Aeneas II: A Standard for ECG Management and Exchange in the Netherlands

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Abstract

This paper describes the revival of a project for exchange of electrocardiograms (ECG's) of the same patient between different centers. A national index-server was set up containing information on patients who's ECG is available in the participating centers. Through the use of virtual private networks and standard browsers each ECG stored elsewhere can be retrieved.

1. Introduction

The electrocardiogram (ECG) is a basic tool for a cardiologist to diagnose the electrical activity of a patient's heart. Especially in cases of an emergency, the examination of possible deviations from previous recordings is very supportive in the diagnostic process. The detection of a different rhythm disturbance compared to previous recordings for example is an essential part of this process.

In 1989 the Interuniversity Cardiology Institute of the Netherlands has investigated the possibilities to set up a computer network for the exchange of ECG's between 8 large Dutch hospitals. This project was called AENEAS: "Automatische ECG-analyse Nederland, Een Algemene Standaard" (Automatic ECG-analysis in the Netherlands, one common standard) [1].

The idea was to have one central ECG-database where all ECG's of the participating hospitals were stored in a uniform format. Although the proposed set-up was technically feasible, the participating centers were not ready to pursue the project, predominantly for financial and legal reasons.

This issue has come into focus again due to the enormous amount of electronic patient data gathered in every hospital a patient visits and the IHE initiatives to share this information between the hospitals. One of the first topics the IHE committee for the cardiology domain addressed was the retrieval of ECG's from different clinics to be viewed in a standard (web based) format (PDF), through ubiquitous (web based) communication [2]. Today, all 8 university hospitals have their own ECG databases from different companies with state of the art web-based techniques to view the stored data. Therefore a new project AENEAS II was started, to design an infrastructure integrating all the necessary ingredients and to study the feasibility of a nationwide ECG network based on the already stored ECG's of about 700000 patients in the different clinics.

2. Methods

Through the use of Virtual Private Networks(VPN) between the different participating hospitals all stored ECG's can be viewed, independent of their physical location.

The main purpose of the project was to set up a national index-server with an index database containing information about the patients of which ECG's are available in participating centers. Because there is not yet a national patient-ID in the Netherlands, we have designed a unique patient-ID code (BSN-DT), consisting of part of patient's last name, date of birth and gender code. A 30 year experience with this ID-code in the national registry of pacemaker- and ICD patients gave us

confidence that this ID-code is sufficiently unique in our country to differentiate between patients and that there are no privacy issues at stake.

As technical problems are all overcome, the real issues to tackle are the permission of the viewer to retrieve the information and the identification of the ECG's:

Each ECG system is protected by a password mechanism. This and logging all usage is sufficient for the purposes mentioned[3].

The index table is stored on a central Microsoft SharePoint server and contains the hospital ID-codes and the BSN-DT of about 700000 patients having one or more ECG's stored in at least one of the participating hospitals. The index table is updated on a regularly basis with ECG information from the hospitals.

The SharePoint server is owned by Surfdiensten[4], an organization providing internet services and software to all universities and university hospitals in the Netherlands. The server is well secured and only a limited amount of users is allowed to use the SharePoint site on which the index table is located. The index table itself is encrypted and only viewable when a password is provided..

3. Results

In order to find out whether there are additional ECG's stored somewhere in connected ECG databases a VPN connection is made with the central SharePoint server.

As input parameters for searching the central index table the local ID-code or the described generated BSN-DT code can be used. When the codes match the information stored in the index-table, the hospital(s) and local ID-codes are returned.

Subsequently the local ECG-databases in the matching hospitals can be accessed through a VPN connection and starting a web browser. Password protection both in setting up the VPN connection and approaching the local ECG-databases prohibits illegal usage. Because of the nearly uniqueness of the generated ID-code, an extra check on additional data has to be performed.

Local ECG databases

Table 1 presents the number of patients (not ECG's) of whom ECG's are stored in each database and what percentage of intra-hospital overlap is generated by the introduction of the nearly unique ID-code. The average overlap is about 1%, with an extreme of 1.91% in the University Hospital of Amsterdam (AMC).

