the diagnostic pathology journal DIAGNOSTIC PATHOLOGY

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

Research

Efficient Pathology Case Distribution Leveraging Workflow and Domain Modeling, and Flexible Definition of Policies

A. Bucur[1], J. van Leeuwen[1], R. Vdovjak[2]

Affiliation:

1- Philips Research Europe, High Tech Campus 11, Eindhoven, the Netherlands;

2 - Philips Healthcare, High Tech Campus 34, Eindhoven, the Netherlands.

Abstract

Introduction / Background: The value of digital pathology and its potential to improve the current pathology practice are increasingly recognized, with a growing number of examples of successful implementation in a variety of use cases. While current widely-spread uses relate to research, consultation, second opinion and education, success stories are emerging demonstrating outcome and cost benefits of leveraging digital pathology for standard diagnosis as well. In all these cases optimization of pathology workflows, standardization and seamless integration in the environment are emphasized as prerequisites to reaching the desired improvements.

Aims: Through implementation of workflow-driven applications we aim to enable clinical users to efficiently and effectively leverage deployed digital pathology solutions. The development of architectural concepts to support streamlining workflow modeling and implementation is a key objective. We also address information integration requirements, and identify and propose solutions for performance bottlenecks in existing processes. A process with high potential for improvement through workflow automation and optimization is the case distribution to pathologists for diagnosis, and we leverage the developed concepts for its implementation.

Materials and Methods: We propose an approach to workflow modeling and implementation that is open and scalable, and leverages existing standards (BPMN2.0) developed in the context of business process modeling and widely adopted in other domains. This enables efficient implementation by giving access to an existing platform (KIE) that delivers a workflow-engine, a rule-engine, and a constraint satisfaction solver. We introduce architectural concepts that allow to externalize the definitions and implementations of tasks within the workflows, and to build workflows that are adaptive to the environment and that can incorporate decision models and applications of any desired complexity. We chose case distribution for diagnosis as a key process to optimize and developed a solution that can be efficiently customized to the

ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

needs of each lab with respect to dispatching rules/constraints, operational domain model, optimization goals and visual elements.

Results: With the defined approach, we implemented an application that optimizes the distribution of cases to pathologists for diagnosis and can be deployed within an integrated workflow implementation. The local policy models are expressed through business rules, domain models with roles and characteristics, and optimization goals. The policy models are built collaboratively by the workflow modelers and the clinical users. To automatically assign cases to pathologists according to defined policies, the optimization component applies the defined policy model (scoring rules within the domain model). The schedules are generated according to the desired optimization goals, e.g. to improve throughput or turnaround. The proposed architectural concepts and the adoption of modeling standards deliver scalability, and ease of implementation and customization.

Conclusions: Following the standards-based approach for definition and implementation of workflows and for integration in the environment, our application for case distribution optimization leverages the local processes and efficiently adapts to the requirements of each deployment site. The explicitly modeled workflows, the externalization of task implementations, and the standard interfaces to the environment allow us to deal with all the relevant sources of heterogeneity: policies, domain models, optimization goals, processes, and information systems. The ease of modeling the local policies and the application customizability that our approach delivers are significant advantages when aiming to cost-effectively reach a large user base.

Keywords: Case distribution; digital pathology; workflow modeling and optimization; automatic dispatching; workflow engine; rules engine.

1. Introduction

The adoption of digital pathology has the potential to enable significant workflow improvements leading to increased efficiency –in terms of better utilization of resources, higher throughput and lower turnaround time of cases–, and more effective collaboration. Additionally, streamlined workflow solutions make it easy to monitor and assess both performance and quality, and help prevent and detect errors.

We develop workflow applications to enable clinical users to leverage a digital pathology system for increased efficiency and better patient outcomes. The work addresses information integration requirements, and aims to identify and propose solutions for performance bottlenecks in existing processes. A process with potential for improvement is the case distribution to pathologists for diagnosis. The policies driving the distribution of cases to pathologists (dispatching) have a large impact on the throughput and turnaround of cases in a pathology lab. Leveraging the availability of digital pathology we develop an application

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

focused on the management of worklists of cases and their automatic dispatching for diagnosis. Our solution includes the modeling, simulation and optimization of the dispatching policies and their adaptation. This paper describes our overall approach to workflow optimization and the implementation of the case distribution application.

In Section 2 we discuss relevant literature focused on identifying current needs in pathology and on driving the change towards the efficient full adoption of digital pathology for standard diagnosis. The challenges, opportunities, obstacles and success stories are reported, which enables us to build on these experiences to provide workflow-driven informatics solutions that address the needs of the clinical users and have a low adoption barrier. In Section 3 we first introduce the main concepts of our approach to workflow modeling, implementation and optimization, and the technologies used. Next we focus on the case distribution application and describe its position in the overall workflow, the key components and the integration with relevant systems in the environment. Section 4 describes the current implementation of the case distribution prototype with screenshots of the UI. Section 5 summarizes the results and the next steps.

