USING A CLASSIFICATION SCHEME TO FACILITATE OUTSOURCING OF RADIOLOGY SERVICES

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Abstract: This paper deals with the issues involved in outsourcing radiology services. Based upon a field study of the work practices at the radiology department at Svendborg Hospital in Denmark, a novel solution (including a prototype of a computer supported reporting tool) that enables outsourcing of radiology services is introduced. The solution is based upon development of a classification scheme of possible radiology findings. Using predefined clinical findings for the radiology reports assure a high quality and enable automatic translation of radiology reports.

1 INTRODUCTION

Many countries in Western Europe suffer from a lack of radiologists, while some Eastern European countries have available radiology resources. According to the Danish National Board of Health (www.sst.dk), Denmark had 102 unfilled radiology positions in November 2007. Outsourcing of radiology services is a potential solution to the problem. However, important issues have to be addressed before this solution becomes viable. Outsourcing of radiology services demands a great deal of trust to the providing organization. The customer must trust that the provider delivers a product which is at least as good as their own both with regards to radiologic competence and linguistic quality. The quality of the radiology service is crucial, since patient treatment will be based upon the radiologist's report. The linguistic quality is an issue when outsourcing, since a radiology report in Denmark must be written in Danish. Having an interpreter translate each report is very time consuming and there are potential problems related to decreased comprehensibility of the reports as well as legal problems in case of mistreatment of a patient due to a wrong translation of a correct radiology report.

Based upon a field study of the work practices in the radiology department at Svendborg Hospital in Denmark, a novel solution (including a prototype of a computer supported reporting tool) that enables outsourcing of radiology services is introduced. The solution is based upon development of a classification scheme of possible radiology findings. Using predefined clinical findings for the radiology reports assure a high quality and enable automatic translation of radiology reports.

2 FIELD STUDY AT SVENDBORG HOSPITAL

The field study presents the current work practices of the radiology department at Svendborg Hospital in Denmark focusing on the lifecycle of an examination.

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2.1 The Radiology Department

An examination starts with a referral from either a general practitioner or from another department within the hospital. The referral contains the identity of the patient and some text explaining what the radiology department should investigate. The referral is either received in paper or electronic form. In both cases the referral is added to the Radiology Information System (RIS), which is used for governing the workflow around examinations within the radiology department.

At a daily conference, the radiologists prioritize the new examinations based on how crucial the referral is and they decide which images to take. If a patient complains about pain in the knee and the general practitioner expects osteoarthritis, which is a very slow progressing disease, the patient will receive a low priority. On the other hand, if cancer is expected, the patient will get a high priority. After the examinations have been prioritized, a secretary will send notification letters to the patients. Acute patients are of course handled as fast as possible.

When the patient arrives at the department, a secretary guides the patient to the relevant x-ray room, where a radiographer takes the images requested by the radiologists. Images are stored in the Picture Archiving and Communication System (PACS). The patient is done and leaves the department again. The RIS is updated, enabling the radiologists to see that the images have been taken.

A radiologist can now describe the images. If the images contain findings that the radiologist is unsure about, a second opinion from a colleague will be requested. The description is entered into the RIS and then electronically transmitted back to the doctor who requested it in the first place.

2.2 The Radiologist

When describing an examination, the radiologist typically follows a workflow that contains five steps: (1) investigate the patient's medical background, (2) investigate what is requested to be examined, (3) examine the images and create a mental diagnosis, (4) report what is actually examined, and (5) report what is found starting with most critical and finish with a conclusion. Some of the steps (1, 2 and 4) in the workflow can be omitted, but the quality of the report will as a consequence be lowered. The radiologist can obviously in some cases iterate back and forth over the steps. The above approach of reporting is problem oriented, meaning that the radiologist searches for an answer to a specific problem. This approach is optimal for swiftly finding the source for the given problem, but there is a risk that the radiologist will not discover secondary findings.

When reporting, the radiologist compiles a more or less complete mental overview of the diagnosis before writing the report. Compilation of the mental overview is based upon a search for findings in the images and then concluding with a diagnosis. Thus, the radiologist knows both the diagnosis and the findings before the report is written.

2.3 Relevant Observations

A radiology department (fully digitalized or not) with multiple collaborating actors requires articulation work "to manage the distributed nature of cooperative work" (Schmidt and Bannon 1992). The cooperative work arrangement is supported by a common information space (CIS) (Bannon and Bødker 1997), which in this case encompass daily conferences among actors and a powerful shared artifact (the RIS). Bossen's framework for analyzing CIS is used to briefly characterize the CIS of the radiology department through its parameters (Bossen 2002).

