O3-Medical Informatics Endeavor for the eHealth Region

Paolo Inchingolo[1], Dejan Dinevski[2]

[1]Health Telematics Lab (HTL), Open Source Lab (OSL) & Neuromodelling Lab (NML) at DEEI & Higher Education in Clinical Engineering (SSIC-HECE), University of Trieste, paolo.inchingolo@bioing.units.it
[2]Faculty of Medicine, University of Maribor & Faculty of Education, University of Primorska, dejan.dinevski@uni-mb.si

The Open Three (O3) Consortium is promoting the adoption of Open Source in e-health on regional, European and World-wide levels. This project aims to contribute to the development of e-health through the study of Healthcare Information Systems and the contemporary proposal of new concepts, designs and solutions for the management of health data in an integrated environment of hospitals, Regional Health Information Organizations and citizens (home-care, mobile-care and ambient assisted living).
Some concrete technical solutions in the field of medical informatics are presented in this paper. The applications presented are the heart of the Radiology information system, which is open to other health institutions, thus forming a basis for the realization of e-health integration. The formation of a genuine e-health region is just one step forward.

Keyword: medical informatics, e-health, open source software, radiology information system

O3 – prizadevanja na področju medicinske informatike za e-zdravstveno regijo

Konzorcij Odprti trije (O3) si prizadeva za sprejetje odprtega vira v e-zdravstvu na regionalnem, evropskem in svetovnem nivoju. Projekt si prizadeva prispevati k razvoju e-zdravstva s pomočjo preučevanja informacijskega sistema zdravstvenega varstva ter sodobnih predlogov novih zasnov, načrtov in rešitev za upravljanje z zdravstvenimi podatki v integriranem okolju bolnišnic, regionalnih organizacijah zdravstvene informatike in pri državljanih (v domači negi, mobilni negi in v primeru bivanja z asistenco v okolju).
V prispevku so prikazane nekatere konkretne tehnične rešitve na področju medicinske informatike. Prikazane aplikacije so bistvo radiološkega informacijskega sistema, ki je odprt drugim zdravstvenim institucijam in tako predstavlja temelj za realizacijo e-zdravstvene integracije. Tako je oblikovanje prave e-zdravstvene regije oddaljeno le še za korak.

Ključne besede: medicinska informatika, e-zdravje, odprtokodni sistemi, radiološki informacijski sistemi, radiološki informacijski sistem

1 Introduction

The applications presented in this paper have a rich history of development and implementation, which will be briefly presented. Additionally, a general description of the systems and standards necessary for the understanding of the paper is given in this introduction.

The Radiology Information System (RIS) is composed of several subsystems and their integration is often very complex technical issue. The most important of the subsystems is the Picture Archiving and Communication System (PACS), which identifies a manager and archiver of the images running on dedicated hardware which is forced to some extent to be proprietary, expensive and largely unscalable, despite the use of standards such as DICOM (Digital Imaging and Communications in Medicine),.

Still, although the usage of PACSs has increased considerably in the last five years, one of the main issues to consider today is the integration between it and the RIS (Radiology Information System), which was one of main aims of the DICOM and Health Level Seven (HL7 2007) supporters. This issue should be considered a transitional step towards the realization of a new generation of hospital information systems based on the integration of distinct elements, as opposed to the development of monolithically-built software with the features of both systems but lacking of the fundamental upgradeability characteristics and real e-health integration.

The way to reach this goal is to integrate systems based not on data typology, as used in previous years, but on the role they assume in the information workflow. The Higher Education in Clinical Engineering (HECE) Program and the Health Telematics Laboratory (HTL) of the Bioengineering and ICT Group at DEEI, University of Trieste have been working on these themes for a long time (since 1991). This paper describes and explains the main results obtained in the last four years.

The recent strategies and results of HTL in this field have been significantly influenced by the last two EuroPACS meetings, held in Oulu (Finland) in 2002 and in Trieste (Italy) in 2004. The presentation of the new trends of the DPACS (Data and Picture Archiving and Communication

System) project at the University of Trieste (21), as in the concluding lecture of the EuroPACS meeting in Oulu in 2002, introduced the DPACS advances in fostering the e-health integration within the enlarged Europe and the combined hospital-territory-citizen environment. The recognized importance of these strategies for the future of Europe led the EuroPACS Society to entrust HECE with the organization of the 2004 EuroPACS meeting in Trieste, which focused on these themes. The successful "EuroPACS-MIR 2004 in the enlarged Europe" meeting in September 2004 (Inchingolo and Pozzi, 2004), with more than 400 participants from 47 Countries, witnessed deep discussion on issues of organization, standards and interoperability in all contexts, ranging from single departments up to transnational integration.

