Expectations and Solutions for HIS/RIS/PACS Dataflow and Workflow

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THE ROLE of radiology as a service department within the current Health care system has been subjected to considerable change because of lack of finance. Increased efficiency in the performance of many individual examinations is necessary. The quality of the medical results, however, should be maintained even if there is a tendency to reduce resources. These problems only can be mastered by applying new information and communication technologies. In this case, the successful integration of all information systems and examination-related equipment is a prime requirement.

VARIOUS EXPECTATIONS

Establishing an information technology infrastructure in a hospital is coupled with various expectations from the participants, according to their areas of interest: for example, all information required should be available at the right place and the performance must be acceptable. Naturally, no loss of data should occur nor should the on-going process be hindered because of an incomplete examination (exposure made, no report available). In addition, department efficiency should be improved substantially through the introduction of DP systems.

TECHNOLOGICAL AND ORGANIZATIONAL DIMENSIONS OF THE INTEGRATION

A functional interface among the radiological information system (RIS), the hospital information system (HIS), modalities, and the picture archiving and communication system (PACS) is the basis for improved efficiency and transparency (Fig 1). The interface connection quality attainable is very variable because of the heterogeneity of the systems.

Connectivity: Defined Data Exchange Between 2 Units

An unequivocal interface agreement is the prerequisite for realizing a communications connection. Both partners must agree on a common language (protocol), that is, on the structure of the message and data formats. Standards such as Health Level 7 (HL7) and Digital Imaging and Communications in Medicine (DICOM) are an ideal basis to reduce

misunderstanding and to communicate successfully.^{1,2} The DICOM standard covers image-related functions like send, receive, query/retrieve or print image series in addition to non-image-related parts. For example, worklists or reports can be exchanged in a standardized form.³ The connection of non-DICOM or non-HL7 compatible systems requires special solutions.

Interoperability: How are the Imported Data Used?

Besides the actual network, the operator primarily would like to use the externally produced data to support his or her daily work as well as possible. This is only possible when the applications functions have all the necessary data at their disposal. This relationship is called *interoperability*, that is, "the ability to exchange medical information which has clinical utility on both sides of the connection" (Fig 2).

Typical questions are:

- To which extent can three-dimensional evaluations be performed on imported data?
- Are the descriptions used in the different systems, for example, for organs, standardized to undertake unequivocal image retrieval?
- Are an adequate number of hierarchical levels (eg, patient ID, case ID, examination ID, and so on) present to "hang" images in a patient folder or to identify them unequivocally at the examination level?
- Are all data elements entered completely and correctly?
- Are the data adequate to build a worklist for reporting or for evaluating status information that is required for on-going routing of images, and so on?

Interoperability is not present in DICOM or HL7 and thus is not standardized.

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Fig 1. Data flow among the networked systems.

Workflow: How Can Work Process Be Recorded and Optimized?

Connectivity and interoperability (Fig 2) mainly are involved with particular interface functionality. On the other hand, workflow is a total approach to supporting work processes using information technology.⁴

Radiology, as an organization, has definite primary duties to perform in the hospital environment: The formulation of the medical question to be answered by radiology in the best possible manner is in the foreground. A multiplicity of job parts involving relatively complex organizational participation are required for the solution of simple to complex processes. Various doctors and medical personnel are involved to perform a relatively simple thorax examination or to undertake a complicated dilatation. The end result, besides the special examination, comprises a report with images that has to be sent to the referring doctor.

Departmental workflow is best recorded using workflow modeling (Fig 3) to:

Fig 3. Basic elements of workflow modeling.

- Systematically describe all tasks with job parts
- Record the information and results arising from the tasks
- Document the operators who undertake the tasks

Then in the so-called process model, all radiological main and part work processes are represented in a dynamic operation whereby the tasks are coupled to the information. These task areas then are related to the given units on which they will be carried out. Software applications can be selected, which give part processes the best possible support, after the actual and future workflow have been recorded.

DATA AND WORKFLOW CAPABILITIES OF SIENET

Siemens, as the worldwide leading supplier of PACS offers networking and system integration expertise to enable intelligent connections among RIS/HIS workstations, archives, and modalities from different vendors. In the next sections, several Siemens PACS (SIENET) examples of data and workflow solutions are shown.^{5,6}

The Open and Flexible System Concept

The SIENET system allows a variety of connections to external systems using a series of dedicated networking modules.⁷ Thus, very individual data-flows (Fig 4) can be constructed, and application functions can be provided for. The various components of SIENET are as follows:

- SIENET MagicLink I is our standard connection between RIS/HIS, modalities and SIENET: The main functional emphases are on the bi-directional exchange of text-related medical data such as patient data, reports, and

Fig 2. Connectivity and interoperability are prerequisites for realizing workflow management.

Fig 4. SIENET connectivity products and applications.

worklists, and the control of important processes such as pre-fetching of historical images and status information about new images. Various interface protocols based on DICOM, HL7, or project solutions are used.