The CIS is characterized by being distributed both in time and space – but mainly in time. There is a high need for precision – primarily in the descriptions made by the radiologists. There is a high degree of common knowledge – the descriptions are distributed among doctors who have a very long identical education. The multiplicity of the CIS is limited to speech and reading/writing and the intensity is quite low due to the RIS. The diversity of artifacts is low since it is mainly the RIS which is used. Articulation work is also limited since the department has very well defined work patterns.

There are three main states in the lifecycle of an examination that requires articulation work: prioritizing the examination, selecting the radiographer, and selecting the radiologist. This coordination of the actors is carried out in conferences and is based on factors like: who is at work, what are their qualifications, and are there other tasks they must attend to.

There is one primary artifact used at the radiology department (the RIS) which helps the actors keep track of the progress of examinations and provides the information at decentralized locations. A radiographer does not have to leave the x-ray room in order to know which patient is coming and what image should be taken. The RIS also helps to assure that patients' data are not mixed up.

Finally, the RIS enforces a workflow that eases the cooperation.

A radiology department also uses classification schemes (Simone 2000) – some are formal and some arises through daily practice. The most formal is perhaps the classification of examination types, which is a unified classification in Denmark. A less formal classification scheme is the findings described by the radiologists. A single radiologist will tend to use standard terms and phrases for the findings. The radiologists as a group will in time develop a common set of terms and phrases. The standardization helps the interpretation of the descriptions. Currently, there exists no single classification scheme for radiologic findings.

3 ISSUES IN OUTSOURCING RADIOLOGY SERVICES

The above field study focus on the current work practice where radiology services are handled in-house. Outsourcing requires changes to the cooperative work arrangement.

The articulation work will change significantly. The management in a traditional radiology department has to deal with quality of services, coordination, motivation, and so on. In a department which utilizes outsourcing, business also becomes an important issue. The articulation work suddenly also constitutes price determination, creation of business relations, and negotiation with the providers.

The CIS is primarily affected in two ways. The CIS will become distributed in space also, since part of the workflow will be handled at a different hospital. The CIS will also become multilingual, since outsourcing is expected to take place in different countries with different native languages. The language issue changes the daily workflow. Translation will introduce a new task. Both the referrals and the reports must be translated.

One of the basic criteria that must be met in order for outsourcing to be successful is that the impact on the workflow when outsourcing should not be much different from the impact of hiring more radiologists. The achievement of that criterion relies heavily on computer support and therefore new artifacts. A number of new artifacts can be introduced to minimize the overhead of outsourcing radiology services:

- *Business relations*. A new artifact can be introduced enabling the management to set up business relations with providers of radiology services.
- *CIS distribution in space*. A new artifact can be introduced enabling the RIS to send images and referrals to and receive reports from the providers.
- *CIS language issues*. A new artifact can be introduced enabling automatic translation of referrals and reports.

In the following, we will primarily focus on addressing the language issues, which we believe is by far the most complex of the issues involved in outsourcing radiology services.

4 TOWARDS A SOLUTION

The approach taken aims at "expanding" the CIS that currently encompass the work in the radiology department at Svendborg Hospital to also include the radiologists at the outsourced locations. More precisely, we wish to develop a "common language" shared by radiologists at Svendborg together with radiologists at the outsourced locations. As mentioned in the field study, a group of radiologists that work together will over time develop a common set of terms and phrases used for the description of findings. This can be viewed as an informal classification scheme.

The work to turn the informal classification scheme into a formal one shared across distributed locations involves radiologists at Svendborg Hospital as well as East Tallinn Central Hospital in Estonia. The work is based on the SNOMED CT health care terminology and involves the Danish National Board of Health. SNOMED CT is owned and managed by the International Health Terminology Standards Development Organization (IHTSDO) (http://www.ihtsdo.org/). The novel classification scheme of clinical findings is organized as depicted in Figure 1.

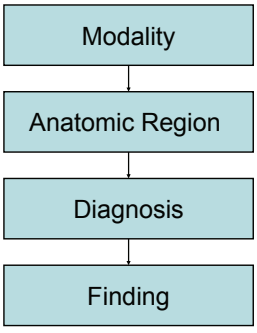

Figure 1: Classification of clinical findings.

Modality is one of {x-ray, CT, MRI, US}, anatomic region is a part of the human body (i.e., a knee), diagnosis is a suspected medical problem (i.e., osteoarthritis) and a finding is supporting medical evidence (i.e., subchondral sclerosis of the medial femoral condyle).

Using predefined clinical findings for creating the radiology reports, makes it possible to once and for all translate the findings into multiple languages. This solution has a number of benefits and allows for a number of features that goes way beyond the issues of language and translation that were the initiating problems (see next section).