2. Background

The opportunities and challenges related to the introduction of digital pathology in labs and the changes in workflow and infrastructure it requires have been discussed in the literature. Workflow optimization is essential for the adoption of digital pathology as the scanning of slides adds steps (and therefore potential time delays) to the tissue processing workflow. Other common themes emphasized by previous research that focused on user needs and requirements for efficient digital pathology implementation are the use of standards to support adoption and the seamless integration with all relevant systems in the environment. Finally, the importance of improving the case distribution is also discussed in the literature. These findings support our approach which is detailed in Section 3.

Digital slides are currently successfully used in pathology for education, archiving, and increasingly for diagnosis. As an alternative to conventional slides, whole slide images also facilitate image processing techniques that can assist in the diagnosis process [1]. While asserting the wide acceptance of digital pathology in education and research, and its potential to support diagnosis, [2] describes several key challenges to its implementation in diagnostic surgical pathology practice. These are related to workflow integration, technological infrastructure, pathologist acceptance, standardization, and cost. The paper also identifies early adopters that have leveraged this new technology in specific niches, such as frozen section services and remote second opinion consultations.

In [3] the experiences of an academic lab with the process of adoption of digital pathology are reported. The approach is gradual, with the end goal to go fully digital. Currently, digital pathology is incorporated as an added service to mitigate the delays that scanning can introduce in the diagnosis workflow. The lab scans all produced slides after diagnosis to

the diagnostic pathology journal DIAGNOSTIC PATHOLOGY

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

support tumor boards, archiving, and education and research tasks. Adoption of standards is promoted as a way to facilitate communication across relevant systems in the lab in order to enable the optimization of the digital pathology workflow and increase acceptance. Opportunities are described related to the use of automatic image analysis algorithms on the digital slides for tasks with high observer variability, or that are tedious and time consuming. For full digitization, the authors identify the need for a workflow manager to guide the diagnostic process and to present pathologists with personalized worklists of cases for review with priorities. The system should also support efficient second opinion requests, joint viewing and collaboration.

In [3] a study comparing digital pathology with traditional microscopy for routine diagnosis is reported. The study was triggered by the early reports that digital reading yields longer diagnosis times. A set of 400 standard cases were diagnosed in 20 sessions of 20 cases each by a senior pathologist, first with digital pathology then six month later with traditional microscopy (complex, difficult and rare cases were excluded to reduce bias as pathologists remember such cases longer). An optimized diagnostic setting with adequate and stable network speeds, fully integrated LIMS and double displays was used. In 13 out of the 20 sessions, digital pathology required shorter diagnosis time than traditional microscopy. In only 4 sessions digital diagnosis was slower. The study estimated that the non-diagnostic time was shortened as well for instance due to absence of physical slide handling and consolidation of multiple tasks in digital reporting systems. The study confirmed the potential of digital pathology to yield savings both in diagnostic and non-diagnostic tasks.

In [5] the integration of digital pathology information in the electronic health record is proposed. The authors discuss the role of digital pathology to support prevention, diagnosis, and second opinion. The integration solution aims at standards-based interoperability. For representing the semantics of the clinical data and metadata SNOMED-CT (a widely adopted ontology in healthcare) is proposed as common terminology, supporting efficient collaboration across organizations. Other prominent healthcare standards such as DICOM, HL7 and IHE are proposed for the efficient storage, representation and exchange of information across systems.

The need to understand, model and optimize the workflows in pathology for all relevant stakeholders and subspecialties to be able to reach desired improvements in productivity and outcomes is emphasized in [6]. Additionally, standardization, data integration across systems and interoperability are again considered essential to face the current challenges and capitalize on the opportunities brought by personalized medicine. In this context, the authors see an important role for pathologists in driving the workflow optimization within the pathology department and beyond for the entire healthcare organization.

To support the adoption of digital pathology, other studies [7, 7] have focused on identifying the needs of the pathologists and supporting the design of the digital pathology workflow to best address these needs. The requirements were derived with contextual inquiry, a

the diagnostic pathology journal DIAGNOSTIC PATHOLOGY

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

qualitative, user-centered, social method used to identify user needs and to collect, interpret and aggregate in-detail aspects of the work. A total of six pathologists were interviewed and observed in a large academic medical center. The current analog workflow was described as labor intensive and lacking scalability. Several processes that could be improved following the introduction of a digital pathology solution were identified: case management, case examination and review, and final case reporting. Context-related specific needs were identified in [7] for military pathologists, such as specific workflows for diagnosis and QA, frequent consultations/second opinions, staffing-related issues, limited sub-specialty experience usually located at the large centers, and efforts to merge and share healthcare services and resources throughout the military. At the same time the study revealed the same underlying needs identified by similar studies with civilian pathologists, such as streamlining the pathology workflow, supporting efficient case distribution, addressing the uneven distribution of subspecialty expertise across the network and effective access to experts for second opinion.

In [8] an analysis was carried out as an economic impact model for a pathology department that receives 219000 cases annually and employs a network of pathologists that are located at both academic and community-based hospitals distributed across a large geographical area. The potential operational cost savings were estimated for a period of 5 years following the implementation of a digital pathology solution. The projected savings were estimated at around $18 million over the 5-year period. The main contributing factors were gains in pathologist time by improved productivity and workload distribution ($12.4 million) and reduced costs of incorrect treatment – over and under treatment costs in oncology ($5.4 million). Workflow improvement benefits were also identified, including a refinement to the current “center of excellence” model and ability to train all pathologists in the network in subspecialties based on the ability to distribute cases across the network. With the digital solution, pathologists at smaller hospitals in the network could receive sufficient cases of particular types to train in sub-specialties. This both reduces the interpretive errors by non-subspecialized pathologists and saves review time of experts in the academic sites.