The real problems with managing the administrative and clinical workflows in any complex situation, including hospital-territory-citizen integration and multi-lingual management, have also been deeply discussed and experimented with through a living-lab that has been built-up in the conference exhibition area, which connects most of the exhibited PACS and RIS systems as well as some hospitals in Italy and in the surrounding countries. The specific problems related to transitional and developing countries have been also addressed.

The discussions in all the conference sessions, especially the ones on interoperability (Bourka et al. 2003, Al Safadi et al. 1998, Chronaki and Chiaurgi 2005) in the one-day workshop that was part of the world-wide IHE (Integrating the Healthcare Enterprise) project, generated strong results and guidelines for future work. Firstly, the "Is there a need for a transnational IHE committee in Central and Eastern Europe?" round table, which concluded the IHE Workshop, closed with the commitment to HECE of creating a transnational IHE committee for Central and Eastern Europe, dealing with technical, harmonization and law-oriented activities in 22 Central and Eastern European Countries.

Secondly, the same round table and most of the IHE workshop sessions underlined that the adoption of open standards and open source solutions is becoming an essential path to facilitate the rapid integration of health systems in Europe and worldwide, fostering this process in both transitional and developing Countries (Drury and Dhalman, 2005). In fact, well supported open source solutions is the only way to ensure the worldwide adoption of manager/archiver and cross-enterprise document sharing systems for medical data and images; furthermore, open source promotes the expandability and modularity of solutions, thus allowing collaboration between developers (Rosset et al. 2006, Hacklander et al. 2005, Lindahl et al. 2005, Kalra et al. 2005 and several others). Finally, open-source assures stability in the usage of the products, with the user – the health-care system in the general sense – able to use it with long-term continuity and also to improve, update, modify and integrate it as much as necessary for his scopes, even if the developer or vendor disappears from the market.

HECE, together with HTL and OSL (Open Source Laboratory) at DEEI, started in 2005, heading in both these directions. In relation to the second one, the Trieste

Figure. 1: The three domains of O3

group presented the new open-source version of their DPACS-2004 project (Inchingolo et al. 2004) together with a universal workstation named HDW2 (Miniussi et al. 2004) and the group from the Radiology Department of Padova presented the new open-source version of their Raynux /MARiS project (Saccavini, 2004)). They decided to fuse and integrate their projects and efforts and hence the Open Three (O3) Consortium Project www.o3consortium.eu was begun (Inchingolo et al. 2006). At this point the Faculty of Medicine of the University of Maribor, which is participating in the development and implementation, also joined the O3 Consortium. The installation of the O3 system is constructed and being tested at the Maribor hospital (2000 beds).

O3 deals with the three domains of the tomorrow's e-health, in the frame of the European e-health programs: hospital, territory and home-care / mobile-care / ambient assisted living (AAL).

2 Development and Implementation

2.1 Premises

The research work on PACSs at the University of Trieste, carried out by HECE and HTL, started in 1991 after a CommView AT&T Philips multi-site PACS system was installed at Trieste's Cattinara and Maggiore Hospitals in 1988. This was the first European installation of a commercial PACS system in a hospital enterprise and also the first installation in Europe of two PACS systems connected together over a metropolitan area network. The HTL work aimed to overcome the limitations of the Commview PACS System and to open the proprietary installation system by developing versatile open source tools (essentially gateways and client workstations) for LAN, MAN and WAN communications with the PACS (Diminich et al. 1993). In this way, it has been possible to distribute images throughout the hospital departments and surgery rooms of the three hospitals and to the bioengineering and medical physics research centres of Trieste, with some connections also going overseas to the National Institutes of Health at Bethesda, MD (USA), which also stimulated the growth of the Informative Trieste System. In 1994, the first PACS browsing interface was developed, allowing virtually worldwide image distribution without needing dedicated client software (Diminich et al. 1995).

However, as the research, the results and the clinical experimentation proceeded, it became clear that an impassable limit had been reached, due to the intrinsic limitations of the Commview PACS System itself. For this reason, a project was started on a totally new system named DPACS (Data and Picture Archiving and Communication System) in 1995 (Fioravanti et al. 1996).

The goal of DPACS was "the development of an open, scalable, cheap and universal system with the accompanying tools to store, exchange and retrieve all the health information of each citizen at hospital, metropolitan, regional, national and European levels, thus offering an integrated virtual health card for the European Citizens". A preliminary version of DPACS was tested in 1996-1997 at the Cattinara Hospital (Fioravanti et al. 1997).

By 1998 the DPACS system was routinely managing all radiological images (CT, MRI, DR, US, etc.) as well as in conjunction with the stereo-tactic neurosurgery, thus completely supplanting the old AT&T Commview PACS system. Some mono-dimensional signals such as ECGs were also integrated into the system.

