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A Service Oriented Approach for Guidelines-based Clinical Decision Support using BPMN

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Abstract. Evidence-based medical practice requires that clinical guidelines need to be documented in such a way that they represent a clinical workflow in its most accessible form. In order to optimize clinical processes to improve clinical outcomes, we propose a Service Oriented Architecture (SOA) based approach for implementing clinical guidelines that can be accessed from an Electronic Health Record (EHR) application with a Web Services enabled communication mechanism with the Enterprise Service Bus. We have used Business Process Modelling Notation (BPMN) for modelling and presenting the clinical pathway in the form of a workflow. The aim of this study is to produce spontaneous alerts in the healthcare workflow in the diagnosis of Chronic Obstructive Pulmonary Disease (COPD). The use of BPMN as a tool to automate clinical guidelines has not been previously employed for providing Clinical Decision Support (CDS).

Keywords. Clinical Guidelines, BPMN, Service Oriented Architecture, Clinical Decision Support

Introduction

The process of healthcare service delivery is composed of workflows. Dwivedi [1] presented a dynamic connection between healthcare, workflow and internet technologies, and proposed that workflow management systems can significantly influence the performance and outcome of a healthcare service. [2] identified that workflow tools have a potential to significantly improve healthcare delivery by augmenting the clinician's decision making in the form of alerts and reminders, a functionality of CDS. Healthcare workflows have been modelled using a number of techniques.[3] and BPMN has been relatively a new technology for this purpose. Several implementations exists[4][5] which are used to model the workflow in a diagnosis or treatment process using BPMN. "*BPMN is a graphical notation that depicts the end to end flow of a business process. It coordinates the sequence of processes and the messages that flow between different process participants in a related set of activities.*"[6]

Clinical guidelines are recommendations on the appropriate treatment and care of people with specific diseases and conditions [7]. They are developed by research into the latest medical evidence base presented in a narrative manner. Clinical pathways

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visually represent a guideline, using process flow diagrams to guide a physician during patient-physician encounters.[4]. Clinical guidelines serve as strong evidence to facilitate a physician in making patient specific decisions[8]. Clinical decision support system (CDSs), assist a physician in making patient-specific inferences by utilizing patient data and clinical knowledge.

There is a need to integrate guidelines with the available information systems used by a physician like Electronic Health Record systems (EHRs). [9] show a mechanism for integrating guidelines within the EHR.[10] propose integrating clinical pathways into CDSs. To improve clinical outcome, there is a need for providing guidelines based CDS for physicians using different EHRs. To avoid complexity while designing such a system, the guidelines based decision rules need to be separated from the actual EHR or CDSs. By taking advantage of the potential of BPM and workflow technology in healthcare, we propose that using a workflow management system(WfMS) as a tool to automate clinical guidelines can be a novel approach for enabling CDS in a healthcare setting. To achieve this goal, the functionality needs to be distributed among various components participating in the healthcare workflow in order to allow maximum independence between the technologies thus enabling interoperability among EHR environments implemented using different software.

As healthcare processes continually evolve, there is a need to separate the business process functionality from technology infrastructure [11]. Service Oriented Architecture (SOA) is a widely adopted approach used for enterprise information systems to address this issue by sharing distributed services like clinical decision support as Web Services[12]. One approach popular with SOA use is the Service Component Architecture (SCA) [13].

1. Methods

Figure 1 shows a brief architecture overview of the project.

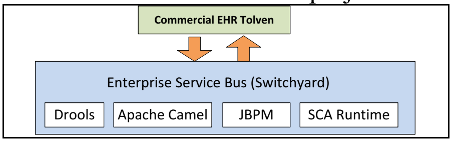

Figure 1: High level Architecture

In order to achieve the aim of providing CDS at the point of care, the architecture is designed using several open source components that allow developing services with different functionality that can work together. Commercial EHR Tolven [14] is used as a physician's interface for capturing patient data. This is also the interface where an alert will be received by the physician to facilitate clinical decision making. We use the enterprise service bus Switchyard [15] which is a "component-based development framework for building structured, maintainable services and applications based on best practices of SOA". jBPM, Drools and Apache Camel are accessed from within the ESB in order to keep our rules functionality easily accessible by EHRs. JBoss Drools is a java based open-source business logic integration platform based upon the RETE's algorithm [16]. jBPM is a java based workflow engine that allows for the execution of a business process using the BPMN 2.0 specification [17]. Apache Camel works as a message transformation and communication mechanism [18]. SCA Runtime is the Service Component Architecture specification supported by the ESB Switchyard.

For our methodology, we have followed BPM Process lifecycle[19]. This lifecycle is used for modeling, automating, and executing business processes and is similar to a software development process from defining requirements to deployment. Using the tools constituting the proposed architecture, the BPM process is divided in the following steps: **1)** ***Identify Business Process Workflow:*** We use the NICE Clinical Pathway for Chronic Obstructive Pulmonary Disease Diagnosis (COPD)[20]. We separate out the decision rules that govern the completion of each step in the workflow. e.g. checking for a patient age, problems and smoking assessment. 2) ***Model Process Visually***: We create a graphic model using Eclipse BPMN 2 Modeller. At this stage the rule logic is separated as tasks. Figure 2 shows a BPMN Model of the diagnosis scenario. A rule for checking the age of the patient is shown in the box.

