Int J CARS (2007) 2 (Suppl 1):S315-S316.

The last 10 years of evolution in teleradiology: An overview of concepts and approaches of CHILI

Uwe Engelmann[a)], H. Münch[b)], A. Schröter[b)], H.P. Meinzer[a)]

[a] *Deutsches Krebsforschungszentrum Heidelberg, Germany*
[b] *CHILI GmbH, Heidelberg, Germany*
u.engelmann@dkfz.de

Abstract. Teleradiology is probably the most developed area of telemedicine. It has been used as a daily routine in thousands of installations since the DICOM standard became available. The applied technology has continued to evolve over the last ten years, and a teleradiology user can choose between different solutions. This paper gives an overview of different technologies and application scenarios in teleradiology to support users in selecting the appropriate solution that best fits their needs.

Keywords: Teleradiology, PACS, DICOM, Telemedicine

1. Introduction

CHILI is a family of software modules for teleradiology and PACS. It started in the early 90s with a scientific project (MEDICUS) as a dedicated teleradiology system that had been developed after a requirement analysis with potential German teleradiology users. In 1997 after the end of the MEDICUS project and nearly 2 years of successful routine application and evaluation [1], the software was redesigned and developed under the name CHILI, and it became a commercial product. The “academic spirit” of the first years has been preserved in the last ten years, and ongoing evaluation and improvement of the software are still key features of the system [2][3]. User requirements are routinely collected and taken into account to support user demands as effectively as possible. Nearly every teleradiology project, even a commercial one, has new requirements and challenges [4]. Thus the building blocks must be as flexible and extensible as possible to establish customer-oriented solutions that can be customized to the specific needs of a project. Several principal architectures with different technical approaches have been developed, implemented, and used as a daily routine.

2. Teleradiology Architecture

2.1 Principal Differences: Push vs. Pull and Peer-to-Peer vs. Server-based

Images are usually pushed from the sender to the receiver in the classical architecture of a teleradiology system. Another way of providing data is to use the pull model. This means that the sender deposits the data at a location where the receiver can pull it. Normally, this location is not a central PACS server or teleradiology storage location, but a dedicated server that is placed e.g. in a demilitarized zone (DMZ). Examples of such servers are mail servers and web servers. The principle difference of server-based pull approach is that the data is submitted to the receiver at the user's access time or to a program which checks periodically for new data.

2.2. Teleradiology Workstation

The classical teleradiology architecture is built with two teleradiology workstations. Both are able to transmit images directly to each other. Data is explicitly pushed to the receivers' site. A prerequisite of this approach is that both machines can reach each other directly via TCP-IP. Different protocols are in use for transmission, such as DICOM C-Store or propriety protocols with built-in data security measures and a teleconferencing functionality. Drawbacks of this approach include the need for a direct connection between the workstations, all connections have to be configured explicitly so that firewalls have to be opened for each bilateral teleradiology link. Extensibility is a bottleneck of this approach because the number of links grows exponentially.

2.4 Teleradiology using E-mail and Mail servers

E-mail is an accepted, widely distributed and available technology to exchange data. Suppl. 54 of the DICOM standard defines DICOM images as MIME attachments of e-mails [5]. The use of e-mail for teleradiology has a number of obvious advantages; however, additional measures have to be implemented, e.g. to assure data security, to avoid size limitations of e-mail systems, and to automatize the submission and reception of many images of one study [6] . A working group of the German Radiology Society (DRG) developed a standard for teleradiology based on e-mail and DICOM Suppl. 54 that takes account of the additional requirements. This standard is recommended by the DRG as the minimum German standard for teleradiology and is in use by more than one hundred institutions in Germany [7]. The advantage of this approach is that a teleradiology network can be easily extended and does not require complicated configurations of teleradiology systems and firewalls. A prerequisite is that a mail server is available in the internet that can be reached by all communication partners. The mail server should be a dedicated server to avoid transmission delays and to handle very large quantities of data. Existing mail servers of university clinics are usually unsuitable because the timely delivery of the data may not be guaranteed due to other mail traffic.