Center	Total	Unique	Overlap	(%)
AMC	121755	119397	2358	1,94%
AZM	80573	80143	430	0,53%
EURMC	83359	82574	785	0,94%
LUMC	90543	90036	507	0,56%
UMCG	115403	114617	786	0,68%
UMCN	24406	24301	105	0,43%
UMCU	135775	134181	1594	1,19%
VUMC	42662	42484	404	0,95%
TOTAL	694476	687733	6969	1,01%

Table 1 Intra-hospital overlap due to the generated code BSN-DT

	#patients	AMC	AZM	EURMC	LUMC	UMCG	UMCN	UMCU	VUMC
#patients		119397	80143	82574	90036	114617	24301	134181	42484
AMC	119397		743	1048	1337	1204	235	2661	2348
AZM	80143	743		759	708	655	315	1028	304
EURMC	82574	1048	759		1109	816	210	1600	419
LUMC	90036	1337	708	1109		952	222	1565	618
UMCG	114617	1204	655	816	952		280	1763	492
UMCN	24301	235	315	210	222	280		520	99
UMCU	134181	2661	1028	1600	1565	1763	520		780
VUMC	42484	2348	304	419	618	492	99	780	

Table 2 Overlap in numbers between any two hospitals

	#patients	AMC	AZM	EURMC	LUMC	UMCG	UMCN	UMCU	VUMC
#patients		119397	80143	82574	90036	114617	24301	134181	42484
AMC	119397		0,62	0,88	1,12	1,01	0,20	2,23	1,97
AZM	80143	0,93		0,95	0,88	0,82	0,39	1,28	0,38
EURMC	82574	1,27	0,92		1,34	0,99	0,25	1,94	0,51
LUMC	90036	1,48	0,79	1,23		1,06	0,25	1,74	0,69
UMCG	114617	1,05	0,57	0,71	0,83		0,24	1,54	0,43
UMCN	24301	0,97	1,30	0,86	0,91	1,15		2,14	0,41
UMCU	134181	1,98	0,77	1,19	1,17	1,31	0,39		0,58
VUMC	42484	5,53	0,72	0,99	1,45	1,16	0,23	1,84	

Table 3. Overlap between hospitals, measured in percentage relative to the number of patients in each row.

Tables 2 and 3 display the overlap between each participating clinic. A clear relation between the overlap and the geographic distances between the centers is visible. In table 2 the absolute numbers are shown and in the other table the percentage overlap related to each center (row-wise). For example the relative overlap between LUMC and AMC is about 1,5% when compared with the number of patients at the LUMC and 1.1% when compared to the number of patients contributed by the AMC.

#clinics	#patients
2	21220
3	1012
4	74
5	6
6	2

Table 4. Number of patients with "hits" in more than 1 clinic

Table 4 presents the number of patients having "hits" in more than 1 clinic. As can be expected, this overlap is inversely related to the number of clinics. Very interesting of course are the patients known in 6 clinics by his ECG. We traced one of these patients and found out that he was a captain of a barge cruising through the Netherlands, testing each hospital of the harbours he was visiting.

Figure 1 shows the locations of the different hospitals and their distances. Figure 2 is a graphic interpretation of the overlap. The size of the circles is an indication of the "contribution" of that clinic, the width of the connecting line is a representation of the overlap relative to the clinic.

