that identify multiple infusions. But there is insufficient information to automatically determine which infusion pump is matched to which flowsheet row. So manual mapping between the pump and the row on the CCIS flowsheet is often required.
Example of Mapping Pumps in the CCIS Flowsheet

Available pumps

Flowsheet row with pumps assigned
In Summary

- Interoperability is a requirement for CCIS
- Interoperability with other systems is better understood and easier to support than with bedside devices
- Key aspects of CCIS interoperability are message syntax, message semantics, mapping, and CCIS role
Thank You

Feel free to contact me with questions

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