- SIENET MagicServe is an intelligent distribution service inside and outside the hospital. Depending on the respective modality type or selected organ, compressed or uncompressed images can be routed to many working places with DICOM-receive capabilities.
- SIENET MagicLink D allows the connections mainly of older modalities to DICOM. The majority of Siemens modalities today have an integrated DICOM interface.
- A number of different RIS systems, modalities, and workstations from other manufacturers have been connected successfully.

The Siemens Conformance Level Definitions

Despite comprehensive standardization (as with DICOM), the data format agreements allow certain degrees of freedom (eg, mandatory and optional data elements). The smooth functioning of a workstation application with external data, however, requires certain data elements as a prerequisite. The *conformance level definition* explains the relationships between the required data elements and application levels.⁸ These levels are management + organization; viewing; simple post-processing; reporting from softcopy; reporting from hardcopy and complex evaluations such as three-dimensional Minimum Intensity Projection (MIP) and Multiplanar Reconstruction (MPR), volume rendering, and so on. Behind these classes a list of data elements must be fulfilled to guarantee a

particular application. After testing images according to these levels, the user knows in advance which application functions or services can be applied to the data set. This will substantially improve interoperability.

Intelligent Image Prefetching, Routing and Distribution

An intelligent dataflow management is largely responsible for the acceptance of heterogeneous and distributed systems. SIENET supports the following mechanisms:

- Every RIS can actively trigger pre-fetching, that is, preloading of images from the SIENET long-term archive MagicStore to the fast disk store and further distribution to reporting workstations.
- If a new examination arrives at a MagicView reporting console, previous examinations are requested automatically. Depending on the type of modality, organ, or time, rules for each preload process can be formulated.
- MagicStore can undertake pre-fetching and autorouting based on similar rules following receipt of a worklist.
- Examination distribution strategies (Fig 5) from the MagicView to any addresses are possible according to given rules. For example, MagicView automatically distributes the images in as far as the RIS delivers ward detail. Additionally, the distribution component can control the dataflow and take into consideration the compression factors, depending on the examination status (eg, study new, reported, signed, transcribed).
- In addition, SIENET MagicServe possesses its own organ- and modality-dependent routes (as described previously).

Fig 5. Dataflow capabilities of MagicView.

Optimized Workflow at the Reporting Workstation

The structure of the workflow at the reporting console must fulfil the highest requirements in order to offer the doctor optimal working capabilities.

- The user only should see those functions that are required for the report: Doctor- and examination-dependent MagicView tool cards can be installed easily (Fig 6).
- The really relevant information about the examination should be displayed on the monitor screen: The basis for this is user-dependent structures (what will be displayed) and flexible sorting of the working place lists (only computed tomography [CT] images, only images for a doctor, and so on).
- Automatic arrangement of the image series on the monitor: Automatic monitor screen partitioning depends on modality type and number of examinations to be opened.
- Combination of individual, repetitive operating steps: Defining macros from all available functions means enormous time savings.
- Automatic management of the local disk capacity: Automatic archival and disk capacity is managed through user-dependent configured criteria.

Fig 6. Flexible structure tool cards.

CONCLUSION

Today's existing connectivity solutions offer a good start for the connection of many systems within and outside of radiology. DICOM and other standards supply an excellent basis for this. Interoperability, however, must be improved considerably. SIENET offers many solutions beyond the scope of the current standards. The expectations of users about the integration of all systems within and outside of radiology can be better met the more the relevant working processes are understood and standardized. Efficiency can be increased, and savings can be obtained with workflow solutions in a heterogeneous landscape.

REFERENCES

1. The National Electrical Manufacturers Association: Digital Imaging and Communications in Medicine (DICOM), in: NEMA PS 3.1-PS 3.12. Rosslyn, VA, NEMA, 1995
2. Health Level Seven: Health level seven—An application protocol for electronic data exchange, in Healthcare Environments (version 2.1). Chicago, IL, 1990
3. Gnoyke H, Offenmüller W, Thieme R: DICOM/MEDICOM standard supplements for the integration of modalities with information systems and IMAC systems. Proc CAR, Paris, 1996, pp 411-416
4. Jablonski S: Workflow Management Systeme: Motivation, Modellierung, Architektur. Springer Verlag Informatik Spektrum 18:13-24, 1995
5. Morin RL, Berquist TH, Rueger W: The Mayo Clinic Jacksonville electronic radiology practice. Proc SPIE 2711:384-393, 1996
6. Lindhardt FE: Viborg Sygehus: Routine digital operation with SIENET—A user reports. Electromedica 63:13-17, 1995
7. Offenmüller W: Managed workflow between HIS, RIS, modalities and PACS: Now with DICOM and beyond? Proc SPIE 2711:144-155, 1996
8. The Siemens Conformance Level Definitions. Erlangen, Siemens Medical Engineering Group (internal documents), 1995