

Personal Health Records in Southeast Asia

Part 3 - Communications with the CCR Standard

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Abstract

Establishment of Personal Health Record (PHR) systems could help solve the problems of computerization of healthcare systems in developing nations in Southeast Asia; if they are Web-based, we call them WWW-PHRs. Such systems allow individuals to own and maintain their personal health records, but they should also allow data collection from healthcare providers and institutions, some of whom maintain their own Hospital Information Systems (HIS). So the problem of data exchange between HISs and WWW-PHRs must be addressed.

WWW-PHR systems such as Microsoft Health Vault use the Continuity of Care Record (CCR) format for input (and output), which is correct, as such systems collect snapshots of personal health information. On the other hand, HL7 v2.x standards are the predominant ones used by healthcare institutions; they have been designed to provide a complete set of messages for the organization and provision of healthcare, but without an explicit patient record in the design.

We describe a solution to match the functionally-oriented HL7 format with the object-(patient)-oriented CCR format – translation packages which run within a general message gateway; it is in the public domain (<http://code.google.com/a/eclipselabs.org/p/hmapper/>), so is open for improvements from knowledgeable institutions and individuals. The mapping approach can be extended to include other plain text formats with, for example, name-value pairs of parameters and data.

Keywords: Continuity of Care Record; CCR; HL7; Personal Health Record; PHR

1 Introduction

There are many Health (or Healthcare or Hospital) Information Systems (HISs) in the world today. Due to the often haphazard development of HISs, since the 1980's interoperability has been a key concern, and it was for this reason that the HL7 standards arose. Accepting that different institutions and even different departments within one institution may have different data, data structures and applications, the HL7 organization developed sets of messaging standards to allow different departments and their computer applications (thus the Level 7 in HL7) to safely exchange data. The HL7 v2.x mes-

sages are still mostly text-based, with defined formats, as they were in the 1980's and 1990's. HL7 did not develop a "standard" medical record. (Later the American Standards for Technology and Materials – ASTM – did develop such a standard, ASTM E1384 [1], but it has not been widely adopted.) Nowadays most major healthcare organizations in North American, Europe and some other nations use HL7 version 2.x messaging.

For financial and other reasons, healthcare facilities in developing nations have, if at all, a plethora of small, variably developed information systems. The question of affordable communications remains a chronic problem.

The relatively recent appearance of Personal (or Personally Controlled) Health Records (PHR) introduces a new factor into health and healthcare communications. Firstly, they emphasize ownership and maintenance by the patient or person concerned. The PHRs collect input directly from the owner (person), who may also allow healthcare providers access to his or her PHR. Secondly, as Web-based systems they allow access to PHRs from anywhere on the Internet. An early PHR was IndivoHealth [2], it gave rise to others, and now there are several commercial, government-sponsored, or even open-source PHRs, as a search of the Web easily shows.

Because PHRs are concerned with the health records of individuals, and not so much with the management of healthcare facilities, they do not need or use the HL7 v2.x set of communication standards. Instead, at least some of them use a more recently introduced standard for healthcare referral content and format, the Continuity of Care Record or CCR [3]. The CCR is well suited to PHRs; a PHR can even be viewed as a longitudinal collection of “snapshots” of the person’s health history. The CCR was developed by the ASTM as a digital form of a healthcare referral. It, like a referral, is a patient-oriented document which describes the state of the individual at the time of the referral. It has been compared to a “snapshot” of the person’s health record [4]. It is directly derived from XML, the standard generic description of data.

PHRs hold considerable promise for developing nations where Internet access has a broader reach than institutional healthcare. On the other hand, in regions of SE Asia the mobile phone network reaches much further than the Internet. This has led Seldon to propose that in developing nations with wider cellphone coverage than Internet coverage, the PHR can be viewed as matching or synchronized Web-based records (WWW-PHR) and cellphone-based (or portable – PPHR) records [13]. Due to the limited resources available on many cellphones, health data there would be stored as name-value pairs using plain text. This format will be discussed below. Uploading data from phone-based records to WWW-PHRs can use the CCR format as a standard for compatibility.