Over the years, DPACS has been enriched with anatomo-pathology, anaesthesia and reanimation, the clinical chemistry laboratory and others; furthermore, its application has been progressively expanded to cover the newly emerging necessities of future health care and assistance to the citizens of the world, based on telemedicine-driven home-care, personal-care and ambient assisted living.

Consequently, some new needs have been pointed out and covered in new developments of the project, such as:

- to have a multi-lingual approach to both client and server managing interfaces and to the presentation of medical content;
- to have a simple data & image display client interface, automatically updatable and highly portable from PC, MAC or LINUX workstations to palms or a cellular-based communicators;
- to be able to connect with a wide variety of communication systems, both fixed and mobile);
- to offer a highly modular data & image manager/ archiver, independent of the platform (UNIX/LINUX, WINDOWS, MAC) and of the selected data-base;
- to improve the interoperability of both the server and the client system components between them and with all the other information system components in the hospital and in the health enterprise);
- to have an efficient and effective tool to "create" the integrated virtual clinical record in the hospital as well as at home or when a citizen is travelling.

2.2 The New Strategic Choices of the DPACS Project and the Creation of the World-Wide Open Three (O3) Consortium

As reported above, the conclusions of the EuroPACS-MIR in the Enlarged Europe Meeting in Trieste addressed solutions for these new needs with the creation of the Open Three (O3) Consortium.

The main characteristics of the O3 open-source products are their multi-language support, their high scalability and modularity, their use of Java and Web technologies at any level, their support of any platform, their high level of security and safety management, their support of various types of data-bases and application contexts, their treatment of any type of medical information, i.e., images, data and signals, and their interoperability through full compliance with the "Integrating the Healthcare Enterprise" (IHE) world project, achieved by building up O3 as a collection of "bricks" representing the IHE "Actors", connecting each through the implementation of a wide set of IHE Integration profiles.

The choice of Open Source as O3's leading solution for the future of e-health anticipates a common trend in the industrialized and political world, recently evidenced by the position assumed by the Department of Health & Human Services and the Department of Defense of the United States at the Open Source Strategy for Multi-Centre Image Management Workshop, held in March 6-9, 2006 at Las Vegas (USA). It was evidenced also by the decision announced by the world's biggest industries at the OSDL Joint Initiatives Face to Face Meeting Review – Health Care Information Exchange, held in May, 10-12, 2006 at Sophia-Antipolis (France), as well as by the European Union in the Riga Declaration, signed during the Intergovernmental Meeting of the European Commission "ICT for an Inclusive Society", held in June 11-13, 2006 at Riga (Latvia).

The first set of O3 products cover all the requirements of image management in Radiology and in Nuclear Medicine at both intra- and inter-Enterprise levels. The most important are:

- O3-DPACS, the new version of DPACS enriched with many new features, e.g., the XDS (Cross-Enterprise Clinical Document Sharing) and the XDS-I (Cross-Enterprise Document Sharing for Imaging) profiles, which allow images and data be exchanged very easily within any environment;
- O3-RWS with O3-MIRC and O3-3D, a revolutionary radiological workstation, including 3D support, management of and access to MIRC (Medical Images Resource Center) data and structured reporting;
- O3-MARIS, a "super" RIS offering many new integration features and MIRC support;
- O3-XDS, one of the first XDS document repositories and registries;
- O3-PDA, a first step towards opening up to home-care and mobile-care;
- O3-TEBAM, allowing accurate electrical reconstruction of the brain in 3D in the case of pathologies
- O3-VMOD, a virtual modality allowing the simulation and pre-programming of any integration with real modalities.

These O3 products have been tested successfully at the IHE 2005 Connectathon in Amsterdam and at the IHE 2006 Connectathon in Barcelona, achieving compliance with 19 IHE actors and 15 IHE profiles, having passed more than 300 tests with most of the European market brands.

From the organizational point of view, the O3 Community is built through all the institutions having an agreement with HECE: in particular those belonging to the ABIC-BME (Adriatic Balcanic Ionian Cooperation in

