Exploring HL7 Standards

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Rose Ann Zuniga | Blogs | January 15, 2020

In 2030, a patient will enter a clinic to have his regular check-up. Upon entering the clinic, the receptionist nurse will bring out her phone and ask the patient for a copy of his ID for the ID number. The nurse will just scan the ID using an application she downloaded online for free. She will then put the patient's ID number in a web portal to obtain vital health data. She will see that the patient is wearing Apple Watch, and she will request if she can transfer the heart beat data, and sleeping record from the watch to her application.

The patient will wait at the Lobby until called. Once called, the Doctor, using her own mobile app, costing 2$ will receive the patient's records from the receptionists. It now includes the Apple Watch data. She will also view the patient's past medical history by querying it from an online record repository. This will also contain records from other facilities.

After the check-up, the patient will be asked by the receptionist to log in to a payment app. Since the patient has his own health insurance, the patient will just share his ID to the payment app and it will automatically make a claim to the insurance provider.

This is the future of digital health. There will be no enterprise Electronic Medical Records (EMRs) or a single monolithic Electronic Health Record (EHR) or Hospital Information System (HIS). Facilities will be using small apps made by startups for each of the workflows. There will be an admission app, a consultation app, and a monitoring app. Data from wearables such as Fitbit or Apple Watch will be available to health providers. Piece-wise health data will be collected and this cannot be done using existing standards such as HL7V2 or HL7 CDA. This requires the use of APIs and the sharing of data

Rose Ann Zuniga

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Introduction to HL7 Standards

HL7 V2, V3, CDA, and FHIR are the health data exchange standards that were released by the Health Level 7 (HL7) International group.

The Health Level 7 (HL7) International group released HL7 V2, V3, CDA, and FHIR health data exchange standards. As health data exchange standards, these are used widely by EHRs/EMRs around the world today. Each of the above-mentioned standards was developed using a different framework and mindset.

A. HL7 V2

Health Level Seven Version 2 (V2) is a purely messaging standard that allows the exchange of clinical data between systems. It is designed to support a central patient care system as well as a more distributed environment where data resides in departmental systems. **(Source: HL7 V2 Briefer)**

Benefits:

As stated on the official website, the following are the benefits of using V3:

- Supports the majority of the common interfaces used in the healthcare industry globally
- Provides a framework for negotiations of what is not in the standard
- Reduces implementation costs
- Generally backward compatible

Message Structure:

An HL7 V2 message is composed of texts, pipes, and hats.

- Sample message

```
MSH|^~\&|GHH LAB|ELAB-3|GHH
OE|BLDG4|200202150930||ORU^R01|CNTRL-
3456|P|2.4<cr>
PID|||555-44-
4444||EVERYWOMAN^EVE^E^^^^L|JONES|19620320|F|||153
FERNWOOD DR.^
^STATESVILLE^OH^35292||(206)3345232|(206)752-
121||||AC555444444||67-A4335^OH^20030520<cr>
OBR|1|845439^GHH OE|1045813^GHH
LAB|15545^GLUCOSE|||200202150730|||||||
555-55-5555^PRIMARY^PATRICIA
P^^^^MD^^|||||||||F||||||444-44-
4444^HIPPOCRATES^HOWARD H^^^^MD<cr>
OBX|1|SN|1554-5^GLUCOSE^POST 12H
CFST:MCNC:PT:SER/PLAS:QN||^182|mg/dl|70_105|H|||F<cr>
```

B. HL7 V3

The Health Level Seven Version 3 (V3) provides a full set of messages, data types, and terminologies. The V3 specification is built around subject domains that provide storyboard descriptions, trigger events, interaction designs, domain object models derived from the Reference Information Model

specifications for data types; the XML technical specifications (ITS) or message wire format; message and control “wrappers”, and transport protocols. (**Source: HL7 V3 Briefer**)

Benefits:

As stated on the official website, the following are the benefits of adapting V3:

- Focuses on semantic interoperability by specifying that information be presented in a complete clinical context that assures that the sending and receiving systems share the meaning (semantics) of the information being exchanged
- Designed for universal application so that the standards can have the broadest possible global impact and yet be adapted to meet local and regional requirements
- Provides a consistent representation of data laterally across the various HL7 domains of interest and longitudinally over time as new requirements arise and new fields of clinical endeavor are addressed
- Allows implementers to take advantage, at any point in time, of the latest and most effective implementation technologies available
- Assures consistent development and the ability to store and manipulate the specifications in robust data repositories rather than as word-processing documents

Message Structure:

Messages and electronic documents are expressed in XML documents, which is totally different from the v2. The object data are included as sub-data in the XML tags.

- Sample message

```
<observationEvent>
<id root="2.16.840.1.113883.19.1122.4"
extension="1045813"
assigningAuthorityName="GHH LAB Filler
Orders"/>
<code code="1554-5" codeSystemName="LN"
codeSystem="2.16.840.1.113883.6.1"
displayName="GLUCOSE^POST 12H
CFST:MCNC:PT:SER/PLAS:QN"/>
<statusCode code="completed"/>
<effectiveTime value="200202150730"/>
<priorityCode code="R"/>
<confidentialityCode code="N"
codeSystem="2.16.840.1.113883.5.25"/>
<value xsi:type="PQ" value="182"
unit="mg/dL"/>
<interpretationCode code="H"/>
<referenceRange>
<interpretationRange>
<value xsi:type="IVL_PQ">
<low value="70" unit="mg/dL"/>
<high value="105" unit="mg/dL"/>
</value>
<interpretationCode code="N"/>
</interpretationRange>
</referenceRange>
```

C. CDA

The HL7 Version 3 Clinical Document Architecture (CDA) is part of the HL7 V3 with a focus on the actual clinical documents. CDA is a document markup standard that specifies the structure and semantics of “clinical documents” for the purpose of exchange between healthcare providers and

A CDA can contain any type of clinical content but typically would contain Discharge Summary, Imaging Report, Admission & Physical, Pathology Report and/or more. The most popular use is for inter-enterprise information exchange, e.g. US Health Information Exchange (HIE). (**Source: HL7 V3 CDA Briefer**)

Benefits:

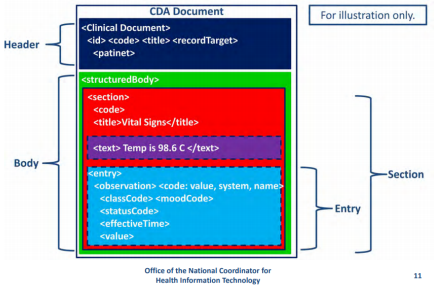
As stated on the official website, the following are the benefits of CDA:

- Supports the exchange of clinical documents between those involved in the care of a patient
- Supports the re-use of clinical data for public health reporting, quality monitoring, patient safety, and clinical trials
- Can be reused in multiple applications

Message Structure:

Since it is basically a V3, CDA is based on the XML.

- Document structure



- Sample message (Link to download sample message)

D. FHIR

HL7 Fast Healthcare Interoperability Resources (FHIR) standards use RESTful APIs as its data access model. FHIR combines the best features of HL7's Version 2, Version 3 and CDA product lines while leveraging the latest web standards and applying a tight focus on implementation The building blocks of FHIR is a set of modular components called "Resources". These resources, since modular, can be pick-and-match depending on one's needs and be assembled into working systems that solve real-world clinical and administrative problems. FHIR is suitable for use in a wide variety of contexts – mobile phone apps, cloud communications, EHR-based data sharing, server communication in large institutional healthcare providers, and much more. **(Source: HL7 FHIR Briefer, HL7 FHIR)**

Benefits:

As stated on the official standard briefer, the following are the benefits of FHIR:

- A strong focus on implementation – fast and easy to implement (multiple developers have

restrictions

- Interoperability out-of-the-box– base resources can be used as-is, but can also be adapted for local requirements
- Evolutionary development path from HL7 Version 2 and CDA – standards can co-exist and leverage each other
- Strong foundation in Web standards– XML, JSON, HTTP, Atom, OAuth, etc.
- Support for RESTful architectures and also seamless exchange of information using messages or documents
- Concise and easily understood specifications
- A Human-readable wire format for ease of use by developers
- Solid ontology-based analysis with a rigorous formal mapping for correctness

Message Structure:

FHIR is described as a 'RESTful' specification however, it relies on the standardization of resource structures and interfaces. This may be considered a violation of REST principles but is key to ensuring consistent interoperability across diverse systems.

Each "resource type" has the same set of interactions defined that can be used to manage the resources in a highly granular fashion. Transactions are performed directly on the server resource using an HTTP request/response.

An application programming interface (API) is a set of instructions written by a developer and is published publicly for the benefit of other developers. The goal of APIs is to give other developers a common, standard way of accessing data/writing software that communicates with one another.

The API describes the FHIR resources as a set of operations/interactions on resources where individual resource instances are managed in collections by their type. Servers can choose which of these interactions are made available and which resource types they support. The API does not directly address authentication, authorization, and audit collection.

- RESTful API interaction's basic form

```
VERB [base]/[type]/[id] {?_format=[mime-type]}
```

- Sample FHIR API interaction

```
http://172.104.170.172:8080/sila-
    fhirserver/fhir/Condition?
     patient.identifier=4954
```

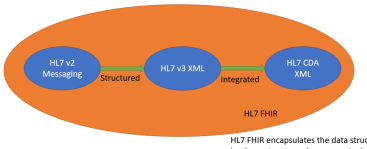
- Sample message

```
                {
          "resourceType": "Patient",
               "id": "example",
                  "text": {
             "status": "generated",
                 "div": "<div
xmlns=\"http://www.w3.org/1999/xhtml\">\n\t\t\t<table>\n\t\t\t\t<tbody>\n\t\t\t\t\t<tr>\n\t\t\t\t\t\t<td>Name</td>\n\
    James \n             <b>Chalmers</b>
       (&amp;quot;Jim&amp;quot;)\n
</td>\n\t\t\t\t\t</tr>\n\t\t\t\t\t<tr>\n\t\t\t\t\t\t<td>Address</td>\n\t\t\t\t\t\t<td>534
        Erewhon, Pleasantville, Vic,
3999</td>\n\t\t\t\t</tr>\n\t\t\t\t\t<tr>\n\t\t\t\t\t\t<td>Contacts</td>\n\t\t\t\t\t\t<td>Home:
```

```
                "identifier": [
                    {
                  "use": "usual",
                     "type": {
                     "coding": [
                         {
                       "system":
"http://terminology.hl7.org/CodeSystem/v2-
                    0203",
                       "code": "MR"
                         }
                        ]
                     },
                   "system":
    "urn:oid:1.2.36.146.595.217.0.1",
                   "value": "12345",
                      "period": {
                  "start": "2001-05-06"
                     },
                    "assigner": {
                "display": "Acme Healthcare"
                     }
                    }
                  ],
                "active": true,
                   "name": [
                    {
                  "use": "official",
                "family": "Chalmers",
                     "given": [
                       "Peter",
                       "James"
                        ]
                     },
                     {
                  "use": "usual",
                     "given": [
                        "Jim"
                        ]
                     },
                     {
                  "use": "maiden",
                "family": "Windsor",
                     "given": [
                       "Peter",
                       "James"
                        ],
                     "period": {
                     "end": "2002"
                        }
                    }
                  ],
                "telecom": [
                    {
                  "use": "home"
                     },
                    {
                "system": "phone",
               "value": "(03) 5555 6473",
                     "use": "work",
                       "rank": 1
                     },
                    {
                "system": "phone",
               "value": "(03) 3410 5613",
                  "use": "mobile",
                      "rank": 2
                     },
                    {
                "system": "phone",
               "value": "(03) 5555 8834",
                     "use": "old",
                      "period": {
                      "end": "2014"
                        }
                    }
                  ],
              "gender": "male",
            "birthDate": "1974-12-25",
                 "_birthDate": {
                  "extension": [
                      {
                    "url":
"http://hl7.org/fhir/StructureDefinition/patient-
                    birthTime",
          "valueDateTime": "1974-12-25T14:35:45-
                    05:00"
                      }
                    ]
                  },
              "deceasedBoolean": false,
                    "address": [
                      {
                    "use": "home",
                    "type": "both",
            "text": "534 Erewhon St PeasantVille,
                  Rainbow, Vic  3999",
                      "line": [
                    "534 Erewhon St"
                      ],
                  "city": "PleasantVille",
                   "district": "Rainbow",
                     "state": "Vic",
                  "postalCode": "3999",
                      "period": {
```

```
                {
                "coding": [
                    {
                    "system":
"http://terminology.hl7.org/CodeSystem/v2-
0131",
                    "code": "N"
                    }
                ]
                }
            ],
            "name": {
            "family": "du Marché",
                "_family": {
                "extension": [
                    {
                    "url":
"http://hl7.org/fhir/StructureDefinition/humanname-
own-prefix",
                    "valueString": "VV"
                    }
                ]
                },
                "given": [
                "Bénédicte"
                ]
            },
            "telecom": [
                {
                "system": "phone",
            "value": "+33 (237) 998327"
                }
            ],
            "address": {
            "use": "home",
            "type": "both",
                "line": [
                "534 Erewhon St"
                ],
            "city": "PleasantVille",
            "district": "Rainbow",
                "state": "Vic",
            "postalCode": "3999",
                "period": {
                "start": "1974-12-25"
                }
            },
            "gender": "female",
                "period": {
                "start": "2012"
                }
            }
            ],
        "managingOrganization": {
        "reference": "Organization/1"
            }
        }
```