At least the WWW-PHR systems should also allow input from “legacy” systems which do not use the CCR message format. But this raises the problem of communications between functionally-oriented HL7 systems and record-oriented PHRs. This paper presents a key component of that communication, namely maps between disparate message formats or terminologies, specifically between the CCR and HL7 v2.5.

Preliminary versions of parts of this work have been presented in Vietnam [5] and Malaysia [6].

2 Methods

2.1 Translation system – Message gateway

Communications between HISs and PHRs (or WWW-PHRs) would likely go through a message gateway as is found in healthcare networks. To be of any use to developing nations, the gateway must be platform-independent and open-source (i.e., free of charge). It must be able to handle all the relevant message formats and transmission protocols which are used within its network.

All of these requirements except the specific translations required by the proposed PHR system are met by Mirth Connect [7], which was therefore chosen as the message gateway within which to implement this translation.

Similar requirements derive from standards such as ISO 18308, which describes an EHR Architecture [8]. It requires an EHR to be portable, integrated with other data repositories, and viewable in a “problem-oriented” manner, among others. Of course “user-friendliness” is also a requirement.

2.2 Message formats

2.2.1 HL7 v2.x Structure

This has been described in many places, so need not be repeated here. We used the HL7 version 2.5 description [9] extensively. Each message comprises segments, fields and components, and each item has rules regarding its content and format. They are described in chapters 2-15 of the standards documents. HL7 message parsers check the content of each message element against the official description. It should be noted that the Mirth HL7 message gateway strictly parses incoming HL7 messages and rejects any which contain an error. Thus, the input to the HL7 => CCR map is a strictly correct HL7 message.

Importantly, the HL7 standards include many message types, with each type being appropriate for a certain action or event. Thus, each message type includes the information relevant to the corresponding action. There is no “overall patient description” message type.

2.2.2 CCR Structure

CCR messages, written in XML, follow the standard description as published in ASTM E 2369 – 05 [3]. CCR messages are intended to be standardized referrals and include “overall patient descriptions” as part of the referrals. The top-level structure includes elements such as

- <Body> (information about the patient)
 - <Functional Status>
 - <Problems>
 - <Alerts>
 - <Medications>
 - <Vital Signs>
 - <Results>
 - <Procedures> etc.
- <Actors> (includes “entities” like the patient, healthcare providers, organizations, etc. References to those are linked here via <ActorID> tags.) among others. See ASTM E 2369-05, Figure A2.1 [3].

2.3 Types of Field Correspondence

The main problem in a HL7 $\leftrightarrow$ CCR map is that CCR elements correspond to fields or components distributed across various HL7 segment types, and there does not seem to be a single HL7 message type which includes all the possible segments which may be required to map a single CCR message. This is because HL7 messages correspond to individual functions or actions rather than to a complete description of a person’s health.

Fields in these disparate message formats can be matched in two ways – directly or conditionally. A direct correspondence means that a field in one always matches a specific field in the other. A conditional map means that the content of a field is a factor in determining which field in the other format to target. In the tables below “Conditional options” indicates what conditions were found for particular mappings.

2.4 HIS $\Rightarrow$ WWW-PHR Messages (HL7 v2.x $\Rightarrow$ CCR)

The WWW-PHR must be able to accept data from existing HISs which may include relevant patient information. As mentioned above, HISs use HL7 v2.x to manage the organization and delivery of healthcare. HL7 messages or segments thus often include management or organizational information, such as orders, billing, acknowledgements, etc, which are not included in a personal health record. So remembering that the HL7 v2.x and the CCR standards have been developed for different purposes and scenarios, they will never match perfectly. Each has some functionality and some elements which are not present in the other.

To establish a consistent translation between the CCR and HL7, copies of the standard descriptions were used,

for HL7 specifically HL7 version 2.5. The first draft of the mapping table was constructed backwards: first, each CCR element was studied for its name, context and intended usage; second, the HL7 v2.5 documentation was searched for a corresponding element (segment, field, etc.). Table 1 shows the closest match between the HL7 v2.5 message segments and CCR high-level elements. An excerpt of the final map is given in the Results section.

The CCR allows free text entry for almost all elements; this comes under the sub-elements <Description><Text>. This can be used for all items which do not correspond to a specific CCR sub-element tag.