5 THE COMPUTER SUPPORTED REPORTING TOOL

A prototype of a Computer Supported Reporting (CSR) tool has been developed. CSR is a new artifact in the CIS based on the novel classification scheme of predefined clinical findings. CSR is shown in Figure 2. The clinical finding on the screen covers osteoarthritis in a knee.

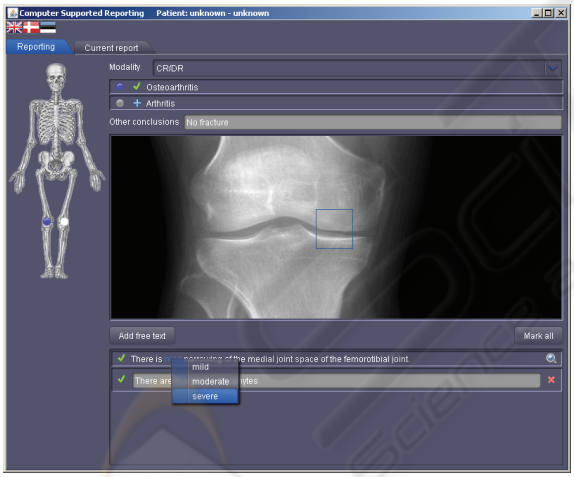

Figure 2: The Computer Supported Reporting Tool.

The workflow for a radiologist using CSR contains the following steps:

1. Select modality,
2. Select anatomic region,
3. Select diagnosis,
4. Add diagnosis to report conclusion, and
5. Add findings to report.

The modality and anatomical region will typically be available from the RIS or PACS system. If they are not, the radiologist will have to select them. As described in the field study, the radiologist has a mental overview of the diagnosis and the findings that supports the diagnosis when writing the report. Findings are typically related to a single diagnosis, and it is therefore appropriate to have a tree structure where the radiologist starts with selecting the desired diagnosis and then the associated findings. If there are enough indicators for the diagnosis, the radiologist can choose to select this diagnosis for the conclusion.

A diagnosis will typically have many associated findings, which makes the list from which the radiologist selects from very long. Therefore, CSR provides a method for filtering the findings and a method for compressing the findings.

1. ***Anatomic Filtering.*** For the selected anatomic region an image of that region is shown. Each finding is defined within an area of that image. CSR enables the radiologist to select an area of interest within the shown image and thereby filter the available findings to only those defined within the area of interest.
2. ***Compressed Content.*** Some findings are compressed into one statement where part of the content is changeable, since some findings are mutually exclusive, which makes it appropriate only to be able to select one of them; severity of the finding is an example. Some findings can be found in only two locations (A, B) which induces three options (A, B, A and B). These options can be made selectable instead of having two separate findings.

The clinical findings supported by CSR can be presented in different languages. The desired language can be selected by clicking at an icon depicting the nationality. Currently, Danish, Estonian, and English are supported. Clinical findings which are not currently predefined can be typed in as free text. Such findings will naturally have to be translated by an interpreter. However, the solution supports that such findings can be assessed later and added to the predefined set if eligible.

The use of a classification scheme for predefined clinical findings combined with the features of the CSR tool enables a number of advanced features:

Automated Translation between Languages. The fact that each predefined clinical finding is translated into numerous languages makes automated translation of reports possible. Translation opens for the possibility of cross border outsourcing of radiology services. Foreign radiologists working at a

hospital can also benefit from automated translation since they can report in their native language.

Clinical Guidance. CSR offers clinical guidance for the radiologist. Each clinical finding is documented by a reference image and some descriptive background knowledge. The reference image aids the radiologist in selecting the correct clinical finding especially when the finding contains severity.

Higher Comprehensibility of Reports. Reports made with CSR will have a higher comprehensibility than traditional reports due to the fact that linguistics is independent of the radiologist who made the report. A lot of effort is put into making good descriptions and translations of the predefined clinical findings. The receiver of a report can benefit from the descriptive background knowledge for each clinical finding in case of uncertainties.

Faster Reporting. Efficiency for the radiologists is one of the primary objectives for CSR. The goal is to have the radiologist use less time for reporting and more time for using their radiologic knowledge. Faster reporting is achieved by organizing the clinical findings in a way which enables the radiologist to rapidly find it.

Automated Translation to Patients. Countries where patients are granted access to their own medical records will suffer from the problem that reports are almost impossible to understand due to the difficult medical terminology. The automated translation feature of CSR can remedy this by translating the findings into an understandable terminology.

Easy and Automatic Testing. CSR can assists in testing radiologists. A group of experts describes a number of examinations and thereby making the "correct" answer for the test. When a radiologist has described the examinations, the reports and the correct answers are compared in an objective and automated manner. The radiologist can either be aware or unaware of the testing depending on the purpose of the test.