3. Methods

The availability of digital pathology supports the adoption of novel workflow solutions focused on enabling and improving the processes and activities in the pathology labs. The clinical processes are formalized into clinical workflows, which can be modeled and optimized.

Workflow-driven applications can help achieve increased efficiency and quality, support collaboration, and provide detailed insights into the lab processes (i.e. workflow models) and into their execution and outcomes (i.e. workflow instantiation) increasing predictability. The implementation of workflow solutions also creates effective means to monitor and measure activities, and to detect and solve issues.

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

Our solution helps improve processes in the pathology lab (with respect to efficiency, predictability and quality) by modeling and optimizing the existing workflows and by incorporating applications and decision models supporting the automatic execution of relevant tasks and path selection in these workflows. Currently manual tasks such as case distribution to pathologists can be optimized and fully automated, while adhering to all the desired policies defined by each clinical organization.

3.1. Flexible standards-based workflow modeling and implementation

To efficiently support workflow execution one needs to deploy a workflow engine, a software component that instantiates the given workflow model(s) into running workflow processes (so-called workflow instances) and oversees the execution of tasks and branching decisions in all of them. It enables performance monitoring, workflow analytics, and traceability. It also implements means to persist the running instances if the application so requires.

If a given application/solution does not utilize a workflow engine with an explicit workflow model, yet it implements a (part of) workflow functionality, it is a good indication that the workflow has been hardcoded into the application itself. Hardcoded workflow is generally a poor choice and should be avoided or considered only if the following conditions hold true: the workflow never changes, there is a very limited number of workflow participants, and there is no interest to record the workflow execution for analytics purposes and/or traceability. In all other cases hardcoded workflows should be avoided. An explicit workflow model interpreted by a workflow engine with an optional rule engine support at decision points should be utilized instead.

We use open source tools previously developed for business processes such as jBPM [9], leveraging the Business Process Model and Notation (BPMN) standard [11]. For the workflow modeling and implementation we have selected jBPM due to its adoption and open source license. Given our choice of a widely accepted workflow modeling standard (BPMN2.0), one can utilize readily available authoring tools that aid the modeler/domain expert with the creation of appropriate workflow models. This enables efficient implementation and gives us access to an existing platform that delivers a workflow-engine, a rule-engine, and a constraint satisfaction solver.

The BPMN standard has been previously successfully used to model anatomic pathology processes [12]. The authors present BPMN models for the sub-processes corresponding to the surgical pathology examination of samples coming from operating theater and conclude that this approach provides understandable graphical representations of those processes and eases the management and the implementation of improvements by healthcare professionals.

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

3.2. WF engine and rule engine symbiosis

Our chosen platform KIE [13] provides both a workflow (WF) engine (jBPM) as well as a rule engine (Drools [14]). While these are fundamentally different concepts, they often benefit from each other. In particular, if a business rule (BR) task is placed in the BPMN model, the WF engine invokes the rule engine execution on demand when the token in the process instance reaches the rule task (this off-the-shelf WF/BR integration is unique to the KIE platform). The rule engine then performs all the reasoning steps (given the facts in the working memory and the rules); the new facts generated by the rule engine can be then subsequently used in the decision points (branches) of the WF model – in this way one can for instance efficiently implement clinical decision support (CDS) components (as validated rule sets) and apply them in the desired WF branches to aid the decisions.

Conversely, when an application is primarily relying on the rule engine, it is an established best practice to impose the rule execution order by means of an explicit WF model, instead of the use of salience in rules, which often causes convoluted and incomprehensible rule sets that lead to implementation errors.

3.3. Decoupling workflow definitions and task implementations

The use of explicitly defined workflows aids discussions regarding actual and desired workflows and allows re-use of (parts of) the workflow definitions. However due to differences in deployment environment, different task implementations may need to be used in different contexts. For instance, the task "*order additional HER2 FISH test*" might require a different task implementation depending on the API of the ordering system in the deployment environment, however (part of) the workflow definition can be reused in a different context/deployment. Most workflow engine implementations (like jBPM) package the workflow definitions and task implementation into a single component, hampering an easy switch of task implementation. To remedy this, the task implementations are separated from the deployments onto the workflow engine and are loosely coupled via a message bus instead. This solution (depicted in <Figure 1>) provides a scalable approach to providing different task implementations for a given task. The approach also decouples task implementations from the workflow engine computationally, the task implementations can be deployed on separate/dedicated computational resources.

