

Toward an integrated User Requirements Notation framework and tool for Business Process Management

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Abstract

A number of recent initiatives in both academia and industry have sought to achieve improvements in e-businesses through the utilization of Business Process Management (BPM) methodologies and tools. However there are still some inadequacies that need to be addressed when it comes to achieving alignment between business goals and business processes. The User Requirements Notation (URN) has some unique features and capabilities beyond what is available in other notations that can help address alignment issues. In this paper, a URN-based framework and its supporting toolset are introduced which provide business process monitoring and performance management capabilities integrated across the BPM lifecycle. The framework extends the URN notation with Key Performance Indicators (KPI) and other concepts to measure, and align processes and goals. A healthcare case study is used to illustrate and evaluate the framework. Early results indicate the feasibility of the approach.

1. Introduction

A Business Process Management (BPM) lifecycle consists of several iterative steps that improve the quality of business processes and overall organization in an incremental approach [6][18][37]. Figure 1 gives an overview of a typical model-driven lifecycle, starting with the discovery and modeling of business processes. Using superficial and outdated process models obscures the understanding of the organization and prevents the next steps of the BPM project from providing optimal results and value [21]. An integrated and tool-supported methodology supporting users who are *modelling* business processes accurately is considered essential for BPM projects. In addition, allowing the integration of business goals and performance models, in

a traceable way to and from business models, greatly contributes to ensuring goal satisfaction and process adaptation [31][34][39]. The integration of goals, processes, and performance in a BPM framework enables many useful capabilities, some of which are explored in this paper. As an example, the traceability between business process models and business goal models plays a significant role in the successful and practical definition of process-oriented Key Performance Indicators (KPI), a common way of evaluating different aspects of a business by qualitative measurement [20].

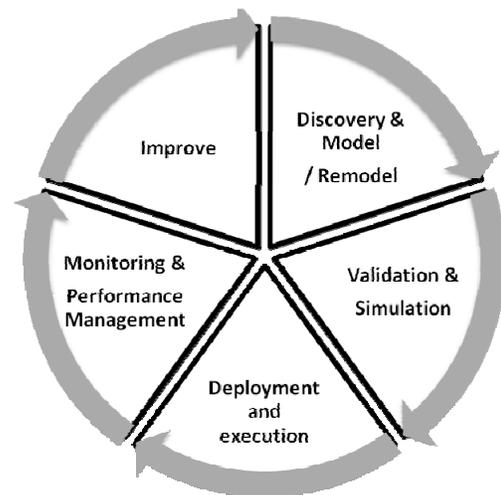


Figure 1: BPM lifecycle

Often, the focus of the *deployment* phase of a BPM project is to automate the modeled processes [18]. However, we believe this phase also offers opportunities for improving the subsequent phases. There are information systems across organizations that produce data useful for the *monitoring and performance management* phase that can provide deeper insight about processes. Deploying a data warehouse (DW) that sup-

ports performance models related to the business models represents a useful design alternative. The DW can be used as a data source for a Business Intelligence (BI) tool integrated to the BPM environment, allowing one to investigate business processes in their associated context along different dimensions [31].

The *improvement* phase can use performance measurement results from the monitoring phase as well as a repository of process redesign patterns like those defined in [32]. In other words, redesign patterns aiming to help the organization improve the target process can be suggested based on a problem observed during the monitoring phase and/or goals defined in the modeling phase. This is one of the main reasons to bring in a performance measurement framework [24].

In this paper, we propose many elements of a BPM framework that supports this vision. Our modelling approach is based on the User Requirements Notation (URN), which integrates complementary goal and scenario views. The notation is extended to support KPI and performance modeling, process portfolio monitoring, and scenario-based performance and impact analysis. Our URN-based approach also provides conformance and compliance capabilities [9][34], which support traceability from goals and scenarios to requirements and policies from the organization or external legislation. Such traceability enables impact analysis as goals, processes, and external requirements evolve.

In addition, we elaborate on the required extensions to the current URN meta-model as well as development and integration efforts done to prototype such enhancements (using tools like the jUCMNav URN editor, Cognos' Business Intelligence tools [5], and Telelogic's requirements management system DOORS). Our framework will be discussed and illustrated in the context of a case study in the healthcare sector related to a hospital's DW approval process.

2. Background

2.1 Business Process Management (BPM)

A *business process* is a “coordinated chain of activities intended to produce a business result” [3] or a “repeating cycle that reaches a business goal” [6]. People from different units and organization are usually involved to complete an end-to-end process. Business Process Modeling is a structural method that helps stakeholders graphically analyze processes and find possible points of improvements. In the course of modeling a process, one usually specifies the defined activities which are performed by different parties. A business process model should be able to answer the famous W5 questions. Why, What, Who, Where and When.

Processes can be simple and restricted to a functional unit of an organization or complex and cutting across several business partners. Today's customer-focused business environment requires much business-to-business cooperation to complete a process and often massive integration between different information systems [26]. However, legacy software applications are usually built based on different functional units of businesses, hindering integration [3].

Business Process Management (BPM) is the management of diverse and cross-organizational processes that integrate methods and tools to support the design, execution, management, and analysis of business processes. *Business Process Management Systems* (BPMS) are integrated tools that enable businesses to perform the required steps in a BPM project.

A BPMS is one of the most recommended investments for process improvement [35]. It adds value to the business, enables the reuse of IT investments and addresses the aforementioned integration issues. In addition, a BPMS helps businesses automate and manage business rules and processes. As a key component of BPMS, business activity monitoring (BAM) is “the real-time reporting, analysis and alerting of significant business events, accomplished by gathering data, key performance indicators and business events from multiple applications” [8]. According to Kronz [20], the principal outcomes of continuous monitoring, controlling and analysis of processes are improved decision making and process optimization.