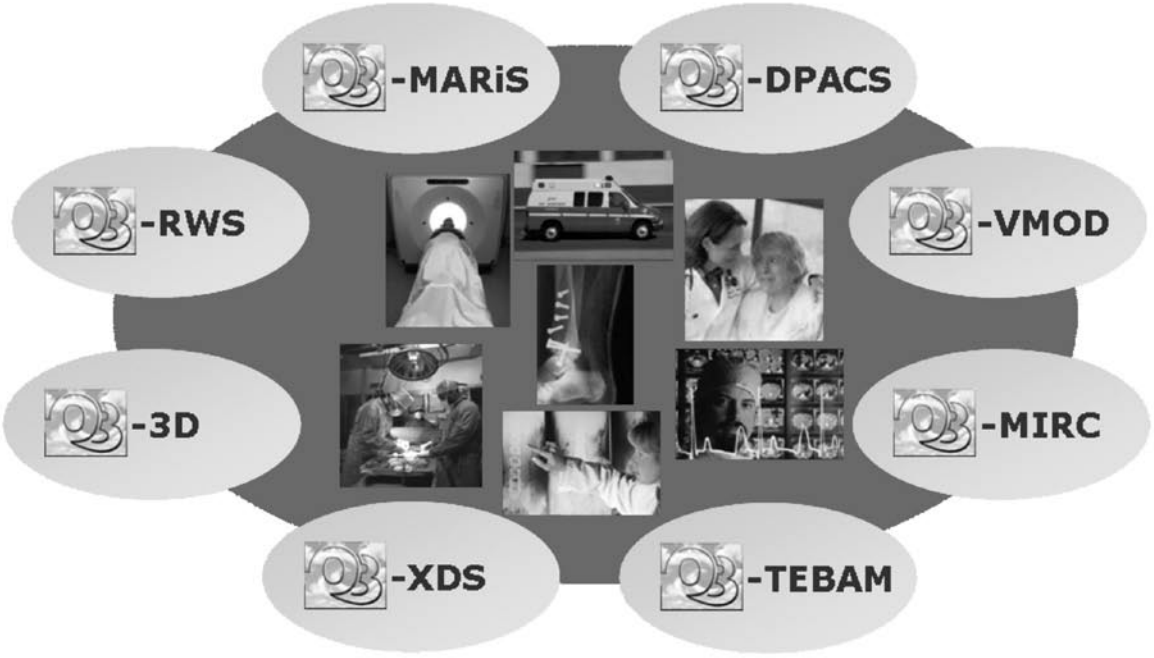

Figure 2: The main O3 products for the Domain of Radiology

Biomedical Engineering) and ALADIN (Alpe Adria Initiative Universities Network) international networks, and –about the approximately 60 healthcare institutions, industrial enterprises and governmental agencies with a bilateral agreement active with HECE. In the O3 Community, an O3 Users' Community and an O3 Developers' Community are designated. Every member of the O3 Community can in principle request to participate in both communities.

The Developers' community was started under the responsibility and administration of HECE, with the Universities of Trieste and Padova in Italy and the University of Maribor in Slovenia as the main contributors, but it grew and acquired many other European and US contributions from universities, research centers and from industries. It provides the active members of the Users' Community with all the necessary project design, site analysis, implementation, logging, authoring, bug solving, and high-level 7/7-24/24 full-risk service. Additionally, training is highly important to the HECE, starting with the preparation of clinical engineering professionals at three different levels, offering both traditional and e-learning courses with particular skills in Clinical Informatics, Health Telematics, E-health integration standards and IHE-based interoperability, as well as providing specific courses and training on-site.

Furthermore, selected radiologists from the Active Users' Community – where O3 is running (in Italy, from Trieste, Padova, Pisa and Siena and in Slovenia from Maribor) – constitute a Medical Advisor Committee, which gives very precious feedback to the O3 Developers' Community.

The growing cooperation of O3 with large industries in the O3 Community is another very interesting aspect, and it is focused especially on the integration with the surrounding territory and home-care.

Two important examples are reported.

The latest developments of Ultrasound Technology and the introduction of High End Compact machines will be at the centre of the cooperation with GE Healthcare, focused on "integration". The challenge is to improve solutions for moving Health Services from the Hospital to the Patients, with regard to some social groups such as the elderly, children and disabled patients. Compact Ultrasound, with their innovative capabilities to receive and transmit the patient's complete data and exams to a remote location for real time consultation, could help to overcome territorial or physical restraints, providing high quality health services at the patient's site, ranging from prevention to treatment.

The development of a Cardiologic Information System (CIS), able to integrate "the patient", either at home, when mobile or in the hospital, with all the types of cardiologic information collected from him/her and with the goal to coordinate the integration with all his/her other clinical data, will be at the centre of a cooperation with Agfa Healthcare.

In the following two paragraphs some details are given of two of the O3 products – a server (O3-DPACS) and a client (O3-RWS) – underlying some of the key properties of the O3 solutions in a real integrative multi-lingual environment.

2.3 The O3-DPACS Open-Source Image-Data Manager/Archiver

O3-DPACS is a Java J2EE (Java 2 Enterprise Edition) application. It has been realized as a modular collection of services, as summarized in Fig. 3 (Inchingolo et all. 2006). As communication protocols, DICOM is used mainly for clinical data, signals and images and HL7 (Health Level 7) for administrative data.