3.4. Main components of the dispatcher application

Optimizing the case distribution in the lab (e.g. with respect to throughput or turnaround of cases) plays an important role for improving the overall workflow. Our application implements key components enabling to manage and retrieve case and pathologist information, to propose an optimized assignation of cases, and to visualize and manage worklists and assign cases to pathologists.

the diagnostic pathology journal DIAGNOSTIC PATHOLOGY

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

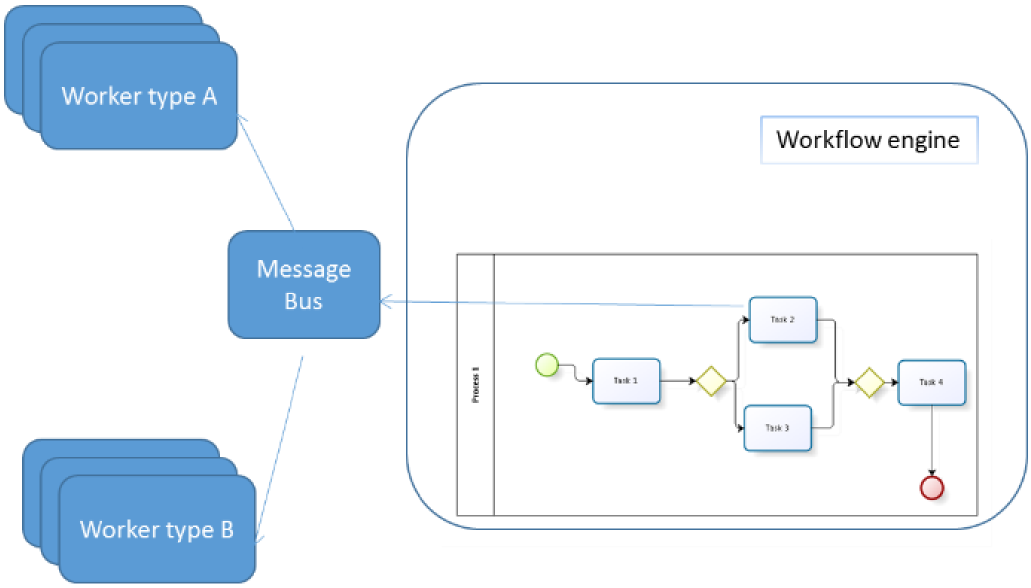

Figure 1: Externalized task implementations.

Worklist visualization: Provides an overview of (active and completed) cases with relevant information (e.g. status, number of slides, organ, clinical question). The tool also displays worklists for each pathologist with the assigned, active and diagnosed cases, specialties, deadlines, time availability, etc. Additional screens show relevant statistics and overviews (e.g. completed cases per pathologist and diagnosis time, cases of each type assigned to a pathologist)

Dispatching optimization module: Proposes assignments based on case features such as type (organ, extraction method), number of slides and samples, complexity/average diagnosis time and difficulty, and on pathologist characteristics (e.g. (sub-)specialty, available time, average diagnosis time per case type). Aims at optimizing user-defined goals, such as the pathologist time and the turnaround of cases.

We use a constraint satisfaction solver, the OptaPlanner package [15] of jBPM, and define the domain model of the problem and the scoring rules according to policies derived from the requirements of the clinical users. We define two types of constraints: hard rules (cannot be broken by the optimization algorithm when computing a solution) such as “case type must match the specialty of the pathologist”, and soft rules (breaking them yield scoring penalties) such as “the case distribution must be fair across pathologists with respect to complexity”. The solver applies the rules on the problem dataset (incoming cases to be diagnosed and available pathologists) and yields the solution dataset (the best assignation of cases to pathologists based on the constraints).

the diagnostic pathology journal DIAGNOSTIC PATHOLOGY

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

<Figure 2> depicts a domain model of the problem implementing typical (i.e. shared by many labs) optimization goals, constraints, and case and pathologist characteristics. <Figure 3> "Building the solver" depicts the process of building and executing the solver to generate a suitable dispatching solution. An earlier implementation of the optimization module is described in [16].

Services for information management: Allow to retrieve the relevant metadata of incoming cases (i.e. all relevant case characteristics to be displayed in the UI and used by the optimization module), and the agenda information of the active pathologists and any changes in their availability.