A new term that has been recently introduced in the industry is *Business Process Intelligence* (BPI). BPI integrates BPMS and *Business Intelligence* (BI) systems. BPI usually includes DW and BI and is used by both business and IT users [12]. BPI tools reduce the traditional gap between process execution and performance monitoring [25] and enable continuous process improvement. “BI 2.0” is the name given to this new generation of BI tools. In [27], BI 2.0 and its ability to track ongoing business behaviour are elaborated. There has also been movement towards integration of BPMS and Corporate Performance Management (CPM) to align corporate goals with business processes [10]. However, neither BPI, nor integration with CPM provides sufficient support in dealing with the business goal models and business process models in an integrated manner.

2.2 User Requirements Notation

The User Requirements Notation (URN) was designed for modeling and analyzing requirements in the form of goals and scenarios prior to design [15][39]. It can be used to model most kinds of reactive and distributed systems, as well as business processes.

The URN combines two complementary notations: the Goal-oriented Requirement Language (GRL) and Use Case Maps (UCM) which are used for modeling goals and processes respectively. Figure 2 and Figure 3 show a brief summary of these two notations.

More complex business process modeling languages exist, but a combined view of goals and processes and traceability features between them are unique capabilities of URN. URN provides the ability to align business goals and business processes by adopting design experts' business knowledge and experience [22].

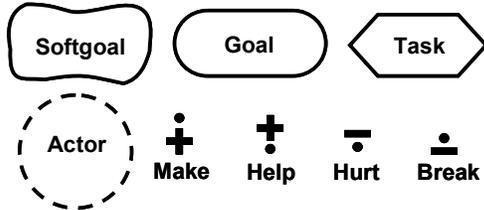


Figure 2: Subset of GRL notation

GRL supports an evaluation mechanism that lets users define sets of initial satisfaction values on chosen intentional elements in GRL model (called *strategies*). Those values are propagated to the other intentional elements in the model via their contribution, decomposition, and dependency links, up to the highest level goals [1][33][34]. This capability can be used for evaluating the effect of different tasks and processes on goal models, enabling global evaluations of alternatives and trade-off analysis [31]. Finding realistic contribution weights and initial satisfaction values to define a GRL strategy can however be difficult, but our framework proposes novel solutions to this issue.

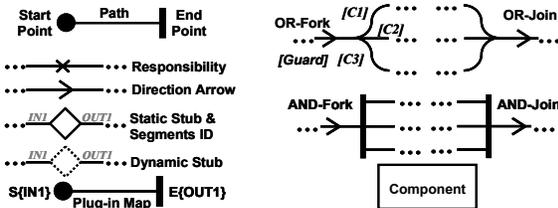


Figure 3: Subset of UCM notation

The UCM process view specifies the responsibilities to be performed (the *what* aspects) by *whom*, *when*, and *where*. The GRL goal view provides a rationale (*why*) for the business process elements, together with an explanation of why alternative solutions were chosen or not. More details on URN are provided in [1][15]. A detailed analysis of the capabilities of URN in comparison with other well-known business process modeling languages is given in [28].

Work on the framework described in this paper was initiated in [38][39], which introduces business process

modeling using URN. The framework's core tool is *jUCMNav*, an open URN modeling, analysis and transformation tool based on the Eclipse platform [33]. The data exchange layer and integration with external tools was formalised in [17]. Integration of goals/scenarios with a Requirement Management System (Telelogic DOORS) [34] was used as a basis for process validation and compliance verification against requirements, goals, and policies, as elaborated in [9]. Business process monitoring and performance management was introduced in [31]. This paper builds on top of this work to help answer a new *how well* question with BPM.

3. An integrated framework for BPM

Our proposed framework consists of different layers of components in an open, extensible architecture. As illustrated in Figure 4 the core component is the framework meta-model, which describes the semantic concepts for creating process, goal, and performance models. A subset of this meta-model is shown in Figure 8 and Figure 9. The *jUCMNav* tool is built on top of this meta-model.

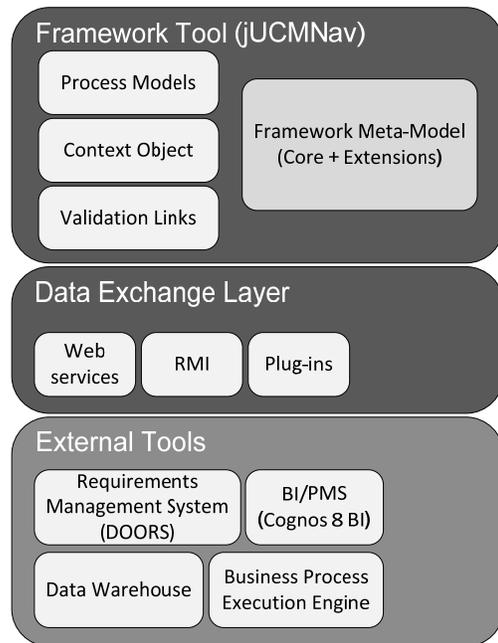


Figure 4: Framework components

The framework allows one to model processes, goals, and context objects (e.g. KPIs and compliance constraints). Validation links allow one to connect models to external tools through the data exchange layer. Although the framework is generic enough to support different type of technologies (e.g. eclipse plug-in, RMI, etc.), we adopted a Service Oriented

Architecture (SOA) solution in the current implementation. SOA provides flexibility, scalability, and small development and deployment cycle times and cost [4].

