Extendable Data Model for Universal Health Records

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Introduction

Despite the significant worldwide effort to combine healthcare enterprise driven Electronic Health Records (EHRs) and certainly wellness oriented Personal Health Records (PHRs) into Universal Health Records (UHR) the interoperability level of the content of two domains remains insufficient. Importance of integration of personal ADL and wellness data with medical information is obvious [1]. Modern IHE systems are typically based on complex RIM data models. Continuity of Care Record and - Document (CCR, CCD) are good attempts for simple and efficient presentation of patient data records. However, home measurements data shall include precise context information and instrument related data (compared to validated, hospital-based measurements) that is difficult to encode into CCD and CCR messages in unambiguous way. Simple examples of additional essential information for home-based measurements include user’s preceding activities and measurement device trust measures (calibration and service due, precision class, etc.) required for practical comparability of home and hospital measurements. On the same time, collecting and linking indirect metadata is technically complex, especially from the data processing point of view.

Extendable data format for UHR messaging

Since 2008 Estonian eTervis¹ (eHealth), a state-operated nation-wide EHR system, is a single cure information access point for citizens and healthcare enterprises. Two years experiences with the operational system have been demonstrating unexpectedly weak interest of citizens to access the (personal) healthcare data. Judgment of eTervis maintainers is that more users can be attracted through the wellness services essentially including adaption of users generated measurement data. Similar conclusions of importance of user created content for PHRs’ success has been stressed in Australia [2] – a leading country of IHE and telemedicine solutions. Redesigning of eTervis portals and data interfaces should result a flexible system for interfacing variety of off-the-self personal sensing and monitoring devices. Architecture of upcoming solution is shown in Figure 1. Important difference compared to of interfacing devices and content sources with conventional EHI systems is impossibility to agree incoming data structures in advance.

Similarly to Australian eHealth standard IT-014² the eTervis data is exchanged currently via HL7 v3 messages not quite suitable for presenting heavily varying context-dependent information of home-based medical/wellness measurement, in particular instrument properties, besides of that, has considerable XML overhead and redesign of existing message formats (for adding context annotation) is rather costly. Significantly more “user/processor friendly” is CCR messaging solution, but it also lacks extendibility when trying to deal with non-conventional measurements.

We propose to use hierarchy-enabled CCR (CCD) data format for transmitting home-made measurements of medical data and accompanying context. The principle of data representation in messages relies in lists of key = value pairs. The key node is always terminal node and refers to an exist-

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¹ e-Tervis SA at http://www.e-tervis.ee/


exerted by a self-monitoring solution for patients at private or nursing homes (with public web interface) in Figure 2.

![Patients’ self-monitoring kiosk: gateway device (touchscreen) with Bluetooth connected blood pressure monitor, pulse oximeter sensor (on the table), and scale (on the floor) on the left and web interface on the right](image)

The following example illustrates these encoding principles, the first entry says laconically that cycling activity took place at the given timestamp, and the second entry gives information about a weight measurement result with a mark before meal and rather detailed device description.

For maintaining compactness a simplified pseudo code presentation is used with list notation \([a, b, c]\). (Patient identification is omitted.) The key weight in pseudo code takes the form of \(<\text{key extension} = "363809009"\ root = "2.16.840.1.113883.6.96"\ codingSystemName = "SNOMED CT"\ displayName = "Weight">\) in an arbitrary XML representation.

```xml
entry = {
    activity = cycling,
    timestamp = 20 Aug 2011 17:15
}

entry = {
    type = measurement,
    before meal,
    weight = [value = 89, unit = kg],
    sensor = {
        TC 100,
        manufacturer = I. E. M. GmbH,
        calibrated = no information,
        max weight = [value = 150, unit = kg]
    },
    timestamp = 20 Aug 2011 17:55
}
```

The given hierarchical key-value pair data format can be effectively used for extendable annotating of typical medical measurements that have one or relatively small number of data items (e.g. weight, blood pressure, blood sugar) and low sampling rate (couple of samples per day or even infrequently). However, it suits as well for enriching EDF/EDF+ data streams with context and instrument data which unfortunately cannot be fitted into the EDF headers even though these carry several items of meta-information like the patient, recording, signals’ parameters, and pre-filtering\(^5\). The described data encoding schema will be used for mobile ECG system (in contrast to HL7 style\(^6\)) currently under development to collect and store “samples” of person’s ECGs during different activities and conditions outside of hospital. Ordinary cell phone is used as a gateway for gathering streaming data from wearable non-professional Bluetooth ECG sensor device, which patients can manage themselves, from company MegaEMG and composing EDF records for sending to remote server. It is crucially important [\(v\)] to include SNOMED CT enabled formal context information of what the patient was doing during the ECG measurement (like cycling, walking, resting, watching thriller) and how he/she felt (normal, pain, arrhythmia, faintness). Semantic search, reasoning, and interpretation based on the metadata will be possible for later analyses of ECG recordings of individuals and groups.

**Summary**

Personal Health Records (PHRs) and wellness systems are emerging and shall enable individuals to take more responsibility of maintaining their own health. However, practical data interoperability with existing IHE systems has not been achieved yet due the wide range of different PHR information collected by users. Electronic Health Record Systems (e.g. eTervis) can satisfy most of the needs of large medical institutions by offering consistent HL7 v3 interfaces for medical case histories, ambulant cases, medical bills, referral letters, prescriptions, etc. CCR protocol, on the other hand, targets patient’s self-made transcripts, still lacking flexibility and extendability. We describe a CCR like but recursive protocol based data interoperability solution that enables seamless integration of telecare data with an existing Estonian nation-wide Electronic Health Record System targeting nation-wide Universal Health Record (UHR) data repository.

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**References**


\(^5\) PHRbox, [http://www.phrbox.com](http://www.phrbox.com)