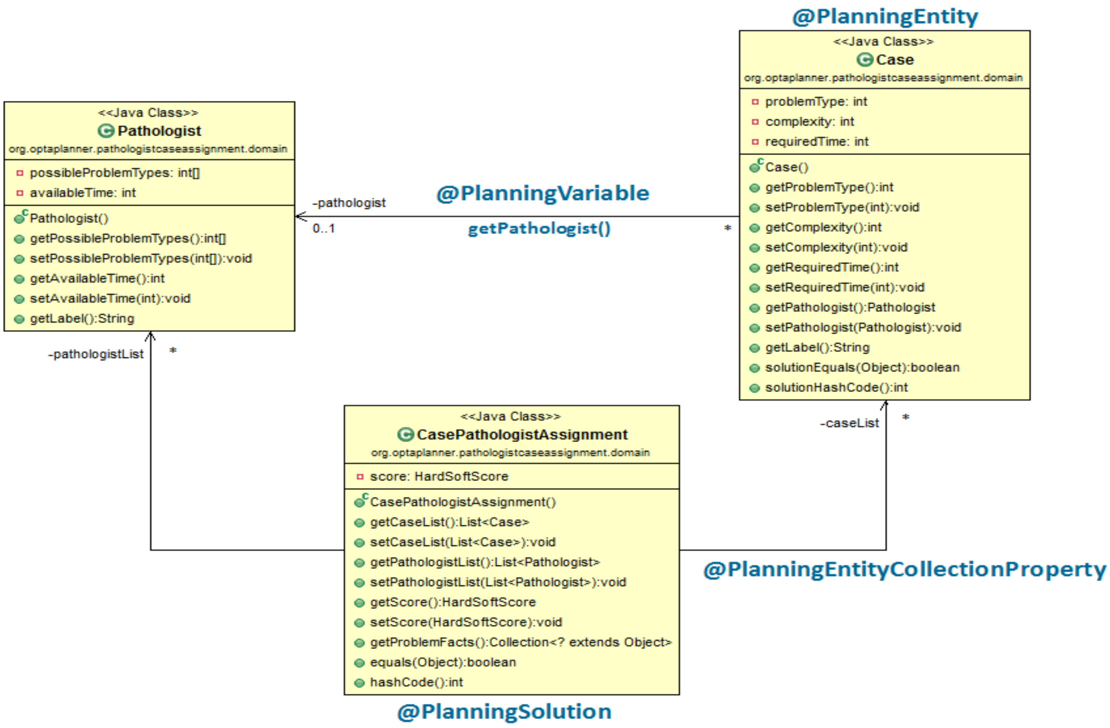

Figure 2: Domain model of the case distribution planning.

3.4. Integration with the Philips Image Management System

The dispatching workflow connects the (physical) production of pathology slides with the slide review activities of the pathologists. Typically, a Laboratory Information Management System (LIMS) supports the workflow (along with data tracking) related to the production of pathology slides and as such contains valuable case information (such as the case features as defined in the previous section). The pathologists on the other hand connect to an image management system (IMS) to (re)view digital pathology slides. The LIMS and the IMS are often connected by means of an integration engine (also known as the message broker) to exchange case state changes and case information.

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

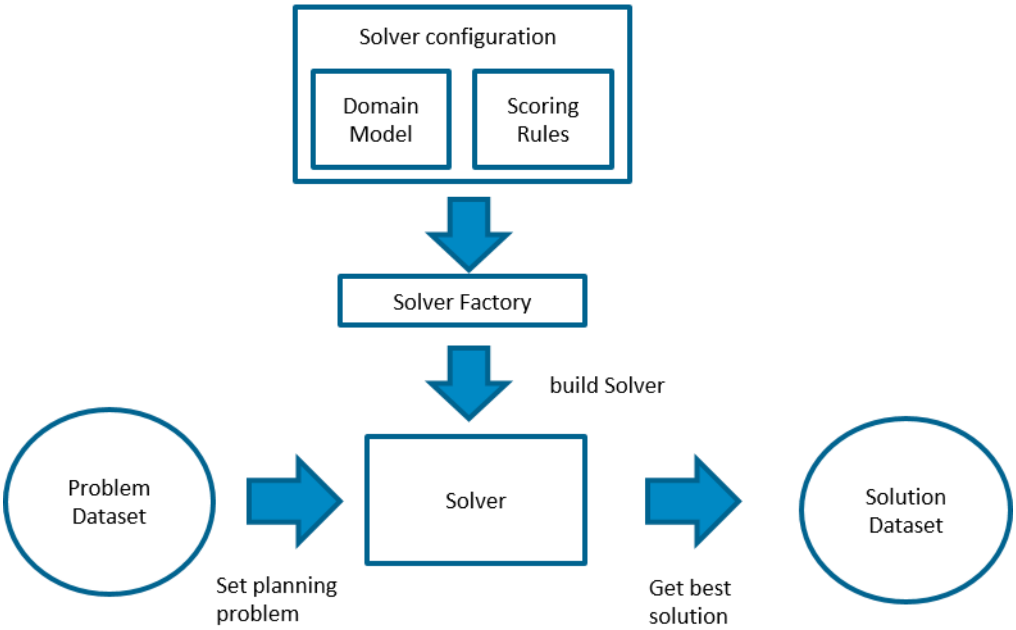

Figure 3: Implementation of the solver: From the problem dataset to the dispatching solution.

For deployment of the dispatching application, the solution is connected to the integration engine to get notifications about case state changes such as “case ready for dispatching”, “case under review by pathologist”, and “case closed”. When cases are ready for dispatching (e.g. all necessary case information is available and all digital pathology slides have been produced), the dispatcher uses the case features, pathologist characteristics, pathologist’s availability and workload information, and dispatching policies to make dispatching decisions (either manual or automatic). These dispatching decisions are communicated to the relevant systems (such as the IMS and the LIMS) via the integration engine. In some situations, external systems can make (additional) dispatching decisions. For instance a policy rule could be that the pathologist performing the gross examination also reviews the case, in which case the LIMS can assign the pathologist for this case and notifies the dispatching solution via the integration engine. Having the dispatching application as a separate component connected via the integration engine allows for a flexible deployment.

4. Results

We implemented an application that can be deployed within an integrated workflow implementation to optimize the distribution of cases to pathologists for diagnosis. This application seamlessly connects with the LIMS and IMS through the integration engine to retrieve relevant data about the cases to be visualized and used in the dispatching decisions, and to provide the case assignation information to the IMS. To automatically assign cases according to defined policies, the optimization component applies the defined policy model

the diagnostic pathology journal DIAGNOSTIC PATHOLOGY

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

(scoring rules within the domain model). The schedules are generated according to the optimization goals, e.g. to improve throughput or turnaround.