A common multi-phase and iterative approach to implementation of the framework is shown in Table 1. The final goal is to include all processes in the framework, execute them, monitor their performance continuously and improve them incrementally. Monitoring and performance management is an ongoing task as there is always room for improvement in both processes and business goals. In addition, changes in business environments lead to changes in processes that require validation and changes in performance models.

Table 1: Framework steps and iterations

Objective	Action	Artifacts	Tools
Clarify the high level picture of the business	<ul style="list-style-type: none"> Identify Re, BG and Pr Specify the relationship between above artifacts Indicate the most important processes 	<ul style="list-style-type: none"> RD GM PrM 	<ul style="list-style-type: none"> RMS BPMS
Finalize pre-deployment tasks	<ul style="list-style-type: none"> Elaborate GM and PrM Specify Performance objectives and designing PeM Design the required DW, PMR and DES Validate the PrM against provided RD 	<ul style="list-style-type: none"> PeM PrM DW PMR DES 	<ul style="list-style-type: none"> RMS BPMS DW
Deployment and implementation	<ul style="list-style-type: none"> Deploy process models Deploy DW Implement and deploy PMR Deploy DES 	<ul style="list-style-type: none"> PrM DW PeM PMR DES 	<ul style="list-style-type: none"> BPMS DW PMS
Utilization and performance management.	<ul style="list-style-type: none"> Process execution Process monitoring and analysis Prioritization of improvement candidates 	<ul style="list-style-type: none"> PrM DW PeM PMR DES 	<ul style="list-style-type: none"> BPMS PMS DW RMS
Remodeling and alignment	<ul style="list-style-type: none"> Improve PrM Improve BG Validation 	<ul style="list-style-type: none"> PrM BG 	<ul style="list-style-type: none"> BPMS

BG: Business Goals
 BPMS: Business Process Management System
 DES: Data Exchange Services
 DW: Data Warehouse
 GM: Business Goals Models
 Re: Requirements
 RD: Requirements Documents
 Pr: Processes
 PrM: Processes Models
 PeM: Performance Model
 PMR: Performance Management Reports
 PMS: Performance Management System
 RMS: Requirement Management System

The first step is to specify business goals and processes. An RMS is used to trace requirements between the process and goal models through the data exchange layer. The most important processes are selected for the first iteration based on goals and requirements using a web-based requirement prioritization tool connected to jUCMNav through the data exchange layer.

In the next stage, the selected process and goals are explained in more detail. After specifying the performance objectives, Key Performance Indicators (KPIs) and dimensions of the performance analysis are added. This refined model is used for designing data warehouse schema and performance reports runnable using a BI tool. Finally, the detailed process model is vali-

dated against the requirements to make sure deployed processes perform as expected.

In the deployment and implementation phase, the required infrastructure is provided and the processes are deployed to a process execution engine. In addition, the designed DW schema is implemented and the performance reports are created in the BI tool.

In the fourth step, the processes are executed and performance management is performed (see section 3.2). The last step relates to process improvement based on results generated from performance analysis. In the next iteration, new processes and revised goals and objectives can be used in addition to the improved processes. In a fast-pace application domain, one could even think of using this framework to provide adaptive processes with dynamic optimizations.

3.1 Framework core models

The three core artefacts of the framework are models for goals, processes, and performance. Figure 5 and Figure 6 describe their associations and mutual effects.

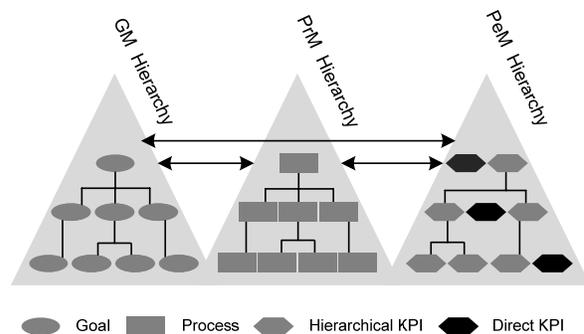


Figure 5: Framework models organization

Figure 5 shows that all three main artefacts are modeled in a hierarchical manner. The hierarchy in the goal model is based on the decomposition of high-level goals into operational goals that can be used to decide about the atomic components of the process models (i.e. tasks, responsibilities, and even architectures). The goal hierarchy can also reflect the process hierarchy. After defining the processes at different levels of abstractions, one can create a goal model for each level. Goal hierarchies are demonstrated using GRL contribution links and diagrams. On the other hand, process hierarchies can be motivated by the organizational structure of a business or by abstraction layers defined by process authors. The process hierarchies are modeled using UCM stubs and plug-ins (sub-maps).

In the performance model, both hierarchical KPI and direct KPI are defined. While hierarchical KPI at higher levels of the hierarchy are the aggregation of the same type of KPI at lower levels, direct KPI only

evaluate one particular process or sub-process and do not affect other layers.

Figure 6 defines these artefacts and the relationships between them. Goals and processes are defined to fulfill the specified requirements. Each process model is a use case map constructed by one or multiple processes. Business goal models can be defined only for one process or depict the objectives behind multiple processes. In addition, each process can have one goal model or multiple goal models to distinguish the (often conflicting) objectives of different stakeholders. Performance models are derived from goal models which have been demonstrated as an association link. Each process can have multiple performance models that evaluate the processes from different aspects of the business or from the perspectives of multiple stakeholders. Performance models are created using performance goals, information elements and KPI.