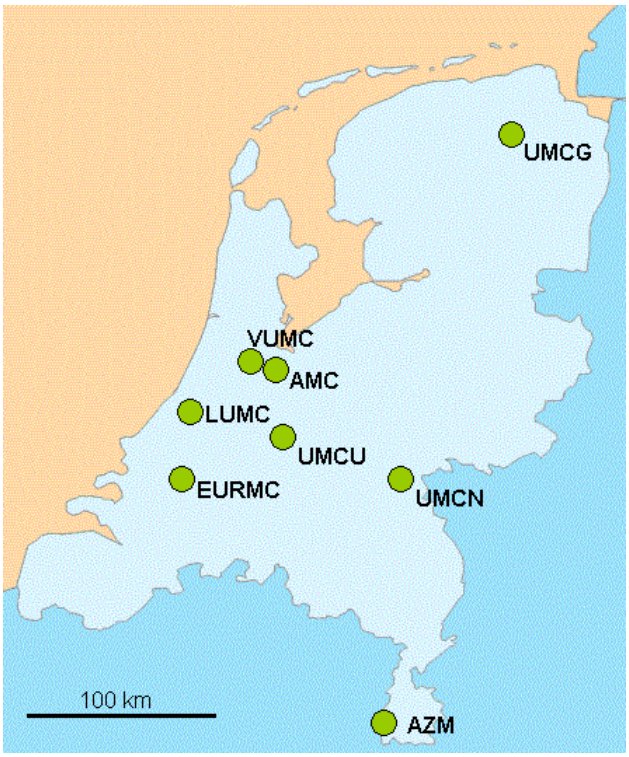

Figure 1. Geographic location of participating clinics

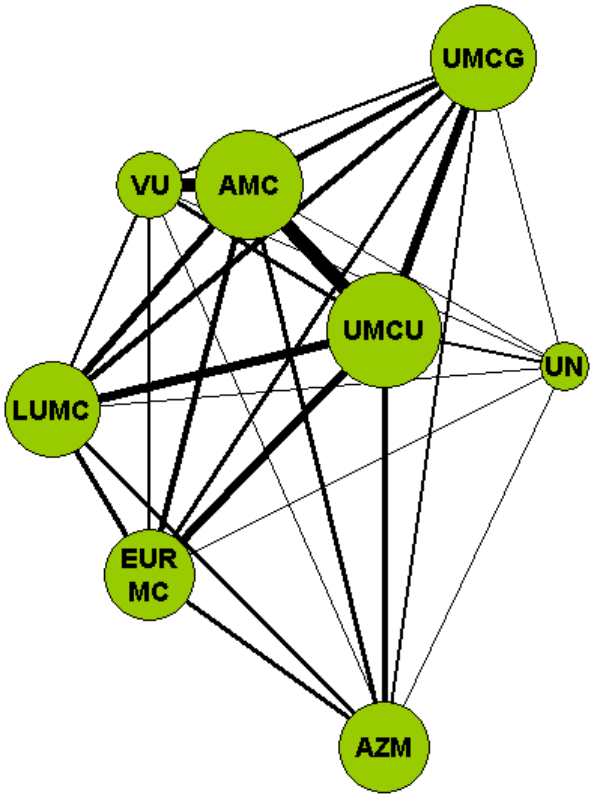

Figure 2. Graphical representation of number of patients in database and overlap between centers.

AMC	210
AZM	130
EURMC	155
LUMC	185
UMCN	48
UMCU	340
VUMC	87

Table 5. Patients showing up at emergency clinic at UMCG also known in another hospital

Of course the most interesting group and the group gaining most from being able to access previous ECG's, are those patients suffering from rhythm disturbances visiting the emergency clinic of another hospital during a trip. For the UMCG we searched for the patients who had an ECG recorded in the emergency room (total number > 20000) and who also had an ECG in another database. Serial comparison of the different ECG's can be very supportive for the diagnose. In table 5 the overlap with other clinics of this patient category is displayed.

4. Discussion and conclusions

The aim of this project was to create a system for easy retrieval of same-patient ECG's made in various hospitals. We have created a method for identifying these patients (by using the BSN-DT number) and we have created a database in which one can find in which hospitals ECG's from a patient with a specific identification can be found. ECG's can then be retrieved using a VPN connection and standard web techniques.

The benefit of this system is that not all hospitals have to be queried one by one to retrieve relevant ECG's.

The uniqueness of the BSN-DT is about 99% within one hospital (1% overlap). Between hospitals, an overlap of about 1% is also found. As a consequence, an extra check on additional data has to be performed in order to be sure that the retrieved data is from the same patient.

The BSN-DT could be made more unique, for example by adding more characters of the surname to the number. It will however never be as unique as the upcoming government-issued patient ID.

The highest overlap was found between the two hospitals in Amsterdam, which is logical, as the regions served by these hospitals largely overlap.

The system proved to work well in a pilot setting where the participants are university hospitals. We foresee extra benefits when the group is expanded with referring hospitals.

References

[1] De Bie J, van Herpen G, Meester GT, Meijler F, Zeelenberg C. Aeneas: A Standard for ECG-management and Exchange in the Netherlands. Computers in Cardiology, Jerusalem: 289-292 (1989).

[2] IHE Cardiology Technical Framework. Year 2: 2005-2006. Volume I: Integration Profiles. www.ihe.net

[3] HIPAA: Health Insurance Portability and Accountability Act was enacted by the U.S. Congress in 1996. http://www.hhs.gov/ocr/hipaa/assist.html

[4] Stichting SURF: www.surfdiensten.nl

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