2.5 WWW-PHR $\Rightarrow$ HIS Messages (CCR $\Rightarrow$ HL7 v2.x)

The result of translating a CCR message into HL7 should be a HL7 message. HL7 v2.5 recognizes numerous message types, each comprising a collection of segments. We originally thought that the HL7 message ORÛR01 (Observation Report Unsolicited) was the closest match to a CCR. However, the ORÛR01 lacks numerous elements which are present in the CCR. Later it was discovered that the HL7 REF (REFerral) message fits more closely to the CCR, but even that lacks a few items which are present in the CCR. In order to accommodate as much CCR information as possible in the translation, the final output would be an “extended” REF message including additional PRB, RXA and RXG segments. (See HL7 [9] for specifications of message and segment types.)

Although this breaks the rigorous HL7 message definition, the alternative would be to generate several HL7 messages from one CCR, depending on its content. Simplicity was one argument in favor of generating a single output message. Furthermore, the decision to use the extended REF message took into consideration the fact that several HL7 message parsers are based on segments rather than message types, hence the modified message could be interpreted by such parsers.

2.6 Extension to map textual name-value pairs to the CCR

As mentioned in the Introduction, health data stored on cellphones can be in the form of textual name-value pairs due to the limited phone storage capacity. A prototype is described in detail by Seldon et al. in another manuscript [14]. The content of each entry is tiered, with the top level being the type of entry as described by the “International Classification for Primary Care” ICPC-2e vocabulary [10] and/or by the CCR <body>

HL7 Segment	HL7 Segment Description	CCR Element
MSH	Message Header	<From>,<To>
PID	Patient Identification	<Patient>
IN1	Insurance	<Payers>
AL1	Allergy	<Alerts>
PR1	Procedures	<Procedures>
PV1	Patient Visit	<Encounters>
PD1	Patient Additional Demographic	<AdvanceDirectives>
NK1	Next of Kin	<Support>
PRD	Providers	<HealthcareProviders>
RF1	Referral Information	<Purpose>
OBX	Observation/Result	<Results>, <FamilyHistory>, <SocialHistory>, <PlanOf-Care>, <MedicalEquipment>, <FunctionalStatus>, <Vital-Signs>
PRB	Problems	<Problems>
RXG	Pharmacy/Treatment Give	<Medications>
RXA	Pharmacy/Treatment Administration	<Immunizations>

Table 1: Top-level CCR and HL7 correlations. Not all HL7 message segments appear here.

elements (with a few requisite additions). ICPC-2e is structured into “components”, e.g. “symptoms, complaints” or “test results”, and for each component into “chapters” which represent body systems or contexts, e.g. “digestive”, “neurological”, “urinary” or “social”. A sample entry might look like

2012-12-20T12:34:56engND|Result> Blood> Glucose morning 3.5-6.4 mmol = 4.4;

which includes the date and time (in standard XML format), some flags, the name (Result ...mmol, extended from the ICPC-2e structure), and the value (4.4). Thus, the problem of mapping these to CCR elements is largely one of mapping the ICPC-2e terms to the corresponding CCR element types. This is relatively straightforward, as the ICPC-2e components are similar to the CCR elements under <Body>, and the body systems can be inserted as <Text> elements, so all translations can be “direct” without the need for conditions.

The ICPC-2e vocabulary includes some mapping of terms to ICD-10 codes. Although the codes would not be useful to a normal user of a cellphone health record, they can be included in a CCR translation for a WWW-PHR.

3 Results

3.1 Translator package

The maps have been implemented as Java packages. The code and full maps are open-source and available

at <http://code.google.com/a/eclipselabs.org/p/hmapper/> (2012 July 14).

3.2 HIS => WWW-PHR Messages (HL7 v2.x => CCR)

The following table is an excerpt from the HL7 => CCR map, showing an HL7 field, the corresponding CCR field, and any conditions for that correspondence. Conditions appear when a direct, 1-1 translation is not possible. For example, “ADD|Body.Alerts.Alert.Type.Text|Allergy|nextComponent” means that a second CCR element should be generated, with type “Allergy”, but only if “nextComponent” is empty. “CHK|OBX|TYP” means only implement this translation if the OBX segment is one of the types shown in the next field. So conditions in the translation table avoid the use of “hard-coding” exceptional cases. The full list of conditions is too long to include here.