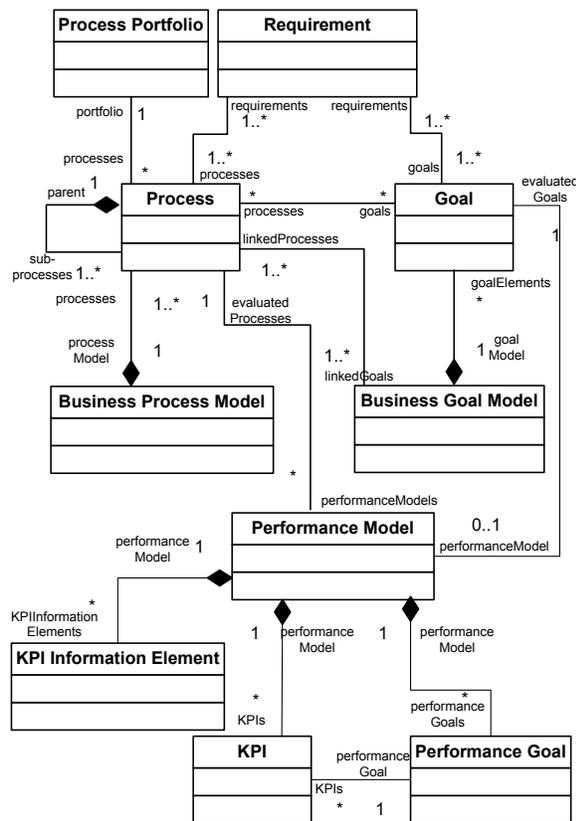


Figure 6: Framework modeling components

3.2 Performance monitoring

Business process performance modeling is a new application area for URN. As a result, the original URN meta-model needed to be extended to support the required functionalities, which are shown as shaded classes in Figure 8 and Figure 9.

KPI evaluation and mapping to GRL initial evaluation levels is done through four value sets associated to each KPI: Target Value, Threshold Value, Worst Value and Evaluation Value. Target Value is the expected performance of the process under evaluation. Threshold Value is used to separate acceptable from unacceptable values, while Worst Value is used to specify the most serious condition from a users' perspective. These three values are adjustable as required. The Evaluation Value is the KPI's *actual* value retrieved from back-end business data sources at run-time or defined by users for test purposes at design time. Figure 7 illustrates how these four values are mapped to GRL evaluation levels. These concepts are elaborated in more detail in [31].

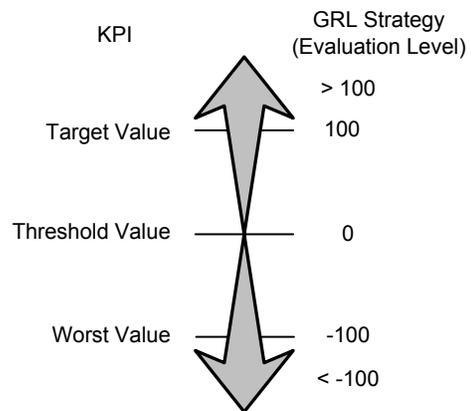


Figure 7: GRL initial evaluation level mapping

As demonstrated in Figure 8, *Indicator* inherits all features of GRL intentional elements. Thus, a KPI can be used for evaluation in a way similar to tasks and goals in a GRL model. Indicators also have some specific features such as groups that can be used to categorize KPIs for redesigning, filtering and other user-defined purposes. In addition, performance model links are used to link indicators to KPI information elements. These elements allow users to add detailed information (e.g. dimensions) to performance models. Dimensions can specify data categories and hierarchies used for aggregating and summarizing data [11][19].

Figure 9 illustrates the extensions to GRL evaluation strategies. Unlike the initial design for indicators in [31], the KPI value sets in the new meta-model are defined as values of KPI strategies. This new design allows users to define multiple strategies and, consequently, evaluation value sets for a KPI. This feature also helps users define and compare different possibilities. KPIInformationConfig contains a set of specific dimension information that will be used for retrieving KPI values under each strategy. Those dimension information include the level of dimension and the value

of dimension. The dimension settings define a specific context for KPI evaluation and the setting information will be used to build data models and KPI reports on the BI server. For example, for the KPI “number of complains” on the time dimension in Figure 17, in different evaluation strategies, users may want to evaluate in both monthly and daily basis, so the level of dimension could be month and day. When building the data model, the smallest or lowest level will be chosen to be the granularity of the data model. On the other hand, when creating KPI reports, the value of dimensions in different evaluation strategies can be used to select ranges of values from the data model, such as the year 2006 or February 2007.

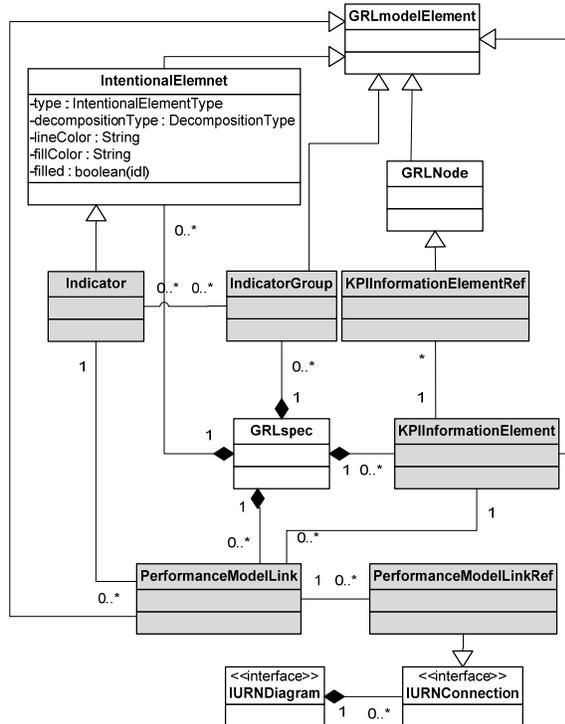


Figure 8: Meta-model for performance models

3.2.1 Performance and impact analysis

Since business processes usually span organizational structures, their monitoring and analysis introduce specific requirements that cannot be fulfilled by ordinary BI tools [27]. Combining business process monitoring with UCM scenarios [17] enables business users to achieve performance analysis and impact analysis on specific parts of the processes of interest.