Relationship of HL7 Standards



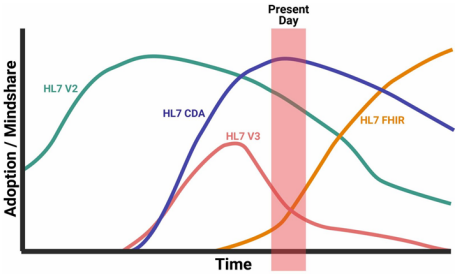
HL7 FHIR encapsulates the data structure allowing implementers to no longer manipulate the actual data structure, but it already have available functions to access the data without knowing the actual structure.

HL7 V2 was originally designed as a message format. It presents a way of how health data can be formatted. EMRs sharing health data just need to follow the format provided by V2 and implement a parser for HL7 V2 messages. HL7 V3 provided structure to HL7 V2 messages. Instead of having a stream of text messages, HL7 V3 messages were written using XML, and follows RIM objects. This eliminates the need to actually parse the data, but instead, a document object model can be adapted. HL7 CDA followed HL7 V3, but instead of being mere messages, it integrated several data objects to form documents. The motivation of HL7 CDA objects are clinical documents.

</admission document>

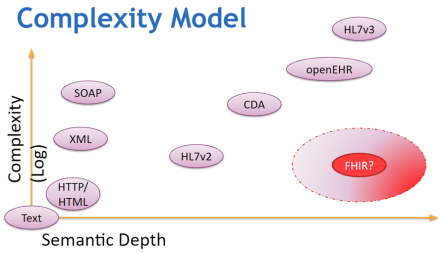
HL7 FHIR encapsulated the data model of earlier HL7 versions and made use of APIs to allow developers to access the data they need. In HL7 FHIR there is no more need to parse the message or use a document object model. It leaves it to the implementer how it will structure health data (though it has specifications that can be followed) – but rather it only defines how data can be accessed, read or modified.