There were some very specific problems with the implementation. Regarding the HL7 to CCR translation, it was found that Google Health used a customized CCR specification, a subset of the original CCR. Since it was a subset, we focussed on the full specification of the CCR according to ASTM and assumed that Google Health and other PHR systems could also handle standard CCR messages. However, the Google Health “h9 development server” did once reject a valid CCR message which contained an element not in the Google subset. (“h9” was a server available to the development community. Its functionality was almost identical to

HL7 Field	CCR Field	Conditional options
MSH.2.1	From.ActorLink.ActorID	
PID.3.1	Patient.ActorID	
PID.5.1	Actors.Actor.Person.Name.CurrentName.Family	
AL1.2.1	Body.Alerts.Alert.Type.Code.Value	ADD Body.Alerts.Alert.Type. Text Allergy nextComponent
AL1.2.2	Body.Alerts.Alert.Type.Text	
PRB.3.1	Body.Problems.Problem.Description.Code.Value	
PRB.3.3	Body.Problems.Problem.Description.Code. CodingSystem	
RXA.3.1	Body.Immunizations.Immunization.DateTime. ExactDateTime	ADD Body.Immunizations.Immunization. DateTime.Type.Text Start Date
RXG.9.1	Body.Medications.Medication.Type.Text	
RXG.9.2	Body.Medications.Medication.Description.Text	
DG1.1.1	Body.Problems.Problem.CCRDataObjectID	UNQ&ADD Body.Problems.Problem. Type.Text Diagnosis
DG1.3.2	Body.Problems.Problem.Description.Text	
OBX.5.1	Body.Results.Result.Test.TestResult.Value	CHK OBX TYP TX.ST.NM
OBX.6.2	Body.Results.Result.Test.TestResult.Units.Unit	
PRD.2.1	Actors.Actor.Person.Name.CurrentName.Family	
PRD.2.2	Actors.Actor.Person.Name.CurrentName.Given	

Table 2: Brief extract of the HL7 v2.5 => CCR map

that of the public Google Health.)

3.3 WWW-PHR => HIS Messages (CCR => HL7 v2.x)

A section of the proposed map is shown in the next table.

For the CCR to HL7 translation, the CCR <Actor> element is radically different from the way HL7 messages handle “actors”. To prevent actor details from appearing multiple times in CCR, all actors (or individuals) are normalized within the CCR. According to the ASTM specification [3], normalized means that everything about each individual, organization, location, or system is listed only once in the CCR <Actor> elements and any data that are from, about, or in reference to that individual, organization, location, or system are then linked within the CCR to that one listing via the <ActorID> tag. While this significantly shortens the length of the message, a simple map table will not be able to differentiate which information of an individual should go to which segment in HL7. For example, if we are mapping an Actor’s telephone number to HL7, we can insert that number in the PID segment. But, that will only work if that particular Actor is the patient; if the Actor is actually the Attending Doctor, then the phone number should go to the PV1 segment. And the only way to determine whether the Actor is a patient, a

doctor, or other individual, is to trace it back to the CCR body and find out which element links to that Actor.

One solution is to *de-normalize* the input CCR file. *De-normalizing* the CCR means to replace every actor link (<ActorID>) inside the CCR body (except for <Source>) with the actual <Actor> elements for that actor. Then, the mapping table can point to a specific actor’s details in the CCR element, such as Patient>Actor>Gender instead of Patient>ActorLink. This solution prevents confusing “if ...else” structures in the map table. (<Source> elements are not replaced because in almost every <Source> element there is a link to the corresponding <Actor>, and because HL7 v2.x has no matching component for the <Source> tag anyway.)

Also complicating the CCR to HL7 translation was the huge number of potential CCR elements. The XML schema (XSD) provided by ASTM shows that almost all elements in the CCR are layered complex types that altogether allow thousands of possible combinations. Most CCR elements use CodedDescriptionType, a type that supports the use of either simple text strings or complete, detailed tagging and coding of discrete data [3]. In the actual implementation, most text-based values are placed within this CodedDescriptionType by putting the values only under the <Text> sub-element tag.