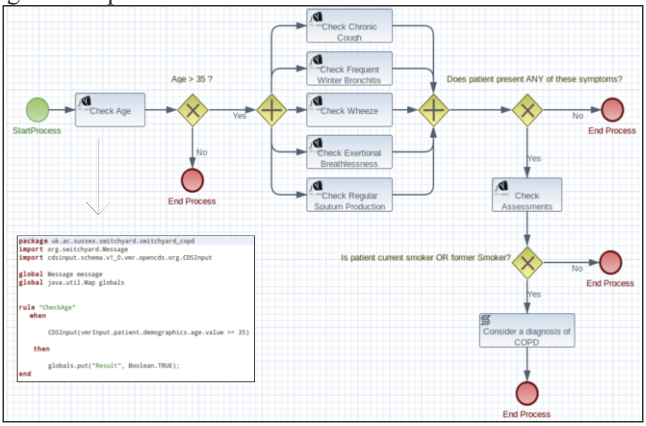

Figure 2: BPMN Representation of COPD Guideline

3)Develop Runtime Components: Develop tasks defined in the workflow as SCA Components. Each Task/component(e.g. check age etc.) can be wired together to a process "COPD Clinical Guideline" as shown in Figure 3.

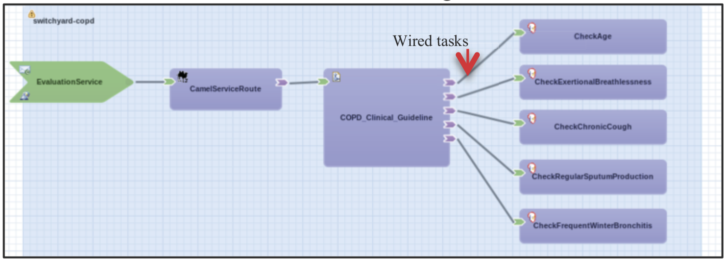

Figure 3: SCA Composite Service

4)Deploy Runtime Engine: This stage involves deploying the composite component to the SCA Runtime environment. The SCA component "Evaluation Service" is exposed as a reusable service for multiple EHRs.***5) Instantiate Runtime Instance:*** Execute Request and response process between SCA composite service and EHR. This is a sequence of five steps: **a)** A request is generated from the EHR to the SCA composite sending the problems list and patient demographics as recorded by the physician. This data is transferred as HL7/OMG CDSS [21] based SOAP message . Apache route service extracts the Base 64 encoded Payload based on HL7 Virtual Medical Record (vMR) [22] format. The vMR is transformed to java objects that are accessible by the processes (e.g. check chronic cough, check wheeze etc).Here the medical terminology is specified according to the incoming semantic language systems like LOINC, SNOMED codes etc. b) Once the rule conditions are met, a response is sent from SCA composite to Tolven in the form of an alert, suggesting smoking assessment. **c)** The smoking assessment is recorded in Tolven by the physician and the results (patient demographics, problems list and smoking assessment) are sent as a request to SCA composite **d)** As a response, an alert is generated by the SCA composite stating "Consider diagnosis for COPD" for the physician at the Tolven interface as shown in figure 4.

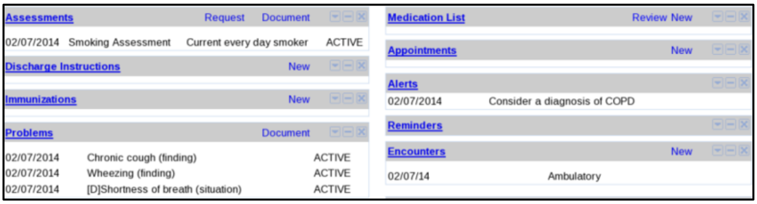

Figure 4 EHR Interface showing Problems, Assessments and Alerts

2. Results

We have presented an implementation of the early stages of diagnosis in COPD Guidelines. We have shown that BPMN can be successfully used to model a clinical pathway. The architecture presented adheres to the SOA principles by using SCA composite web services, Drools, Apache Camel and jBPM deployed in the ESB. The ESB allows for robust message transformation and communication across EHRs. The combined functionality of these components enables a CDSS. The CDS capability was manifested in the Tolven interface resulting in alerts. We evaluated our system by recording the response time for CDS service for simultaneous requests by 20 users . The service response time was less than one second. The same results were recorded for requests by 40 and 50 users. The guidelines can be interacted with a number of different EHRs. This is possible because the clinical guideline is presented as a web service rather than being tied to a particular clinical decision support system or an EHR.

3. Discussion

The modelling approach we have used provides an alternate mechanism to model a clinical process. BPMN provides a visual interface to model the processes specified in the clinical guidelines. While basic clinical knowledge is represented using IF-THEN format as rules. This allows for the physicians and the domain experts to model the rules and processes in a guideline without looking at the implementation details. The clinical knowledge expressed in rules using Drools are human-readable and can be modified dynamically. The aim of automating clinical guidelines based decision support is to improve clinical outcome. This solution triggers alerts in the current workflow for the physician which facilitates the diagnostic process by saving time and improving patient safety. From a software development point of view ,SCA hides complexities such as web service security and policies, hence allowing the developers to focus on business logic. One of the most promising characteristic of SCA is that it provides reusability. A decision Support system based on ESB as an architectural approach provides loose coupling for collaborating applications that can accept data formats from various sources and integrate data flows into the appropriate EHRs, thus ensuring interoperability and reusability An ESB separates the integration logic into manageable pieces and is highly scalable .The future directions for our work are two-fold: 1) Add a terminology web service to address semantic interoperability of data coming from systems using different terminology standards. 2) Integrate related guidelines for example: alternate diagnosis requests for guidelines on other diseases/conditions. The current implementation (SCA composite) is a relatively simple guideline but it can be utilized by more complex guideline implementations, hence promising reusability.

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