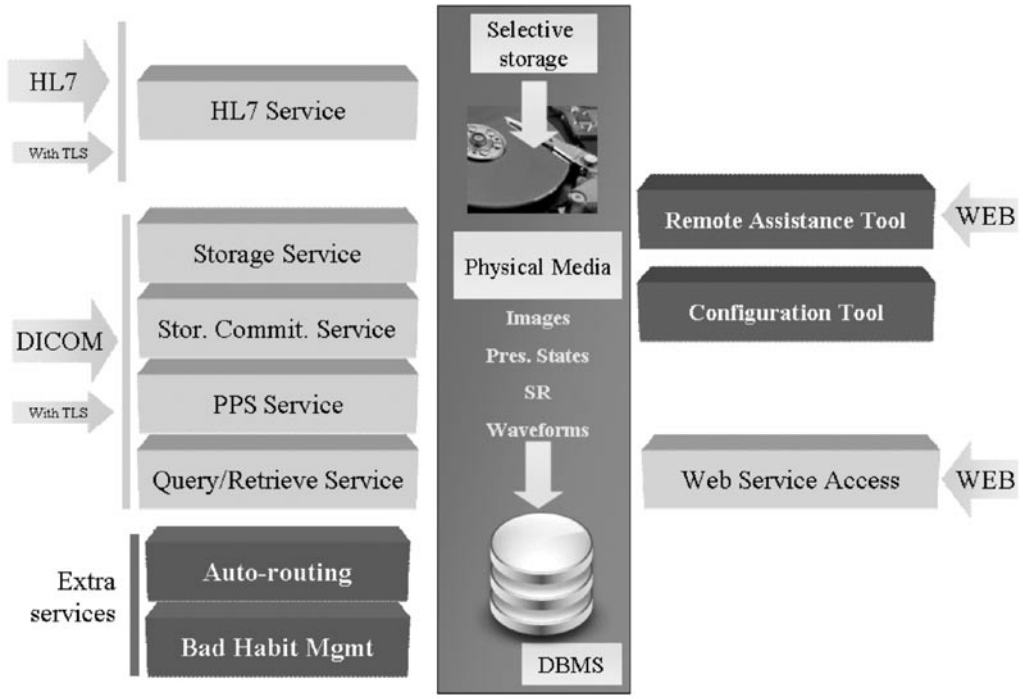

Figure 3: The modular structure of O3-DPACS (Inchingolo et al. 2006)

On the left column of Fig. 3, the DICOM and HL7 communication modules connect the external world with the modules of the services:

- Storage: to store DICOM objects. The server allows the storage of: 1) images (as with all the PACS systems), 2) data, such as reports, in the form of DICOM Structured Reports and Presentation States, and 3) waveforms, such as ECG, EMG, EEG etc., as DICOM waveform data;
- Query/Retrieval of DICOM Objects: to execute query and retrieval of the stored objects via the DICOM protocol;
- The Modality Procedure Performed Step: to receive messages about the completion status of exams exam and link them with the stored data;
- DICOM Storage Commitment: to verify that data is properly stored and to confirm this to modalities;
- HL7 message interpretation: to manage administrative data, such as identifying information exchanges, or checking for the re-alignment of inconsistent patient information, i.e., due to a first-aid procedure.

In addition, the following IHE-based services have also been implemented:

- Evidence Documents, for optimal management within the radiological workflow of all added objects created in referral steps (report, notes and graphic objects);
- Key Image Notes, to create notes on the details of some images to make them more recognizable, as well as to apply and visualize them in a simple and intuitive way;
- Workflow Reporting, to allow any step in the complex referral procedure to be monitored and organized so as to guarantee maximum simplicity and transparency, which are fundamental requisites for obtaining a complete, accurate and error-free diagnosis.
- Cross-Enterprise Document Sharing for Imaging, which allows the retrieval of original health enterprise clinical images from outside at any time.
- Audit Trail Node Authentication, which manages security in all the communications between the heterogeneous systems.

2.4 The RWS Image-Data Display

The RWS Workstation has the functionality of a display manager with many additional services and it fully supports authentication. Three different authentication systems are provided: smart card authentication, a basic username/password authentication and a network authentication. This last provides a fully-traceable sub-system for the management of the usage of RWS.

Its object-oriented design offers a common base for essential services for the correct management of different types of data for different types of source: it is possible to open medical files both from a remote image/data manager (from a PACS) or from the local disk; the file can contain images, signals or pure SR (Structured Reporting) data.