As shown in Figure 10, scenarios are used to highlight parts of processes which include tasks and responsibilities that go through different organizational units. The process models are connected to performance models from one side and goal models from the other side. After a scenario definition is enabled by the

user, our tool activates all the KPIs that have been defined in that path. Thereafter, the performance of that part of process is shown. This displays the impact of the highlighted part of the process on the related goals of the organization.

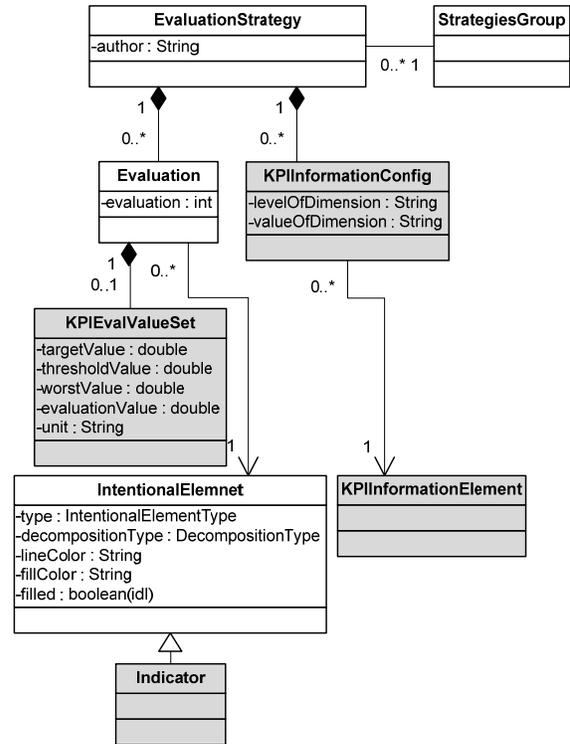


Figure 9: Meta-model of KPI strategies

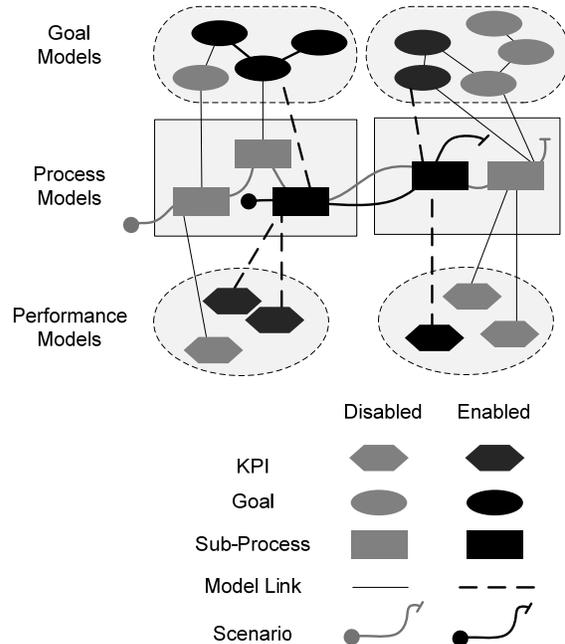


Figure 10: Scenario-based process analysis

Based on work for integrating scenarios and goals in [34], monitoring and performance analysis of processes in an automated and integrated manner is a new concept that demonstrates the real value of URN in the context of BPM. Figure 11 shows the workflow of scenario-based impact analysis among several modules of the tool.

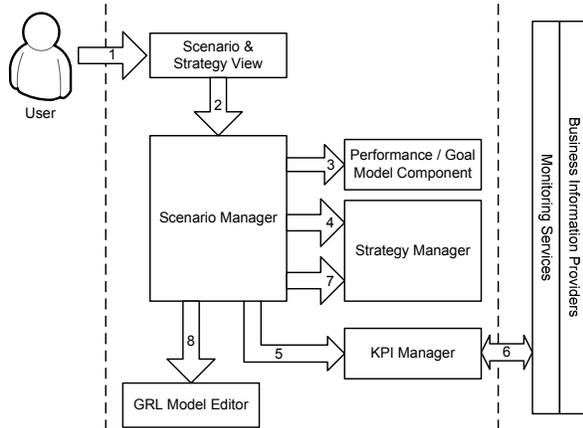


Figure 11: Scenario-based performance and impact analysis – run-time sequence model

First, the user chooses a scenario and a performance evaluation strategy to give the evaluation a context (1), the scenario & strategy view sends a request to the scenario manager (2), which triggers the scenario and finds relevant performance models. The responsibilities and sub-processes in the scenario get mapped to their counterpart in the performance models (3). Subsequently, by scenario manager's request (5), the KPI manager retrieves KPI values from the monitoring services (via the data exchange layer) and maps them to evaluation levels (6), as seen in Figure 7. The strategy is then triggered by scenario manager (7) and the evaluation results are presented to the users on the new jUCMNav KPI View, with their impact simultaneously shown on the goal model.

Figure 12 highlights the extensions made to jUCMNav's user interface to support the new framework. jUCMNav extends standard Eclipse views (Outline, Properties, and Problems) with graphical editors for UCM (process model) and GRL (goal model). In our framework, the GRL editor was further extended to support the definition of KPI and dimensions. The Scenarios and Strategies view is used to define and execute GRL strategies and UCM scenarios, which result in colour feedback in the models.