HL7 Standards Usage

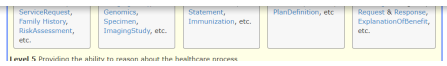


In terms of usage, currently, HL7 CDA is still the leading data exchange standard in the world. It has already surpassed HL7 V2 during the early 2010's. HL7 FHIR is the leading draft standard, and upon its adoption by countries and corporations, it is projected that FHIR will exceed CDA before 2020. This is accepted since HL7 FHIR has been very useful (most useful) for digital health implementers and developers, as they are the once who first accepted this technology.

Complexity Model



In terms of complexity of use, HL7 FHIR is pretty simple to use since one only needs to invoke (C)reate, (R)ead, (U)pdate and (D)elete to manipulate the FHIR database. No additional operations are needed and there is no need to parse any text (HL7v2) or XML file (CDA). In terms of semantic usage, FHIR provides a reach set of resources, each with its corresponding data files modeling the whole health – care processes. There are a total of 150 resources that models all aspect of health care – from actual patient data to financial-related objects. It is richer than HL7 V2 or HL7 CDA.



General Comparison

Show 10 entries

Search:

Criteria	HL7 V2	HL7 V3	HL7 CDA	HL7 FHIR
General Structure	Message	Structured Message	Document	Application Programming Interface (APIs)
Use - cases	Purely medical record exchange	Purely medical record exchange	Purely clinical document exchange	Health data exchange. Data from other sources (wearables, mobile apps, laboratory devices) can be shared. Clinical documents can be shared. Medical records can be shared. Individual patient data can be shared. Provider data can be shared, facility data can be shared
Platform	EMR/EHR/HIS	EMR/EHR/HIS	EMR/EHR/HIS	EMR/EHR/HIS/ Phone applications/wearables
Flexibility	Flexible as it requires few fields	Less flexible as it requires more fields	Less flexible as it requires more fields	Very flexible as very few fields are required
Extensibility	Not extensible	Not extensible	Not extensible	Extensions of resources is allowed

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Technical Comparisons

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Search:

Criteria	HL7 V2	HL7 V3	HL7 CDA	HL7 FHIR	Comments

Format	pipe and hat characters			API based access	mostly a message format it only use standard text format for its messages. V3 and CDA are more structured while for FHIR - functions are already available to handle the data and there is no need to manipulate the actual data
Learning overhead	order of weeks	order of months	order of months	order of weeks	It is easier to study HL7 FHIR since the implementation details are already encapsulated.
Interoperability Method	Syntactic	Syntactic and Semantic	Syntactic and Semantic	Syntactic and Semantic	FHIR and HL7 V3 offers a reach platform since it enables object fields to be connected to a single term. This is not possible with V2 or V1 since they only define a way to write health messages.
Security	Security on the transmission layer	Security on the transmission layer	Security on the transmission layer	Security can be built in the transmission layer and SSL can be used	For HL7 V2/V3/CDA - security must be implemented separately since these are merely a messaging standard. FHIR can have its security in the transmission layer but it can also be embedded in the server itself.
Requires special tool	Parser	Model compiler	Model compiler	None (use only console + browser)	

				sample files on the FHIR reference site
Use of ICD	Support to ICD is limited and static	ICD can be embedded as an object	ICD can be embedded as an object	ICD can be embedded as an object
Use of LOINC	Support to LOINC is limited and static	LOINC can be embedded in RIM object	LOINC can be embedded in RIM object	LOINC can be embedded in RIM object
Use of DICOM	Support to DICOM is limited	DICOM can be embedded in RIM object	DICOM can be embedded in RIM object	DICOM can be embedded in RIM object
Compatibility	All V2 features are compatible	V3 not compatible to V2	CDA not compatible to earlier version	Back compatible with V3/CDA. Not compatible with V2

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Sources

- Comparative Study of Healthcare Messaging Standards for Interoperability in eHealth systems
- HL7 FHIR: An agile and RESTful approach to healthcare information exchange
- 4 Basics to Know about the Role of FHIR in Interoperability

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