Once the clinical data is taken by one of the different sources, such as a PACS, a DICOMDIR (a unique and mandatory DICOM file within a file set that contains the SOP Class Media Storage Directory) or a local disk, it can be viewed using one of the appropriate viewers:

- Image Viewer (also for multi-slice images);
- DICOM Structured Reporting (SR) viewer;
- Waveform Viewer.

It is also possible to use these types of data with other modules:

- Print Module, allowing DICOM and non-DICOM

print procedures;
- Study Move Module, letting the user move the selected data to from one PACS server to another;
- Patient CD module, providing a simple way to burn data onto removable devices, like CDs or DVDs, as well as creating an html tree model with all the images in jpeg format.

The DICOM SR is used both to present numerical data such as those related to the Clinical Chemistry Laboratory, and to offer a new type of presentation for medical reports, based on structuring the report contents. This approach has been initiated with radiological reports and is under test and evaluation by an international multi-centric group of radiologists.

RWS supports many add-on modules. One of the most acclaimed modules is O3-3D, an open-source module for the three-dimensional reconstruction and manipulation of images. Another add-on module is O3-TEBAM, which actually performs the 3D reconstruction of electrical brain activity using an 8-16 CPU computing system. A third one is O3-MIRC, which allows the connection of RWS with any Medical Imaging Resource Centre (MIRC) site, allowing the radiologist or other medical specialists or teachers to retrieve MIRC images in order to compare them with images under examination or for teaching purposes.

O3-RWS is fully internationalized for use even in a multi-lingual hospital or territorial body, and therefore allowing the efficient exchange of images and reports between hospitals of different countries with their own language and character set in each country. This is particularly important in multi-lingual regions and countries, such as Friuli Venezia Giulia in Italy or in Switzerland, which both have four official languages: Italian, German and Ladin/Friulian, plus Slovenian in the first case and French in the second.

3 Conclusions and Future Plans in the Region

Thanks to the practical experimentation in the solutions described above, the experience of a 15-years study on the integration of health systems using ICT technologies, from the hospital department to the single citizen in the e-health context of the future information-based society, has shown that some key methodological and organizational elements are extremely relevant to the success of the e-health integration process.

From the point of view of the organization of our cooperative work with other user and developer centers, the initiative of the Open Three (O3) Consortium (O3, 2007) has proved its real efficiency and efficacy in the last months. All the O3 sub-systems are developed in the mode of compatibility and can be adjusted to any scale including the national and the international. O3 is completely developed as Open Source and with Java and Web technologies

Figure 4: An example of multiple image visualization on the O3-RWS workstation

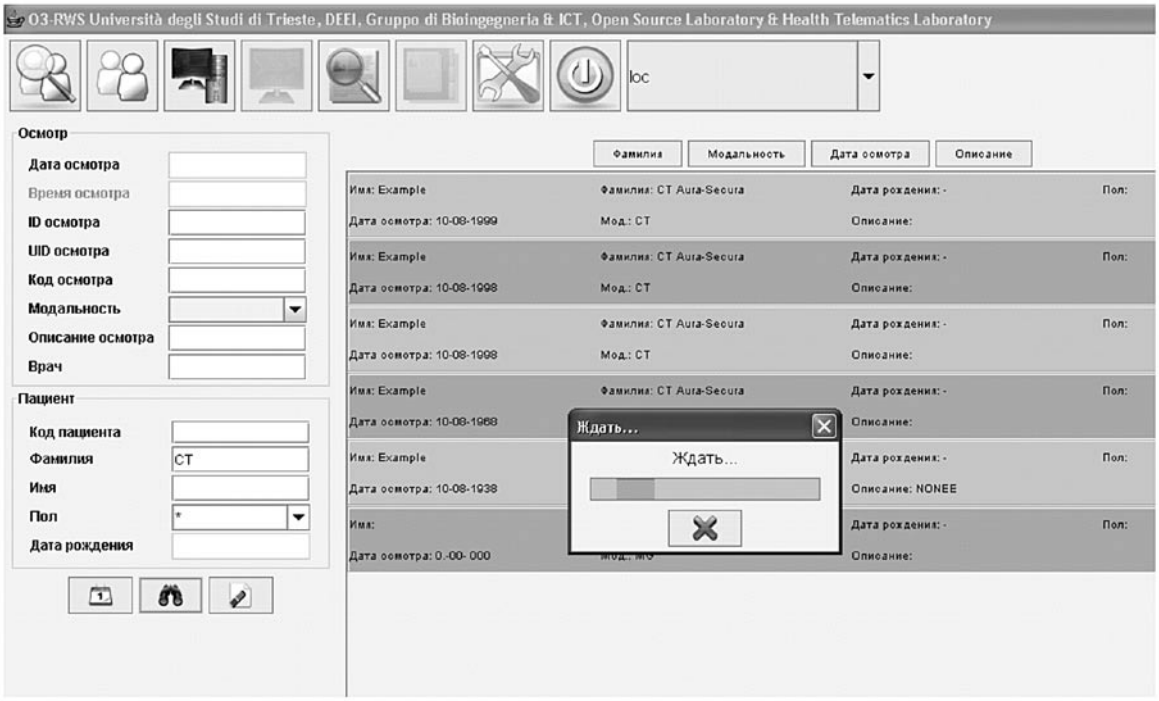

Figure 5: An example of a Russian language version (using Cyrillic characters) of the RWS Workstation