<Figure 4> depicts the worklist overview with all cases to be dispatched and the relevant information about these cases such as the status, the type, etc. <Figure 5> shows the overview of the worklists of the active pathologists with the assigned cases. <Figure 6> depicts a detailed graphical view of the workloads of the available pathologists with status of cases and estimated or actual diagnosis time.

Show data from [ ] to [ ] All ▼ Search

Case ID	Arrival	Organ/Clinical Question	Status
T00-00000 02		Vaerify Basal Cell Carcinoma	Assigned
T00-00002 02		Lymphocite Count	Ready for dispatching
T97-5839430	2016-03-02	Tissue Examination Melanoma	Unassigned
T94-2288519 01	2016-02-03	Lymphocite Count	Assigned
T12-1191702 01	2016-02-03	Examination Maligne/Beninge	Assigned
T87-5084601 01	2016-02-03	Tissue Examination Melanoma	Assigned
T56-1746361 11	2016-02-03	Lymphocite Count	Assigned
T39-3332307 01	2016-02-03	Tissue Examination Melanoma	Unassigned
T23-8581795 01	2016-02-03	Tissue examination	Ready for dispatching
T75-6744534 01	2016-02-03	Tissue Examination Melanoma	Assigned
T77-5982909 01	2016-02-03	unknown	Unassigned
T89-3167763 01	2016-02-03	unknown	Unassigned
T79-4870272 01	2016-02-03	unknown	Assigned
T89-5936729 01	2016-02-03	unknown	Ready for dispatching
T36-7963350 01	2016-02-03	unknown	Ready for dispatching
C17 01	2014-11-11	wef	Assigned
C16 03	2014-11-07	carcinoma	Ready for dispatching
C15 02	2014-10-23	Verify Basal Cell Carcinoma	Ready for dispatching
C14 01	2014-10-23	Tissue examination for melanoma	Ready for dispatching

Figure 4: Overall worklist of incoming cases to be dispatched.

the diagnostic pathology journal DIAGNOSTIC PATHOLOGY
Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

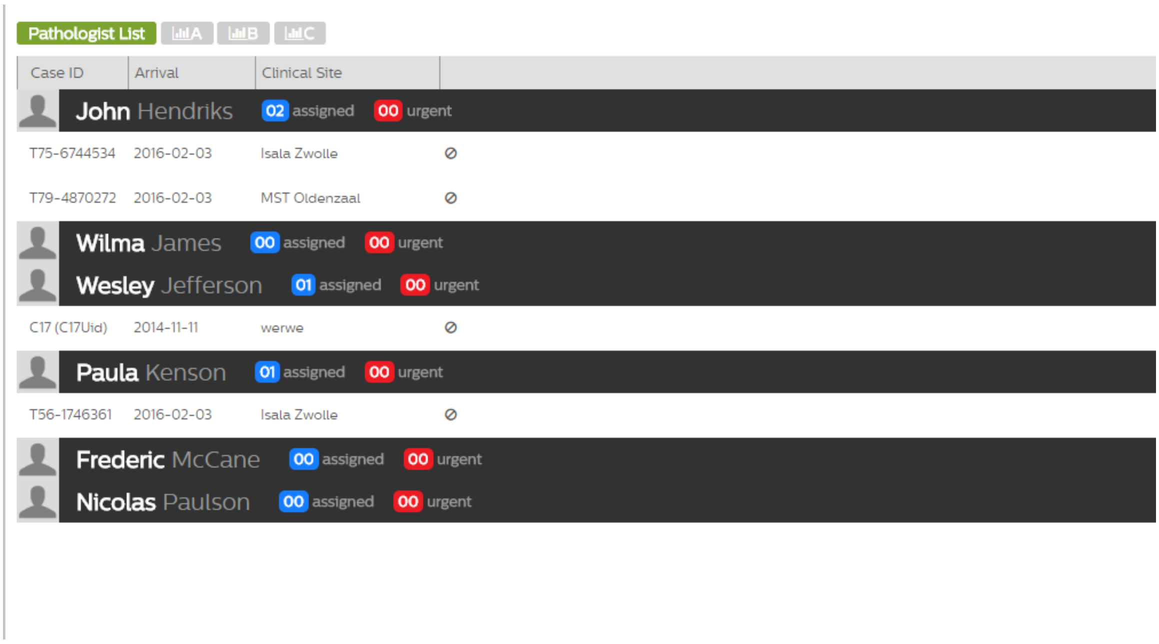

Figure 5: Worklists of active pathologists.