CCR Field	HL7 Field	Conditional options
.Patient.*.CurrentName.Given	PID.5.2	
.Language.Text	MSH.18.2	
.Alerts.Alert.Type.Text	AL1.2.2	
.Alerts.Alert.Type.Code.Value	AL1.2.1	
.Alerts.Alert.Type.Code.CodingSystem	AL1.2.3	
.Medications.Medication.Product.Form.Descrip	RXG.8.1	
.Medication.Type.Text	RXG.9.1	
.Procedures.Procedure.Type.Text	PR1.3.2	
.Procedures.Procedure.Type.Code.Value	PR1.3.1	
.Problems.Problem.Description.Text	ZZZ.PR.3	CHKIPRBIVAL/Diagnosis=DG1.3.2&Problem=PRB.3.2
.Problems.Problem.Description.Code.Value	ZZZ.PR.4	CHKIPRBIVAL/Diagnosis=DG1.3.1& Problem=PRB.3.1
.Immunizations.Immunization.Description.Text	RXA.9.2	
.FunctionalStatus.Function.Status.*	OBX.5	CNV %
.FamilyHistory.FamilyProblemHistory.Descript	OBX.5	CNV %
.VitalSigns.Result.Test.Type.Text	OBX.2	
.VitalSigns.Result.Test.TestResult.Value	OBX.5	
.Results.Result.Test.TestResult.Value	OBX.5	
.Results.Result.Test.TestResult.Units	OBX.6.1	
.SocialHistory.SocialHistoryElement.Descriptio	OBX.5	CNV %

Table 3: Brief extract of the CCR => HL7 v2.5 map. * - at the start of a line means the super-element, at the end means any following tags

3.4 Extension to map ICPC-2e terms to the CCR

A sample of some direct mapping is given in the Table below; the CCR element lists have been abbreviated to save space; the ICD-10 codes are included in the ICPC-2e specification. This can be used to map cellphone-based health data to a standard for transmission to a WWW-PHR which supports the CCR format.

3.5 Integration into Message Gateway

The mapping classes have been integrated into Mirth [7]. As mentioned above, Mirth Connect is an open-source HL7 message gateway used for healthcare messaging. Mirth Connect (version 1.8.2.nnnn) [7] uses “Channels” to receive and forward messages. See the figure below for a summary of the message processing in a Channel. Briefly, Mirth accepts messages via a variety of protocols and converts them to an internal XML format. It then applies user-defined filters to decide whether to process a message further or not. The actual translation to an output format can be made either at this stage or after a message has been put into a destination queue – the latter would be chosen if a message is to go to multiple destinations which require differing formats. Outgoing messages can be transmitted via various protocols.

In this case the CCR <=> HL7 translators are integrated as “Source Transformers”. For the CCR => HL7

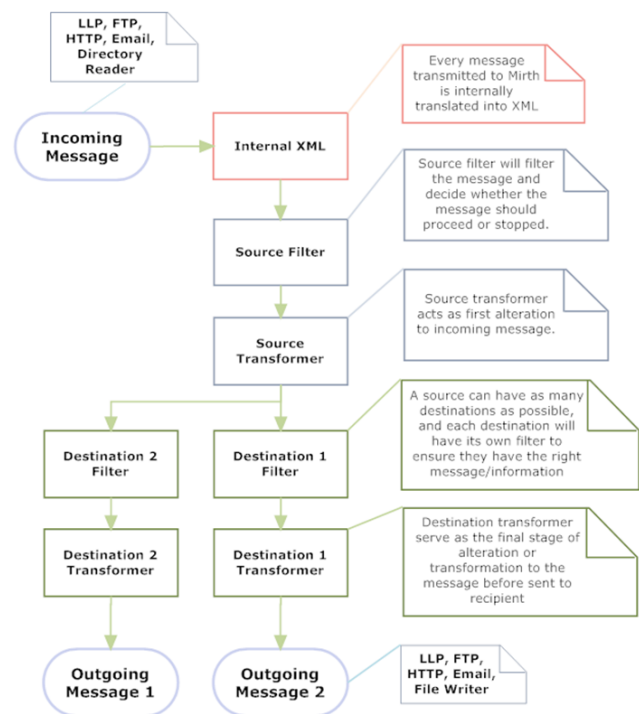


Figure 1: Mirth Connect Channel processes [7].