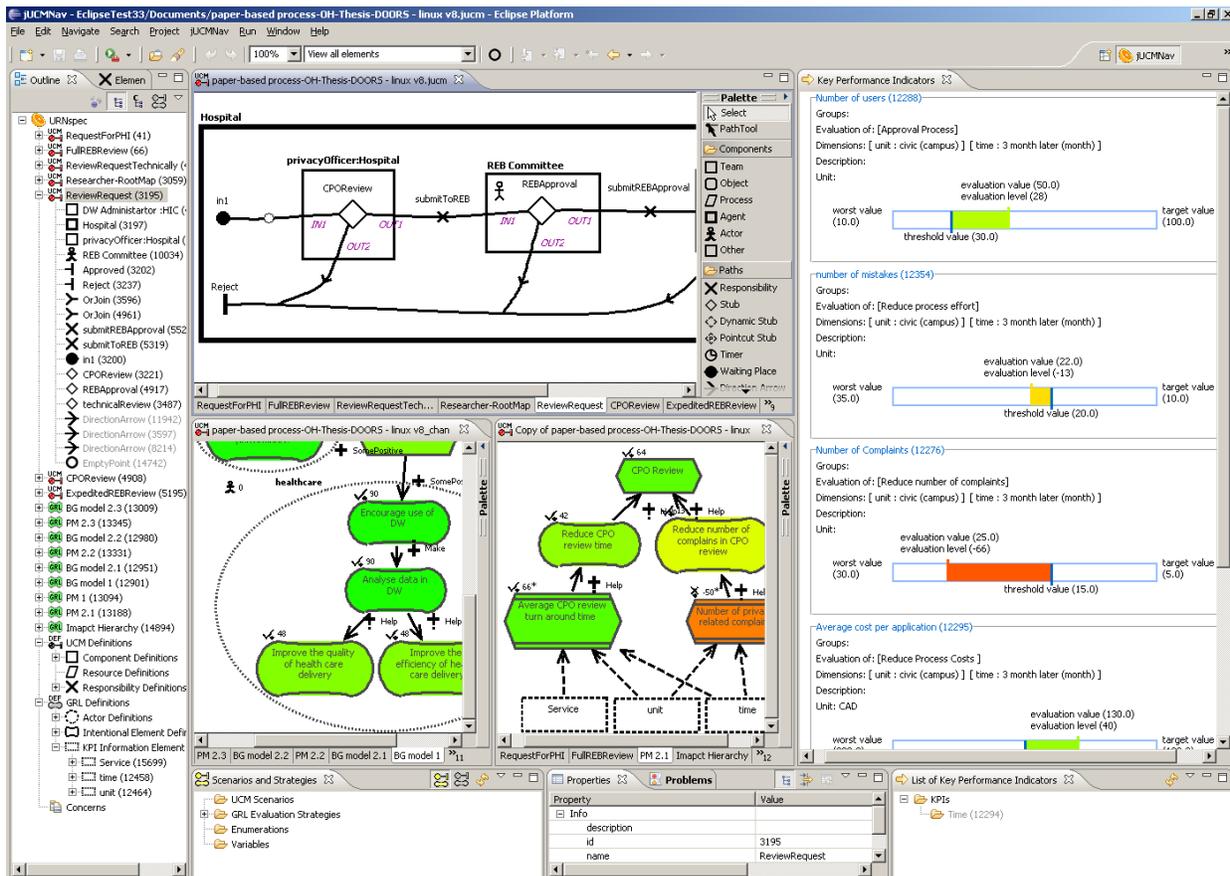


Figure 12: jUCMNav views for KPI and BPM

This view was extended to support KPI strategies and evaluation. Another view was added to list KPIs. Last but not least, the new Key Performance Indicators view (on the right side) is where the KPI results are visualized in terms of the four value sets discussed in the previous section.

3.2.2 Process portfolio analysis

A *process portfolio* consists of multiple processes modeled in an organization. This view is a representation of all processes in a hierarchical quadrant with drill-down and drill-up capabilities. It gives users an overall understanding of the current status of existing processes and helps them decide the next step in a BPM project (e.g., prioritization of the next targets for improvement or the next candidate process for outsourcing [13]). In addition, it provides the capability for users to pinpoint a malfunctioning process and drill-down to the next levels of abstraction to find out the sources of problems (Figure 14).

Although using quadrants for analysing process portfolios has been already introduced in [13], using process models (UCM), goal models (GRL), and performance models (GRL+KPI) to provide this capability in a hierarchical structure is a novel concept. Goal and performance models are used respectively to calculate the *importance* and *performance* values of the processes that are the two axes of the quadrant (Figure 14) and process models are used to specify the hierarchical structure.

In our definition, the importance value is the average satisfaction level of the top-level business goals when a process performs at its 100% capacity. In other words, importance is the impact of the business process on the business goal model. The performance value is computed from the performance model as described in section 3.2.

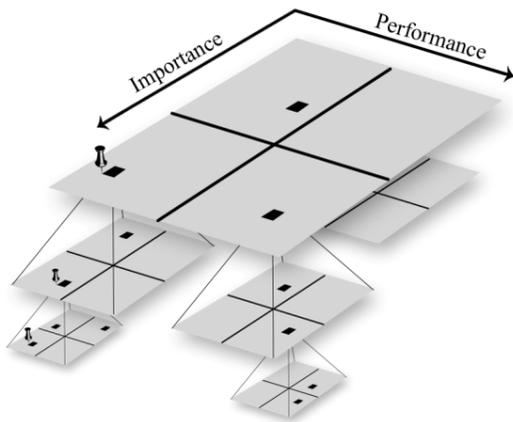


Figure 14: Process portfolio – drill down scenario

Each layer of a process portfolio view includes all the responsibilities and sub-processes (stubs) of a UCM map. This view is synchronized with the process view and the KPI view. Hence, while users browse the processes (i.e. individual UCM maps) this view and the KPI view are changed based on the current process being observed.

