Reviewer's report

**Title:** A Cloud Computing Based 12-Lead ECG Telemedicine Service

**Version:** 1  **Date:** 15 June 2012

**Reviewer:** Paul Rubel

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This is an interesting paper showing how cloud computing could improve remote, standard 12-Lead ECG interpretation services by facilitating inter-hospital 12-Lead ECG consultation and overcome the limitations of vendor-specific solutions while reducing the overall hardware and software possession costs. The paper is comprehensive, scientifically and technically sound and well written, and there are only a few issues that we would ask the authors to take into consideration to improve the overall quality of the paper.

**Minor Essential Revisions**

1. There are a few typing errors in figure 4 (Blob, not Blog; ECG Decoding, not ECG Decording; Data encryption, Data verification, not Deta) and in figure 5 (SQL command, not commond; Data encryption, Data verification, Data Decryption, not Deta).

2. There are also a few typing errors all over the manuscript, for example page 4: “cannot provide”, not provides; page 9: “we have designed”, not design; page 10: “a detailed 12-lead ECG report”, not detail; page 11: “can easily and quickly or rapidly browse”, not rapid; page 11: “clinically-used”, not clinically-use; page 13 section 4.3: “we designed”, not design; page 13 section 4.3: “telecommunication services do”, not “telecommunication service does”; page 17 reference 24: “Windows”, not Wndows.

**Discretionary revisions**

3. The paper would benefit from amending or completing some statements about SCP-ECG and from citing or discussing some reference papers in the field of serial ECG analysis and advanced, easy to use ECG based pervasive telemedicine architectures.

4. Indeed, as stated in section 3.1, one of the “most important references for clinicians to determine whether the patient is at an immediate risk of dying” is to grant a timely access, anytime and anywhere, to both the patients’ “past and current ECG records”. This statement is strongly supported by Luepker RV (“Delay in acute myocardial infarction: why don't they come to the hospital more quickly and what can we do to reduce delay?”, Am Heart J 2005;150(3):368–70) and by the ACC/AHA/ACP-ASIM Task Force (Kadish et al, ACC/AHA clinical competence statement on electrocardiography and ambulatory electrocardiography: a report of the ACC/AHA/ACP-ASIM Task Force on Clinical
Competence (ACC/AHA Committee to Develop a Clinical Competence Statement on Electrocardiography and Ambulatory Electrocardiography), Circulation 2001;104:3169–78), that highly recommends, to electrocardiogram readers, to compare the current ECG with previous recordings to enhance the accuracy of some diagnoses, in particular of acute myocardial ischemia. Performing serial ECG analysis is however only possible if we are able, thanks to services as the ones proposed in this paper, to timely retrieve almost one previous ECG, if any, and if the record has been stored in a format that is compatible with the serial analysis software and/or with the provided ECG viewer. SCP-ECG could be as suggested by the authors one of these interchange formats.

5. However, in section 1.2, the authors state that most ECG manufacturers having implemented SCP-ECG “change a portion of the format using vendor-specific rules, especially the ECG waveform data encoding rules”. This is not exactly true, as the waveform data encoding rules are an essential part of the SCP-ECG standard and thus must be strictly followed to be compliant with the standard. Only section 9 can be manufacturer specific, for example to store computed measurements that are not yet standardised. Some manufacturers abusively use this facility to store their textual interpretation report and sometimes omit to store the standard lead by lead measurements in section 10 and the textual interpretive statements in section 8. It is the customer’s role to demand the manufacturers to provide solutions that are fully compliant with the SCP-ECG protocol, and to select only those products that are really compliant with the standard. To my knowledge, almost all well known manufacturers have fully implemented SCP-ECG, but sometimes omit to tell that they can provide a product that is fully compliant with SCP-ECG because “customers are not requesting it”.

6. In section 4.5, the authors soundly state that “we need an open and unified ECG data format, which resembles the open and unified medical image format DICOM”. But this was exactly the reason for developing SCP-ECG at the end of the eighties, concurrently with DICOM, to overcome the “inconvenient monopoly situations” of the manufacturer specific solutions (Willems et al “A standard communications protocol for computerized electrocardiography”, J Electrocardiol. 1992;24 Suppl:173-8). SCP-ECG was designed from the beginning both to encode and store any type of diagnostic ECG signal and every technical or clinical information cardiologists might need to interpret the ECG, an approach that has also been adopted later on by DICOM. Around eighty percent of the manufacturers of that time participated in the effort, and a first SCP-ECG standard was set up as a European pre-Norm in 1993 (prENV 1064: 1993) and extensively tested within the Open European Data Interchange and Processing for Electrocardiography (OEDIPE) project (Rubel et al “New trends in serial ECG analysis”, J Electrocardiol. 1993;26 Suppl:122-8). The wireless transmission of high quality 12-lead SCP-ECG records from the ambulance was demonstrated during the G7 conference on the Information Society in Brussels in 1995 using GSM based mobile phones and the same year for the follow up of the heart diseased French minister Jean-François Deniau during his solo transatlantic
race, using INMARSAT C. The main reason, in my opinion, for SCP-ECG not having taken over as largely as DICOM has, is the difficulty of implementing and maintaining secure and cost effective ECG repositories, hospitals being usually reluctant to facilitate remote access to their HISs (for images they usually only provide a CD-ROM). The cloud computing solution proposed in the present paper should help overcoming this gap and provide additional means to easily implement SCP-ECG and converters between different ECG standards and even manufacturer specific solutions (Jumaa et al “XML based mediation for automating the storage of SCP-ECG data into relational databases”, IEEE Comput. Cardiol., vol. 35, pp. 445–8, 2008). Another open solution, which is based on a very similar architecture than the one presented in this paper, is the pHealth approach that has been proposed by the EPI-MEDICS project, where the patient’s previous ECG records and the clinical history are stored on the patients’ or the GPs’ smart media card and the newly recorded ECG together with the previous and/or the reference ECGs are either automatically or on demand transmitted to an alarm server which itself notifies the attending cardiologist or a mobile expert to review the ECG(s) and the health care record by remotely accessing the alarm Web server and by providing means to forward his/her recommendations to the requestor (Fayn et al, “Towards a Personal Health Society in Cardiology”, IEEE Trans Inf Technol Biomed. 2010;14(2):401-9, Atoui et al, “Ambient Intelligence and Pervasive Architecture Designed within the EPI-MEDICS Personal ECG Monitor”, Int J of Healthcare Information Systems and Informatics. 2008;3(4):69-80).

**Level of interest:** An article whose findings are important to those with closely related research interests

**Quality of written English:** Acceptable

**Statistical review:** No, the manuscript does not need to be seen by a statistician.

**Declaration of competing interests:**

I declare that I have no competing interests