6 SYSTEM OVERVIEW

The system architecture is optimized to support the CSR tool, which is the central component used for the actual reporting by the radiologists as described in Section 5. The clinical content will continuously be under development and undergo a lot changes. The CSR tool will be used by numerous radiologists. The overall architecture should insure efficient updating of the clinical content. It is therefore desirable to separate the clinical content and the CSR tool as depicted in Figure 3.

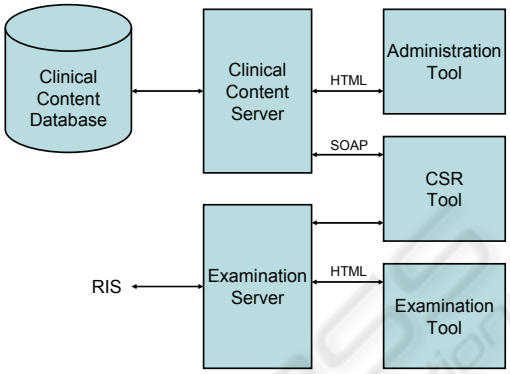

Figure 3: The overall system architecture.

The clinical content is stored in the clinical content database, which is accessible via the clinical content server. The roles of the clinical content server are to protect the database by validating the data before it is stored in the database and to publish an easy accessible SOAP interface for fetching the clinical content. The clinical content server also provides a web interface for the administration tool, which is used to create and manage the clinical content. The reports created with the CSR tool are stored in the examination server, which in a real world scenario needs to be connected to the RIS. The examination tool is used by the local hospital to manage users (radiologists) at the remote hospitals and to add new tasks to be handled by the remote hospitals. The examination tool is used by the radiologist at the remote hospitals to login into the system, to find their tasks, and to create radiology reports (by opening and using the CSR tool).

Additional details about the CSR tool and the overall system can be found in (Schønnemann 2008).

7 RELATED WORK

The presented work is inspired by previous work on the structured reporting tool developed as part of the Baltic eHealth project (www.baltic-ehealth.org).

Dixon and Fitzgerald (2008) discuss potential benefits and risks of outsourcing radiology services. They outline language, terminology, and accuracy issues as risks. They propose that outsourced reports should be in the same style as the usual reports from the outsourcing hospital. CSR and the radiology classification scheme handle these issues by

introducing a common language used for radiology reports.

Some hospitals already have experiences with outsourcing of radiology services (i.e., Esbjerg Hospital in Denmark (Rasmussen 2007)). They use a Danish radiologist who was formerly employed at Esbjerg Hospital. Therefore, they do not have to deal with language, terminology, and accuracy issues.

To our knowledge, this work is the first attempt to develop a classification scheme of radiology findings with the degree of precision and structure needed to allow computer tools to automatically manipulate the clinical content.

8 CURRENT STATUS

The classification scheme currently only provides clinical findings regarding one anatomical region (the knee) and using one modality (x-ray). Future work will focus on expanding the classification scheme with additional modalities, anatomical regions, and languages.

The CSR (with its limited clinical content added using the administration tool) has been used in a test scenario involving radiologists in Denmark and Estonia. A senior radiologist at Svendborg Hospital in Denmark provided images for the tests. The tasks were added to the examination server using the examination tool. The images were examined by a senior radiologist and three medical students from East Tallinn Central Hospital in Estonia using the examination tool and the CSR tool.

The users found the system quite easy to use and clinically relevant. They concluded that the system could be useful to structure reporting methods inside their own radiology department. More importantly, they also concluded that the system would have even more value for outsourcing radiology reports.

The users also commented on a few minor issues relating to the layout of the features in the main window of the CSR tool. These issues are relatively easy to fix and did not hinder the use of the CSR tool.

9 CONCLUSIONS

The primary contribution of this work is the development of a classification scheme of clinical findings and a set of tools for computer supported reporting. Together, they provide a novel solution allowing radiology services to be outsourced. We have demonstrated that is it possible to introduce classification into a limited medical domain and that doing so enable automation of many tasks.

The tests of our solution were very promising and encouraging. We envision that such systems for outsourcing medical services will find their way into hospitals within few years.

One could imagine that an internet based world wide market place for outsourcing medical services would appear some time in the future to fulfill the needs of hospitals that find it difficult to recruit certain medical specialist.

The approach of outsourcing medical services is appealing compared to the alternative of enticing medical specialist from less resourceful countries to move to more resourceful countries. Such an approach would, of course, eliminate the problems in Denmark, but it would create new problems in other less resourceful countries.

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