The workflow among the relevant modules of the framework to support the process portfolio view is very similar to the one in Figure 11. First, the user chooses a process from the outline view or drills-down (using stubs) to a sub-process in the UCM view (1). A request is then sent to the process portfolio manager (2). Subsequently, the process portfolio manager finds all the performance and goal models that are related to the selected map/process (3). Next, an importance strategy is created, initialized, and triggered dynamically to calculate the importance value for each process (4). The process portfolio manager then creates a performance strategy and retrieves KPI values through the KPI manager to initialize the evaluation levels of KPIs (5 and 6). Finally, importance values and performance values for each sub-process or responsibility in the selected process are used by the portfolio manager to calculate their locations on the quadrant.

4. Case study

To improve its quality of care, a large research hospital in Ontario aims to facilitate the access to its data warehouse (DW) to researchers and administration staff. However, granting access to a large DW can cause many issues, including compliance with personal health information protection regulations in Ontario (PHIPA) [30]. As these issues need to be addressed by the hospital, the latter has defined a business process called *DW Approval Process*. Figure 15 illustrates the top-level view of this process, whereas Figure 16 and Figure 17 describe the business goals and performance models respectively.

The most important part of this process is the *review request* sub-process, shown in Figure 18, which is the focus of this case study. In a nutshell, the CPOReview responsibility is performed by the chief privacy officer (CPO) to ensure that the requested data will not violate the relevant privacy laws. For REBApproval, the research ethics board (REB) of the hospital evaluates the intended usage of the data. The data warehouse administrator reviews the request (technicalReview) to make sure the requested data can technically be obtained from the warehouse and that the users' access rights are defined properly. However, this process takes time to be completed, and therefore it needs some improvement.

