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Radiology interpretation process modeling

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Abstract

Information and communication technology in healthcare promises optimized patient care while ensuring efficiency and cost-effectiveness. However, the promised results are not yet achieved; the healthcare process requires analysis and radical redesign to achieve improvements in care quality and productivity. Healthcare process reengineering is thus necessary and involves modeling its workflow. Even though the healthcare process is very large and not very well modeled yet, its sub-processes can be modeled individually, providing fundamental pieces of the whole model. In this paper, we are interested in modeling the radiology interpretation process that results in generating a diagnostic radiology report. This radiology report is an important clinical element of the patient healthcare record and assists in healthcare decisions. We present the radiology interpretation process by identifying its boundaries and by positioning it on the large healthcare process map. Moreover, we discuss an information data model and identify roles, tasks and several information flows. Furthermore, we describe standard frameworks to enable radiology interpretation workflow implementations between heterogeneous systems.

Keywords: Radiology; Interpretation; Diagnostic report; Process modeling; Workflow modeling; Workflow management systems; Process reengineering; Business process redesign; Integrating the healthcare enterprise; Digital imaging and communications in medicine

1. Introduction

Information and communication technology (ICT) is deeply shaping every organization in our society. Healthcare organizations are being profoundly transformed with the introduction of ICT. However, despite ICT promise of delivering quality of care while ensuring efficiency and cost-effectiveness, the results achieved so far in heath care are far from expectations [1]. In fact, technology by itself will not bring the predicted changes without any process reengineering [2]. Healthcare process reengineering is ever more unavoidable since healthcare organizations are increasingly pressured to deliver optimized patient care for an aging population with limited resources.

Process reengineering or business process redesign (BPR) has retained great attention in the last decade [3,4]. Its methodology, success and failure conditions have been extensively studied and documented [5]. BPR has been defined as the critical analysis and radical redesign of existing business processes to achieve breakthrough improvements in performance measures [3]. ICT, the most powerful tool for reducing the costs of coordination [3], is the key enabler of BPR [6]. In the last decade, BPR tremendously transformed the manufacturing industry and the retail sale process.

To perform BPR, guidelines have been proposed and documented [3]. Analysis of an existing business process is essential to its redesign. Analysis is achieved by identifying the process, by modeling its workflow and by monitoring its execution to collect performance measurements [7].

In healthcare, process modeling has been identified as fundamental to provide suitable solutions to the

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problems of designing and building innovative healthcare information systems [2]. In radiology, for example, in order to achieve cost reduction and improvement in productivity with picture archiving and communication systems (PACS), it has been demonstrated that workflow redesign was much more important than filmless operation [8–14]. The Baltimore Veterans Affairs Medical Center case study revealed that the introduction of PACS did not achieve improvements in productivity and cost savings until the diagnostic imaging process had been reengineered. The reengineering efforts resulted in much fewer workflow steps, fewer member staff, and dramatically increased efficiencies [8].

Even though in many cases in the literature, 'workflow' and 'business process' are used interchangeably, a subtle difference exists between them. A business process is a structured, measured set of activities designed to produce a specified output for a particular customer or market [3]. Therefore, a process has boundaries, a customer, and a specified output. Furthermore, a process produces the output by means of interrelated activities, the workflow. Consequently, process modeling implies identifying the process by depicting its boundary, customer and output; it also implies modeling its workflow by describing who does what, when [15].

Since a process coordinates people, resources, systems, and work, an information system that manages a process workflow controls the work of individuals and may introduce delays or constraints on how and when tasks are performed. Consequently, analyzing and optimizing a process consists in analyzing and optimizing each task involved in its workflow as well as each hand off of work between tasks [15]. But, a complex task may be performed according to its own sub-process. So, analyzing and optimizing a large process can be achieved by analyzing and optimizing its sub-processes, recursively. Therefore, even if the healthcare process is a large, not very well-modeled process, its sub-processes can be modeled individually and their respective models are important pieces of the whole model.

In this paper, we propose a model for the radiology interpretation process. Radiology interpretation is a subprocess of radiology, which is itself a sub-process of the healthcare process [16]. Its goal is to generate a diagnostic radiology report that is made available for clinicians outside the radiology department. The generated report captures the radiologist's interpretations and impressions. The radiology report is an element of the patient healthcare record and contains important clinical information to assist in healthcare decisions [17].

An accurate interpretation model is needed to design and implement information systems that efficiently manage the interpretation process workflow. The interpretation workflow model is necessary for designing and implementing digital signature [18] and authorization control [19,20]. The workflow model has major consequences. An inaccurate model introduces inefficiencies, frustrations and may result in a useless information system.

Modeling the interpretation workflow consists in describing who does what, when or in other words, describing the roles, tasks, and sequences of tasks [21]. The radiology interpretation process implies different information flows. Although information flows may vary between institutions, there are simple common workflows such as the one that involves dictation, transcription, and verification steps; there are also other more complicated and exceptional workflows, but yet very common, such as the one that involves resident performers or delays. An exceptional workflow is a deviation from an ideal care delivery workflow. Exceptions can arise from changes in resources availability or tasks priorities for example. Even though exceptions are infrequent, they can be expected. Moreover, the same exception can be expected regardless of the institution. Since exceptions can occur in any process implementation, modeling specific exceptional workflow enables systems to handle them consistently and effectively.

We propose a model for the radiology interpretation process by following a formal approach. In Section 2, we identify the interpretation process boundaries by specifying the event that triggers it, the result achieved, and the customers that receive the result. We also position the interpretation process on a larger process map with respect to the radiology process, which is by itself a subprocess of the large healthcare process. In Section 3, we propose and discuss a data model for the information involved. In Section 4, we propose a workflow model by identifying roles, tasks and information flows. Several common interpretation workflows are discussed and presented by using the unified modeling language (UML) swimlane notation [22,23]. Moreover, since interpretation may involve heterogeneous systems, we describe, in Section 5, how to implement the proposed model using transactions defined by the digital imaging and communications in medicine (DICOM) standard. We also discuss the integrating the healthcare enterprise [24] (IHE) reporting profile that specifies a general framework to allow various workflow implementations between different systems. Finally, as process improvement requires collecting performance measurements, we present, in Section 6, general process measurements and how they translate into specific measurements that are relevant for the radiology process.

2. Radiology interpretation process boundaries

The only reason a business process exists is to deliver a specific result to a customer who is the recipient or beneficiary of the result. The process is initiated by an event that is a specific request for the process result.