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Defining and Reconstructing Clinical Processes Based on IHE and BPMN 2.0

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Abstract. This paper describes the current status and the results of our process management system for defining and reconstructing clinical care processes, which contributes to compare, analyze and evaluate clinical processes and further to identify high cost tasks or stays. The system is founded on IHE, which guarantees standardized interfaces and interoperability between clinical information systems. At the heart of the system there is BPMN, a modeling notation and specification language, which allows the definition and execution of clinical processes. The system provides functionality to define healthcare information system independent clinical core processes and to execute the processes in a workflow engine. Furthermore, the reconstruction of clinical processes is done by evaluating an IHE audit log database, which records patient movements within a health care facility. The main goal of the system is to assist hospital operators and clinical process managers to detect discrepancies between defined and actual clinical processes and as well to identify main causes of high medical costs. Beyond that, the system can potentially contribute to reconstruct and improve clinical processes and enhance cost control and patient care quality.

Keywords. Integrating the Healthcare Enterprise, Clinical pathways, Workflows, Clinical core processes, BPMN 2.0

1. Introduction

Process management in healthcare is used to increase the quality of care and to decrease treatment costs [1, 2]. Medical guidelines are often used to define the workflow of a treatment based on a certain diagnosis. Nevertheless, these guidelines are not commonly used [3].

Although, many systems and approaches to define clinical processes exist, all of these systems share the following drawbacks: either these systems are not able to share information with other systems [4, 5, 6, 7] (interoperability issues), or these systems only cover parts of a clinical process [8]. Interoperability problems can now be addressed by using Integrating the Healthcare Enterprise (IHE) compliant components [9]. Using Business Process Model and Notation (BPMN) 2.0 in combination with medical guidelines, structured medical processes can easily be defined. Moreover, the usage of IHEs' Audit Record Repository (ARR) enables a standardized way of process mining [10].

In literature similar approaches exist but none of them are using IHE Integration Profiles to define clinical processes. Anzböck and Dustdar present an approach based on web services to model medical e-services [5, 8]; Dogac, Bicer and Okcan are focusing just on IHE Integration Profiles to model collaborative business processes [11].

In this paper we present an approach aimed to define clinical processes based on BPMN 2.0 and selected IHE Integration Profiles. Moreover, this approach is able to reconstruct a patients' history based on a standardized audit database.

2. Methods

An integral part of interoperable workflow processes is the use of established standards such as BPMN and IHE. The following two sections describe all necessary standards used by the presented approach. The remainder of the section discusses the methods and detailed steps taken in the research project *IHExplorer* [12].

2.1. Integrating the Healthcare Enterprise

Integrating the Healthcare Enterprise (IHE) is an international initiative by healthcare professionals, IT professionals and industry to improve the integration and interoperability of information systems in health care with standardized descriptions of medical use cases and the use of communication standards. IHE is structured in Domains [13] and Integration Profiles [14]. Our approach is mainly based on following Integration Profiles:

Patient Administration Management (PAM): This profile maintains the consistency of patient data (e.g. attending physician or relatives) and coordinates the exchange of patient account, encounter and location information among care systems. The PAM profile is important for the process reconstruction, because it delivers current information about the patient's location in a health care facility and the patient's state.

Audit Trail and Node Authentication (ATNA): This profile controls the access to protected health information, like patient demographic data and clinical documents and logs every access in a protocol database - the Audit Record Repository (ARR). Using ATNA in combination with the PAM Integration Profile, all transfers and states during a patient's treatment are stored in the ARR.

2.2. Business Processes, Workflows and Clinical Guidelines in Healthcare

There are several definitions of the term Business Process (BP) available in literature. Van der Aalst defines a BP as a process aiming on the production of a certain product or service [15]. Another source suggests that a BP is a set of activities using different inputs to produce a certain output [16]. Davenport extends the previous definition with regard to a customer or a certain market [17].

On the other hand, a workflow is an automated part of a business process [18] which means that a workflow is an executable instance of a BP. A workflow is built of a set of activities and is triggered by a defined start event; the main difference is that a workflow is automated [18]. Moreover, workflows can be categorized into three groups: Structured Workflows, Semi-structured Workflows and Ad-hoc Workflows [4]. Structured Workflows are characterized as not too complex and are always predictable.

Semi-structured Workflows are partially predictable, though parts of it can be modeled. Ad-hoc Workflows are not predictable and too complex which makes it impossible to model them.

Clinical Guidelines (CG) are a set of principles to help health care practitioners during the care of a patient to ensure consistent high quality clinical practice [3]. The main objectives of CG are to improve the quality and to standardize health care. Moreover, these CGs' are provided in several repositories, such as Map of Medicine [19], which are maintained by many different organizations.