2.5 Web Server

The distribution of medical images inside hospitals with web technology is standard practice in modern PACS systems. The distribution of images to referring providers or to the radiologist at home requires additional features, such as data protection measures and performance improvements. We have developed a web server with specific features for the distribution over slow and public networks [8]. Further improvements are teleconferencing between web users and even between web clients and classical workstations. This approach is well-suited to the distribution of images from one location to many consumers, e.g. to the referring providers [9].

2.6 Web Portal

This is an extension of the web server approach to collect images from many potential sources at one location. It provides web-based DICOM services and uploading of images (and other) data to the central system. The collected and uploaded data is then integrated into the clinical workflow and can be distributed throughout the entire enterprise [8].

2.7 Teleradiology Gateways

Different combinations of the aforementioned functionality can be combined into dedicated blackbox devices that transparently integrate teleradiology into legacy environments. Teleradiology users can still use their normal equipment for image acquisition and reporting, and can transmit images with locally available standard protocols, such as DICOM and HL7, to that gateway. The gateway performs all the necessary adaptations and conversions for the wide area network, such as selection of the correct protocol (depending on the receiver), data security, compression, and fault tolerance. This technology is well-suited to interconnect many locations in a large region or even a country. We used teleradiology gateways to establish a “country-wide” teleradiology network between hospitals in Greenland [10].

2.8 Heterogeneous Networks

Combinations of the described techniques can be used to establish communication between systems that “speak different languages” and which would not interoperate directly. An example of such a heterogeneous network has been established around the University Clinic of Freiburg in Germany. The local partners in this network use the protocols DICOM over VPN, DICOM-E-Mail and https to communicate by means of standard radiological workstations, teleradiology workstations, web servers, and e-mail servers. The central component in this network is a CHILI communication server that speaks all protocols and which auto-routes the data between the communication partners [11].

3. Workflow Integration (IHE)

Teleradiology is very often an isolated island in the IT landscape of the hospital. The integration into the clinical workflow is an important requirement for the success of teleradiology in daily routine. The Integrating the Healthcare Enterprise Initiative (IHE) provides mechanisms that allow this to be achieved in a standardized and vendor-independent way [12]. This means that data from external sources are integrated into the internal information systems and that they can be processed like local data. The IHE profile Import Reconciliation Workflow (IRWF) defines the necessary steps of the different actors to integrate foreign data in a clean and efficient way [13].

4. Quality Assurance

Teleradiology for emergency cases has to fulfill certain quality measures, such as transmission time, completeness, correctness, and display quality. The German standards organization DIN recently released a draft of a new standard for quality assurance in teleradiology (DIN 6868-59) [14]. Teleradiology systems for images that have been acquired with ionizing radiation without an onsite radiologist require legal permission for their operation in Germany if the images are to be transferred to a tele-radiologist for primary diagnostic purposes. Compliance with this new standard will probably become mandatory in the near future. Advanced teleradiology systems will provide technical measures and functional features to support teleradiology operators in carrying out the necessary acceptance and constancy tests (daily and monthly) in an efficient and reliable manner. The CHILI system supports users with a teleradiology statistic module to track and evaluate quality parameters.

5. Discussion

Over the years, there has been a steady evolution from isolated systems to integrated environments. The establishment of a teleradiology network or the connection to an existing network necessitates an analysis of the existing IT infrastructure (HIS/RIS/PACS, imaging modalities and other teleradiology systems), existing security policies and systems (firewalls), and, last but not least, the needs of future teleradiology users. The selection of the appropriate solution must be based on this information. The various available teleradiology concepts and systems have been realized with the CHILI software family and can be combined and seamlessly integrated [15].

6. Conclusion

A strong focus on standards such as DICOM and HL7, utilization of the results of the IHE Initiative, integration of different principal communication methods (push vs. pull, web-based vs. peer-to-peer), adaptation of different protocols (e.g. DICOM, HL7, e-mail), and the possibility of converting between them has created a flexible software architecture that can be adapted to the user's requirements.