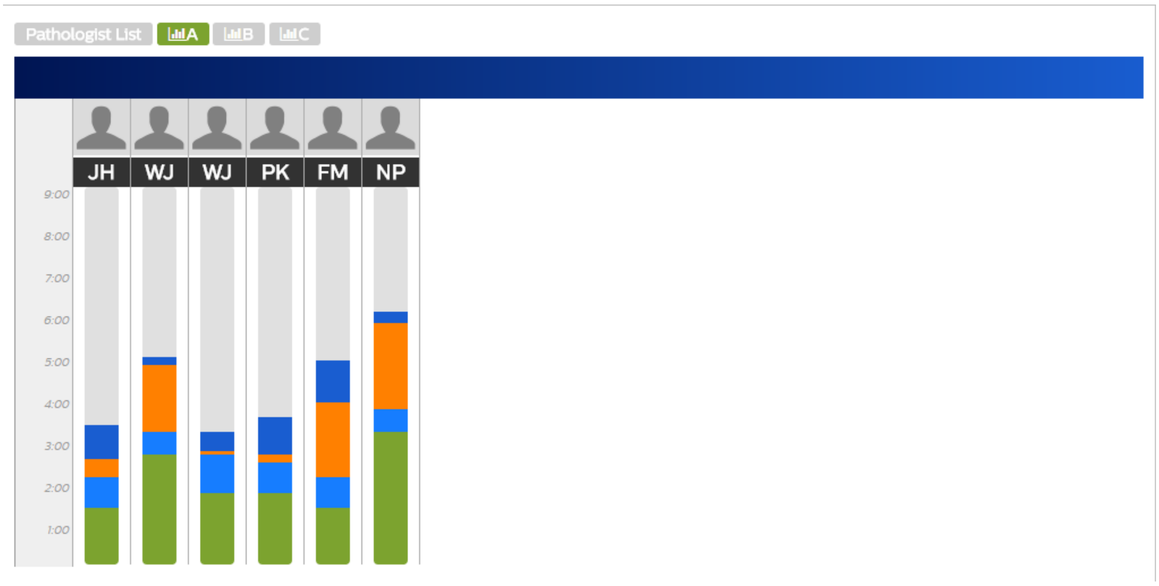

Figure 6: Workload overview with time estimates for the active pathologists (Grey: available time; Dark blue: Other planned non-diagnosis activities (from agenda); Orange: work pending (estimated time); Light blue: work in progress (estimated time); Green: Completed cases).

the diagnostic pathology journal DIAGNOSTIC PATHOLOGY

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

Additionally, we implemented an administration view enabling to customize the user interface to the needs of each lab, to define the local policies for case distribution and to select the optimization goals. <Figure 7> shows the main screen in this view where the information shown in the worklist can be customized. The users can also decide here whether they want to receive scheduling recommendations from the optimization module and whether the tool can automatically carry out the case distribution according to these recommendations (i.e. move the unassigned cases from the global worklist to the worklists to the pathologists' worklists and change the case status to "assigned" for previously unassigned cases).

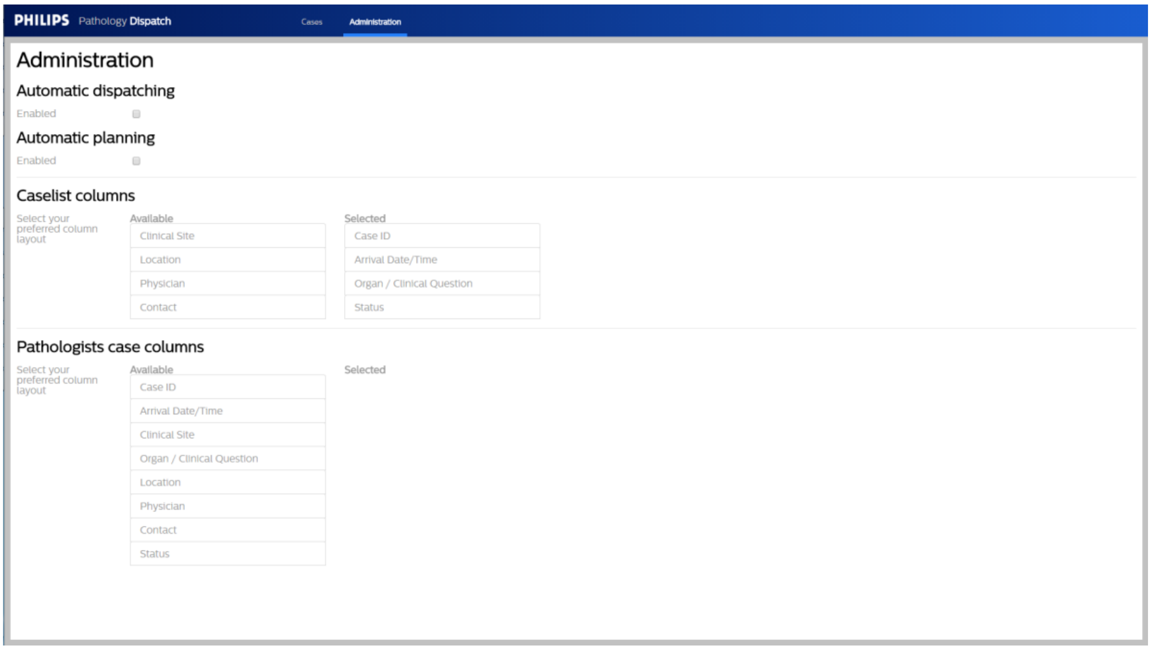

Figure 7: Administrative screen: Configure visualization and select settings for the automatic dispatcher.

5. Conclusions

We define an approach to workflow modeling and implementation that is open and scalable, and leverages existing workflow standards that are widely adopted in other domains. This enables efficient implementation and gives us access to an existing platform that delivers both a workflow and a rule-engine. The proposed concept of externalizing the definitions and implementations of tasks within the workflows allows us to build workflows that are adaptive to the environment and that can incorporate decision models and applications of the desired complexity.