2.3. Process Definition

Processes are defined using the BPMN 2.0 standard currently developed by the Object Management Group [20]. Compared to prior versions of BPMN or Event-driven Process Chain (EPC) the main advantage of BPMN 2.0 is that BP are executable directly. BPMN supports the user in the modeling of processes and ensures the generation of a valid and well-formed BPMN process definition. In addition it is mandatory to orchestrate the defined processes, thus to make them executable. Typical actions that are summarized under the term orchestration are on the one hand the association between specific BPMN 2.0 tasks (Service-Tasks) with a service implementation (e.g. Java class, web service), and on the other hand the assignment of a task to an user or a group that is responsible for its execution. The execution of an orchestrated XML based process definition is done by a BPMN 2.0 workflow engine.

2.4. Process Execution

In order to execute a defined process, a specific workflow engine is needed, which is responsible for the lifecycle of a process, often referred to as process instance [21].

To make a process available for execution, the process definition and any additional process resources have to be deployed in a running instance of the workflow engine. The engine creates a new process instance associated with certain trigger events and executes each task defined in the process definition. To guarantee the compliance to an existing IHE environment, these tasks interact with IHE actors. IHE actors are information systems or software components that process data. Task executions generate HL7 messages, which are stored in the ARR.

2.5. PAM Based Process Mining

To reconstruct a patient's way through a healthcare facility the PAM Integration Profile has to be implemented. The ARR stores all messages generated during admission, discharge and transfer of the patient.

By querying the ARR collecting all messages for a specific patient and sorting them according to their date of creation, all stays of a patient can be identified. The initial diagnosis is stored in the admission/registration message - so every pathway of every patient can be compared to a defined process.

3. Results

A prototype has been developed which allows the definition of business processes based on BPMN 2.0. This prototype enables the definition of business processes as well as the execution of workflow processes. Furthermore, the system supports the reconstruction of a patients' pathway throughout a healthcare organization. Figure 1 shows a part of a process definition based on the approach described above.

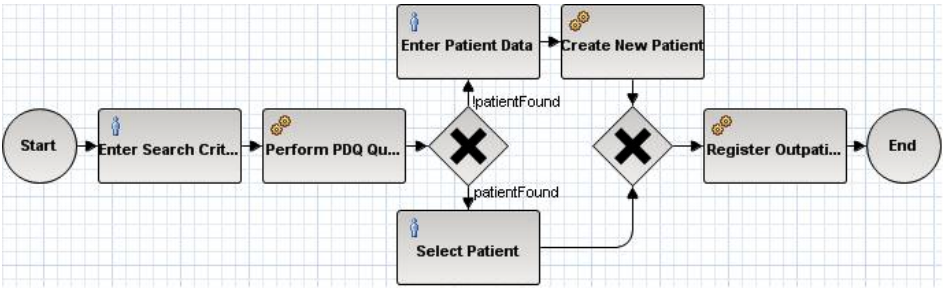

Figure 1. A BPMN 2.0 Process Definition

The service tasks of the BPMN process definition are bound to IHE consumer actors which in turn communicate with an IHE infrastructure to obtain all necessary patient data for treatment. Each action performed by a service task is logged into the ARR of the underlying IHE infrastructure, which is the basis for reconstructing the patient pathway (see Figure 2). Departments visited by the patient which are present in the process definition are highlighted. Moreover, the total time of each pathway is calculated allowing further analysis.

Currently the reconstruction of patient pathways is not based on realistic workload.

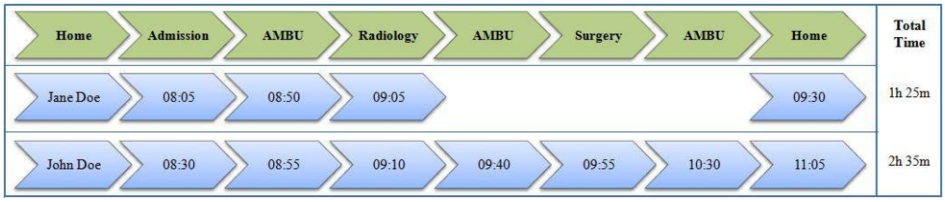

Figure 2. Three reconstructed patient pathways based on ARR entries

4. Discussion and Conclusion

The presented approach shows how IHE Integration Profiles and BPMN 2.0 process definition are used to model and execute clinical processes. The advantage of this approach is obvious: the business process definition and execution are detached from the underlying systems, which means that clinical processes can be defined independently from a hospital information system (HIS).

Nevertheless, this approach has several limitations. As IHE currently doesn't provide enough Integration Profiles a comprehensive clinical process definition is not possible. Moreover, the reconstruction of the underlying business process based on entries in the ARR has some limitations. Currently it is not possible to reconstruct the

BPMN 2.0 definition without using the event log of the workflow management system executing the process.

To achieve further details the reconstruction should be combined with the history service of workflow management system. The history service stores metadata related to all executed processes. Although the level of detail increases using the built in history service, reconstruction is completely independent from the workflow engine, as it depends only on the information provided by the ARR. Reconstructed patient pathways combined with defined processes enable delta analysis and as there are often discrepancies between the defined and the actual process it should help to point out opportunities and threats and therefore to adjust and optimize the target process.

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