ICPC-2e-derived Name	CCR Elements
General swelling	<Problems.Problem.Type.Text>Diagnosis...<Description.Text>... <Code.Value>R22.7 R23.8...<CodingSystem>ICD...
Local rash	<Problems.Problem.Type.Text>Diagnosis...<Description.Text>... <Code.Value>L53.9 R21...<CodingSystem>ICD...
Flu	<Immunizations.Immunization.Description.Text>...<Code.Value>Y59.0... <CodingSystem>ICD...
Influenza	<Problems.Problem.Type.Text>Diagnosis...<Description.Text>... <Code.Value>J09...<CodingSystem>ICD...
Glucose after meal 3.5-11 mmol	<Results.Result.Test.Type.Text>Blood Glucose after meal... <Description.Text>...<Code.Value>53094-9...<CodingSystem>LOINC... <TestResult.Value>...<Units>...
Cholesterol 0-5.2 mmol	<Results.Result.Test.Type.Text>Blood Cholesterol...<Description.Text>... <Code.Value>14647-2 2093-3 2565-0 29765-5 32308-9 35200-5 50339-1 5932-9 9342-7...<CodingSystem>LOINC... <TestResult.Value>...<Units>...

Table 4: Brief extract of the ICPC-2e => CCR map.

translation Mirth read sample CCR input files from a local directory; for the HL7 output the Channel automatically scrutinized the MSH segment to determine the recipient “Destination” – in the test cases this was a “hl7in” directory belonging to an installation of the “myCare2x” (now “my 1Healthcare Solution”) HIS [11]. For the HL7 => CCR translation the test input was from the “hl7out” directory of “myCare2x”; CCR output was passed to a “Connector” in the Destination channel; in our implementation the Connector established and authenticated a connection to the Google Health “h9 development server” and then passed the message; the message contents could then be viewed via the h9 (i.e. Google Health) Web interface. (This system was developed during 2009-2011, before Google closed its Google Health service.)

Microsoft Health Vault and others. At the time of this work the Mirth message gateway supported neither the CCR nor the CCD format.

There is a dearth of systems available for comparison. A Web search in 2011 revealed only one (Aquiver CCR ViewPort) which would provide HL7 => CCR translations for user input [12]. A comparison of the CCR output from a set of HL7 messages showed that the mapper described here yielded overall more detail, especially for HL7 segment types AL1 (alerts), NK1 (next of kin), PR1 (procedure), PRD (healthcare providers), RXA and RXG (medications). The Aquiver product provided more detail for segment IN1 (insurance). A publically available CCR => HL7 v2.x translation has not been found. HL7 Australia has been informed of ours, via the second author, who is a member.

4 Discussion

Translating between message formats originally designed for different scenarios and different purposes (and by different organizations) is not trivial. After the publication of the CCR in 2005 the HL7 and ASTM organizations collaborated to bridge the gap between the CCR and HL7 standards which were intended for similar purposes. The result was the “Continuity of Care Document” or CCD, which is a specification of the HL7 CDA standard to match the CCR; the CCD is also available from HL7 [9]. To the user the CCR and CCD appear very similar. Others have discussed the advantages or disadvantages of each, e.g. [4]. We chose the CCR because the XML structure behind it is simpler, and because it was or is supported by Google Health,

5 Conclusion

The availability of a CCR <=> HL7 v2.x translator in a message gateway should allow those HISs which use the HL7 v2.x message standard to communicate bi-directionally with those PHRs which have implemented the CCR message standard. This should allow summaries of or excerpts from medical records to be uploaded to a (Web-based) PHR, from where they are available to the individual and to other caregivers selected by him or her. Conversely, although this would be used less often, extracts of an individual’s PHR could, with his or her permission, be downloaded as extended HL7 v2.x REF messages into the HIS of caregivers.

The PPHR => CCR translator can be integrated into a standard healthcare messaging gateway. For this work

the Mirth gateway was used.

The full CCR $\Leftrightarrow$ HL7 maps and the Java transformation code are available in the Google repository (<http://code.google.com/a/eclipselabs.org/p/hmapper/>). The authors would appreciate notification of any detected errors or suggestions for improvement.

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Conflicts of Interest

None.

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