References

[1] Engelmann U, Schröter A, Baur U, Werner O, Schwab M, Müller H, Bahner M, Meinzer HP, Borälv E, Göransson B. The German teleradiology system MEDICUS: System description and experiences in a German field test. European Journal of Radiology 26 (1998) 219-225.
[2] Engelmann U. Schröter A, Baur U, Werner O, Schwab M, Müller H, Bahner M, Meinzer HP. Second Generation Teleradiology. In: Lemke HU, Vannier MW, Inamura K (eds): Computer Assisted Radiology and Surgery. Amsterdam: Elsevier (1997) 632-637.
[3] Engelmann U, Schröter A, Baur U, Werner O, Schwab M, Müller H, Meinzer HP. A Three-Generation Model for Teleradiology. IEEE Transactions on Information Technology in Biomedicine 2 (1) (1998) 20-25.
[4] Engelmann U, Schröter A, Schwab M, Meinzer HP. Reality and perspectives in teleradiology: a personal view based on personal experiences. International Journal of Medical Informatics, Vol. 64 (2-3) (2001) 449-459.
[5] DICOM Standards Committee, Digital Imaging and Communications in Medicine (DICOM). Supplement 54: DICOM MIME Type. http://medical.nema.org/Dicom/supps/sup54_pc.pdf. [Accessed 11.03.2007].
[6] Engelmann U, Schroeter A, Schweitzer T, Meinzer HP. The communication concept of a regional stroke unit network based on encrypted image transmission and the DICOM-Mail standard. In: Lemke HU, Vannier MW, Inamura K, Farman AG, Doi K, Reiber JHC (eds). CARS 2002. Heidelberg: Springer (2002) 612-617.
[7] Weisser G, Walz M, Ruggiero S, Kämmerer M, Schröter A, Runa A, Mildenberger P, Engelmann U., Standardization of teleradiology using Dicom e-mail: recommendations of the German Radiology Society. Eur Radiol. 2006 Mar;16(3):753-8.
[8] Münch H, Engelmann U, Schröter A, Meinzer HP. The integration of medical images with the electronic patient record and their web-based distribution. Acad Radiol 2004; 11:661-668.
[9] Münch H,, Schröter A, Meinzer HP, Engelmann U. A webbased approach to distributing medical images for referring physicians outside hospitals without specialised user management. Int. J CARS (2006) 1:130-132.
[10] Engelmann U, Münch H, Schröter A, Schweitzer T, Christoph K, Eilers R, Olesen H, Møller Jensen J, Meinzer HP. A teleradiology concept for entire greenland. Int. J CARS (2006) 1:121-123.
[11] Engelmann U, Münch H, Schröter A, Meinzer HP. Jäckel A (ed). Von der bilateralen Teleradiologie zur Vernetzung von Regionen: Der CHILI-Ansatz. Telemedizinführer Deutschland, Ausgabe 2005. Ober-Mörlen: Deutsches Medizin Forum (2004) 265-269.
[12] Hussein R, Engelmann U, Schröter A, Meinzer HP. Implementing a full-feature PACS solution in accordance with the IHE technical framework: The CHILI approach. Academic Radiology 11/4 (2004) 439-447.

[13] Integrating the Healthcare Enterprise Initiative (IHE). Import Reconciliation Workflow. http://wiki.ihe.net/index.php?title=Import_Reconciliation_Workflow [Accessed 11.03.2007].
[14] Deutsches Institut für Normung e.V. DIN 6868-59:2007-02. Image quality assurance in diagnostic X-ray departments - Part 59: Acceptance and constancy testing in teleradiology according to RöV. Berlin: Beuth 2007.
[15] CHILI GmbH, Heidelberg. List of CHILI related publications. http://www.chili-radiology.com/de/pub/ [Accessed 11.03.2007].