The choice for explicitly modeled workflows (instead of hard-coded) requires slightly more implementation effort and the integration and proficiency with several tools, but provides significant long term benefits. The process models are easy to understand, develop and change, enabling their collaborative definition and adaptation in a multidisciplinary team of

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

modelers, clinical experts and IT specialists. The models are cost-effectively maintained and customized, and allow for the efficient collection of large amounts of data to drive analysis for a deep understanding of the clinical processes.

The optimization of the case distribution for diagnosis has been identified in the literature as an important area when aiming at workflow improvement and automation of the processes in the pathology labs. Our case distribution solution facilitates both the manual dispatching of cases to pathologists (supporting the current way of working), and the automatic assignation according to defined policies. In our solution the configuration can be easily customized to apply dispatching rules and optimization goals specific to each deployment site, which helps reduce implementation costs and supports adoption.

The visualization components provide insight into the status of the cases and into the workloads of the pathologists, and enables users to modify the assignation of cases when needed (e.g. when agenda changes occur and cases need to be reassigned). The information that is shown in the user interface is customizable as well to the needs of the users.

Building on positive user feedback to the prototype, in our future work we will evaluate the application next to the current dispatching process in a pathology lab. We model the local policies and apply our optimization module to the local workload to demonstrate time savings and improvements according to the optimization objectives selected by the lab. We also aim to further evaluate the interaction of the users with the tool, the ease of use and potential acceptance. The user feedback will drive the refinement of the prototype.

Acknowledgment

The authors gratefully acknowledge the support of LabPON (Laboratorium Pathologie Oost Nederland) while carrying out this work. LabPON provided information on the local case distribution process and policies, and feedback on the application. The planned evaluation next to a current dispatching process will also take place in collaboration with LabPON.

References

1. Al-Janabi S., Huisman A., Van Diest P.J., Digital pathology: current status and future perspectives., Histopathology 2012, 61(1):1-9.
2. Jara-Lazaro A.R., Thamboo T.P., Teh M., Tan P.H., Digital pathology: exploring its applications in diagnostic surgical pathology practice., Pathology 2010, 42(6):512-8.
3. Stathonikos N., Veta M., Huisman A., van Diest P.J., Going fully digital: Perspective of a Dutch academic pathology lab., J Pathol Inform 2013, 4:15.

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

4. Vodovnik A., Diagnostic time in digital pathology: A comparative study on 400 cases., J Pathol Inform. 2016; 7:4.

5. Rojo M.G., Castro A.M., Gonçalves L., COST Action "EuroTelepath": digital pathology integration in electronic health record, including primary care centres., Diagn Pathol. 2011, 6(Suppl 1):S6.

6. Park S., Pantanowitz L., Parwani A.V., Wells A., Oltvai Z.N., Workflow organization in pathology., Clin Lab Med. 2012, 32(4):601-22.

7. Ho J., Aridor O., Parwani A.V., Use of contextual inquiry to understand anatomic pathology workflow: Implications for digital pathology adoption, J Pathol Inform. 2012; 3:35.

8. Ho J., Aridor O., Glinski D. W., Saylor C. D., Pelletier J. P., Selby D. M., Parwani A. V., Needs and workflow assessment prior to implementation of a digital pathology infrastructure for the US Air Force Medical Service. J Pathol Inform. 2013, 4:32.

9. Ho J., Ahlers S.M., Stratman C., Aridor O., Pantanowitz L., Fine J.L., Kuzmishin J.A., Montalto M.C., Parwani A.V., Can digital pathology result in cost savings? A financial projection for digital pathology implementation at a large integrated health care organization., J Pathol Inform. 2014, 5(1):33.

10. JBoss, (2015), jBPM Business Process Management Suite. Available from: www.jbpm.org [Accessed: 2016-01-01]

11. BPMN Standard, Available from: http://www.bpmn.org.

12. Rojo M.G., Rolón E., Calahorra L., García F.O., Sánchez R.P., Ruiz F., Ballester N., Armenteros M., Rodríguez T., Espartero R.M., Implementation of the Business Process Modelling Notation (BPMN) in the modelling of anatomic pathology processes., Diagn Pathol. 2008, 3(Suppl 1):S22.

13. JBoss (2015), KIE (Knowledge Is Everything) group. Open source projects for business systems automation and management. Available from : http://www.kiegroup.org/.

14. JBoss (2015), Drools Business Rules Management System. Available from: www.drools.org.

15. JBoss, (2015), OptaPlanner constraint satisfaction solver. Available from: www.optaplanner.org [Accessed: 2016-01-01]

16. Juby Joseph Ninan, (2014), Integrating rules and automated planning in business processes, Eindhoven University of Technology, Master Tesis, Available from:

Anca Bucur et al., diagnostic pathology 2016, 2:115
ISSN 2364-4893
DOI: http://dx.doi.org/10.17629/www.diagnosticpathology.eu-2016-2:115

http://alexandria.tue.nl/extra1/afstversl/wsk-i/ninan2014.pdf, [Accessed: 2016-01-01].