to facilitate its re-use and portability, fostering a wide distribution in Italy and abroad. It is independent of database, OS, HW and language and 100% compliant with the IHE world-wide interoperability initiative.

As far as the implementation of the O3 system is concerned, there are several concrete initiatives happening at this moment. The Faculty of Medicine, University of Maribor, joined the O3 Consortium to participate in the development process and support the Slovenian health institutions in its implementation. The Maribor hospital first installed O3 in January 2007 and is now testing it for potential full implementation. Talks with other Slovenian, Austrian and Croatian health institutions are also underway. The parallel initiative of the e-learning program in Medicine is also being born as a consequence of cooperation under O3.

The choice of Open Source as the leading solution for the future of e-health anticipates a common trend in the industrialized and political world, recently evidenced by the position assumed by the Department of Health & Human Services and the Department of Defence of Unites States at the Open Source Strategy for Multi-Centre Image Management Workshop, held in March 6-9, 2006 at Las Vegas (USA), as well as by the decision announced by the world's biggest industries at the OSDL Joint Initiatives Face to Face Meeting Review – the Health Care Information Exchange, held in May, 10-12, 2006 at Sophia-Antipolis (France) – and finally by the European Union in the Riga Declaration signed during the Intergovernmental Meeting of the European Commission "ICT for an Inclusive Society", held in June 11-13, 2006 at Riga (Latvia). It is interesting to emphasize that O3-DPACS and the O3 Consortium have been presented by invitation at all these three events.

In conclusion, the O3 Consortium seems to represent a significant contribution that will really support the increase of e-health integration, not only in the local region, but also across Europe and the world.

With respect to our Alpe-Adria Region, O3 is demonstrating relevant actions in cross-border eRegion Development that improve the way people work together, live together and grow together, without frontiers. It links vital processes in the moving and integration of information thanks to an e-integration approach, such as that started four years ago with our ALADIN – the Alpe Adria Initiative Universities' Network, www.aladin-net.eu – one of the first citizen-centric initiatives in Europe.

Literature

AlSafadi, Y., Lord, W.P.& Mankovich, N.J. (1998). PACS/Information systems interoperability using enterprise communication framework. *IEEE Trans Inf Tech Biomed* **2**(2):42-47.

Bourka, A., Polemi, D. & Koutsouris, D. (2003). Interoperability among healthcare organizations acting as certification authorities. *IEEE Trans Inf Tech Biomed*; **7**(4):364:377.

Chronaki C.E. & Chiarugi F. (2005). Interoperability as a quality label for portable & wearable health monitoring systems. *Stud Health Technol Inform*, **117**:108-116.

Diminich, M., Inchingolo, P., Magliacca, F. & Martinolli, N. (1993). Versatile and open tools for LAN, MAN and WAN communications with PACS. In: Computational Biomedicine. Editors: Held, K.D., Brebbia, C.A., Ciskowski, R.D.& Power H., Computational Mechanics Publications, Southampton, 1993, pp. 309-316.

Diminich, M., Inchingolo, P., Martinolli, N., Dalla Palma, L., Giribona, P., Pozzi, R.& Stacul, F. (1995). ARIS: an Autonomous Remote Image Station offering both local and remote IMACS/RIS resources in an open environment. In:

Proceed 3rd Europ Conf Eng Med, 1995, p. 241.
Drury, P.& Dahlman, B.(2005). Open source approaches to health information systems in Kenya. *World Hosp Health Serv* **41**(3): 36-39.
Fioravanti, F., Inchingolo, P., Valenzin, G. & Dalla Palma, L. (1997). The DPACS Project at the University of Trieste. *Med Informat*, **22**(4):301-314.
Fioravanti, F., Inchingolo, P., Valenzin, G., Dalla Palma, L. & Vallon, R. (1996). The DPACS Project at the University of Trieste: architecture and working environment. In: *Proceed 14th Internat EuroPACS Meeeting. Creta, Greece, 1996*.
Giribona, P., Bravar, D., Stacul, F.,& Ukovich, W. (1992) PACS experiences in Trieste. *Int J Biomed Comput* **30**(3-4):285-293.
Hacklander, T., Martin, J. & Kleber, K. (2005) Informatics in radiology (infoRAD): an open source framework for modification and communication of DICOM objects. *Radiographics*, **25**(6):1709-1721.
HDW2, HTL Dicom Workstation project, HTL, DEEI, University of Trieste. Available from: http://www.bioing.units.it/PRG/HTL2, 1.1.2007
HL-7 - Health Level 7., available from: http://www.hl7.org, 1.1.2007
IHE – Integrating the Health Care Enterprise. Available from: http://www.ihe.net, 1.1.2007
Inchingolo, P., Beltrame, M., Bosazzi, P., Cicuta, D., Faustini, G., Mininel, S., Poli, A. & Vatta, F. (2006). O3-DPACS Open-Source Image-Data Manager/Archiver and HDW2 Image-Data Display: an IHE-compliant project pushing the e-health integration in the world, *Computerized Medical Imaging and Graphics*, Elsevier Science **30:** 391-406
Inchingolo, P., Bosazzi, P., Cicuta, D., Faustini, G., Barbaro, A., Miniussi, E. & Vittor, A. (2004). DPACS-2004 becomes a java-based open-source modular system. In: EuroPACS-MIR 2004 in the Enlarged Europe. Editors: P. Inchingolo, R. Pozzi Mucelli, EUT, Trieste, 2004, ISBN: 88-8303-150-4, pp. 271-276.
Inchingolo, P. & Pozzi Mucelli, R. (eds) (2004). EuroPACS-MIR 2004 in the Enlarged Europe. EUT, Trieste, 2004, ISBN: 88-8303-150-4. Also available from: http://www.tbs.units.it/europacs2004.
ISCELS, Interreg IIIA "Italian Slovenian Cooperative E-learning Space", available from: http://is.aacels.eu, 1.1.2007
Kalra, D., Beale, T. & Heard, S. (2005). The openEHR Foundation. *Stud Health Technol Inform*, **115**:153-173.
Lindahl, F. & Torgersson, O. (2005). mGen - An Open Source Framework for Generating Clinical Documents. *Stud Health Technol Inform*, **116**:107-112.
Miniussi, E., Bosazzi, P., Inchingolo, P., Masè, M. & Vittor, A. (2004). HDW2: a powerful and customization-friendly java-based Dicom Workstation. In: EuroPACS-MIR 2004 in the Enlarged Europe. Editors: P. Inchingolo, R. Pozzi Mucelli, EUT, Trieste, 2004, ISBN: 88-8303-150-4, pp. 215-218.
O3 - Open Three Consortium, available from: http://www.o3consortium.eu, 1.1.2007
Rosset, A., Spadola, L., Pysher, L. & Ratib, O. (2006). Informatics in radiology (infoRAD): navigating the fifth dimension: innovative interface for multidimensional multimodality image navigation. *Radiographics*, **26**(1):299-308.
Saccavini, C. (2004). The MARIS Project: open-source approach to IHE radiological workflow software. In: EuroPACS-MIR 2004 in the Enlarged Europe. Editors: P. Inchingolo, R. Pozzi Mucelli, EUT, Trieste, 2004, ISBN: 88-8303-150-4, pp. 285-287.

Paolo Inchingolo is a full professor of Bioengineering, Biological Control Systems and Health Telematics at the Faculty of Engineering at the University of Trieste, Italy. He is head of the bioengineering and ICT Group at the Department of Electrotechnics, Electronics and Informatics (DEEI) of the University of Trieste. He is visiting professor of bioengineering at the National Institutes of Health, Bethesda, USA, since 1987. He promoted many research projects and centers in the fields of neuromodelling, clinical engineering, telemedicine, medical informatics and advanced biomedical instrumentation. He is a director of the "Higher Education in Clinical Engineering" international program. He is founder and coordinator of the University "Adriatic-Balcanic-Ionian Cooperation on Biomedical Engineering" (ABIC-BME) and a Delegate of the Alpe-Adria Universities Network (ALADIN). He is Chair of the IHE Transnational Committee for Central and Eastern Europe and President of the Open Three Consortium. He is the author of 360 papers.

Dejan Dinevski is an associate professor of Medical Informatics and Bioinformatics at the Faculty of Medicine, University of Maribor, Slovenia and an associate professor of information systems in education at the Faculty of Education, University of Primorska, Koper, Slovenia. He is also the head of the Center for e-education and lifelong learning and Deputy Secretary-General of the University of Maribor. He has initiated and coordinated several national and international research and development projects, especially in the field of e-education and lifelong learning. He is the author of 85 research and technical publications.

The authors began cooperation in 2002 in several European and national projects coordinated by both of them.