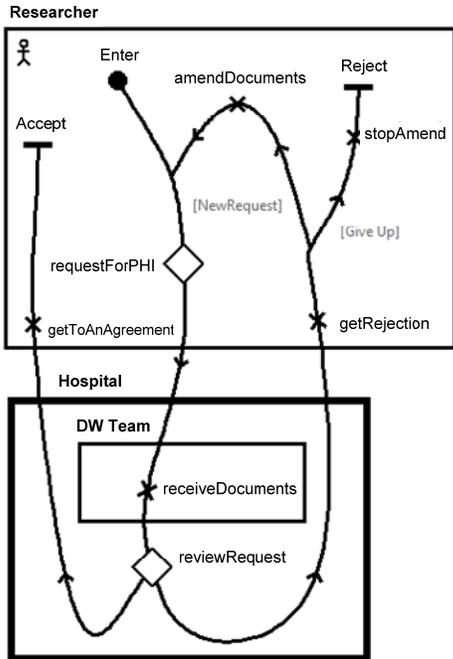


Figure 15: DW approval process

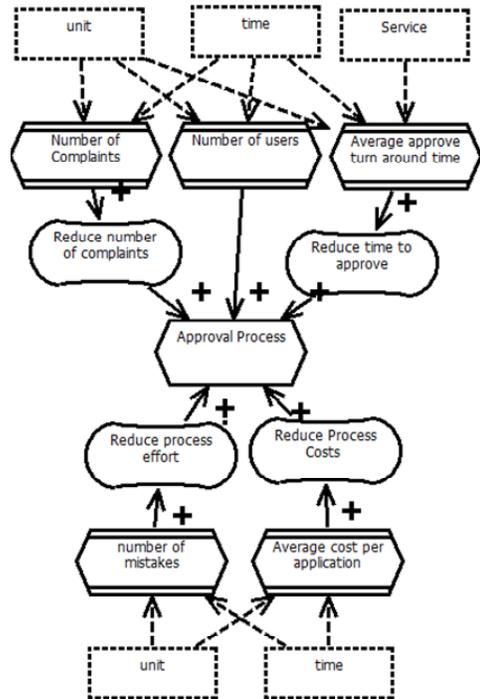


Figure 17: Approval process performance model

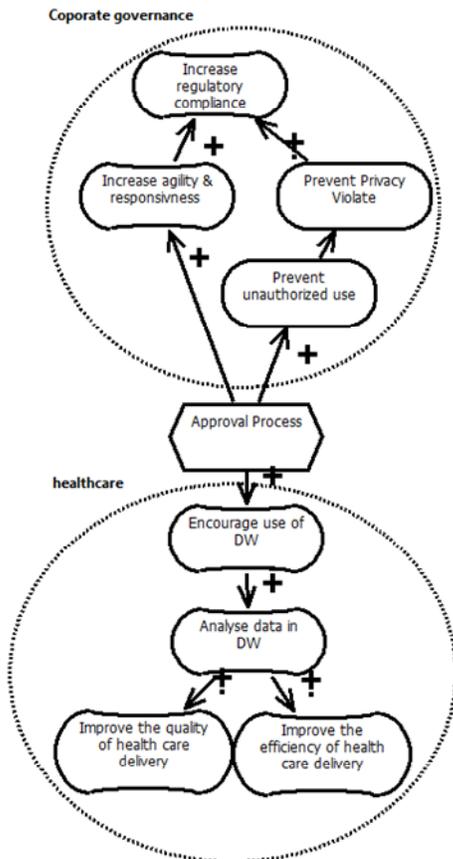


Figure 16: Approval process goals

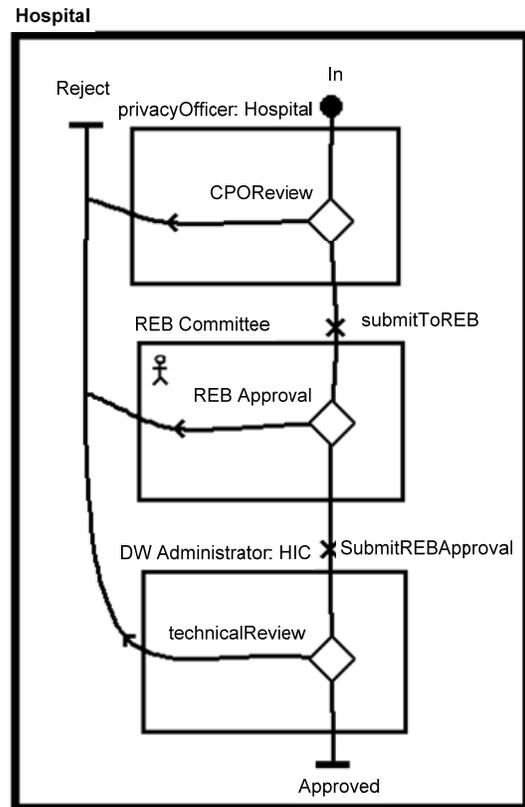


Figure 18: Review request sub-process

As illustrated in Figure 16, several KPIs have been defined which can improve this process. In the initial step, the business goals and performance models of these three sub-processes are created using jUCMNav. For example, Figure 19 and Figure 20 define the models for the technical review sub-process.

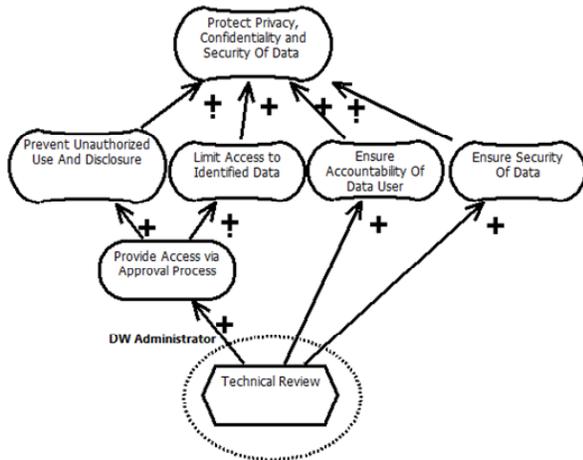


Figure 19: Technical review goal model

Based on these models and KPI values defined in Table 2, we obtained the result reported in Table 3. We replicated the hospital's DW schema and infrastructure in our lab for this experiment, but we used a fake data set for privacy reasons. Figure 21 shows the corresponding process portfolio view. So far, all sub-processes have almost similar levels of importance, but the REB review has the highest performance.

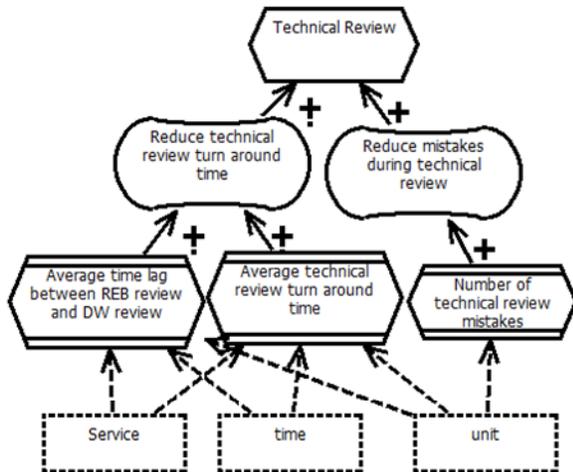


Figure 20: Technical review performance model

Table 2: KPI value sets

KPIs	T	Th	W	EV	EL
Average CPO review turn-around time (days)	3	15	30	7	66
Number of privacy related complains	2	7	15	4	60
Average time lag between CPO review and REB review (days)	1	5	15	3	50
Average turnaround time of viewing REB (days)	2	8	15	6	33
Number of review mistakes	5	12	20	8	57
Average time lag between REB review and DW review (days)	2	6	16	3	75
Average technical review turnaround time (days)	2	7	15	5	40
Number of technical review mistakes	5	8	15	6	66
Number of complaints	5	15	30	9	60
Number of users	100	30	10	35	7
Average approve turn-around time (days)	7	30	60	18	52
number of mistakes	10	20	35	12	80
Average cost per application	100	150	200	130	40

T: Target Value; Th: Threshold Value; W: Worst Value
EV: Evaluation Value; EL: Evaluation Level (GRL)

Table 3: Initial results

	CPO Review	REB Review	DW Review	Approval Process
Importance	37.6	36.7	37.6	32.67
Performance	71	78	60	89

To further showcase the properties of our BPM framework's methods and tool, we considered the following scenario. After a three-month period, the hospital substantially increased the number of DW users. Presumably, the results observed in this new context would be updated as shown in Table 4 and Table 5.

Table 4: Modified results after changing KPI values

	CPO Review	REB Review	DW Review	Approval Process
Importance	28.25	27.5	57.75	40
Performance	50	76	49	50

Table 5: Modified KPI value sets

KPIs	T	Th	W	EV	EL
Number of privacy related complains	2	7	15	6	20
Number of review mistakes	5	12	20	10	28
Average number of DW performance complains	3	8	15	10	-28
Number of complaints	5	15	30	16	-6
Number of users	100	30	10	50	28
number of mistakes	10	20	35	15	50

T: Target Value; Th: Threshold Value; W: Worst Value
EV: Evaluation Value; EL: Evaluation Level (GRL)

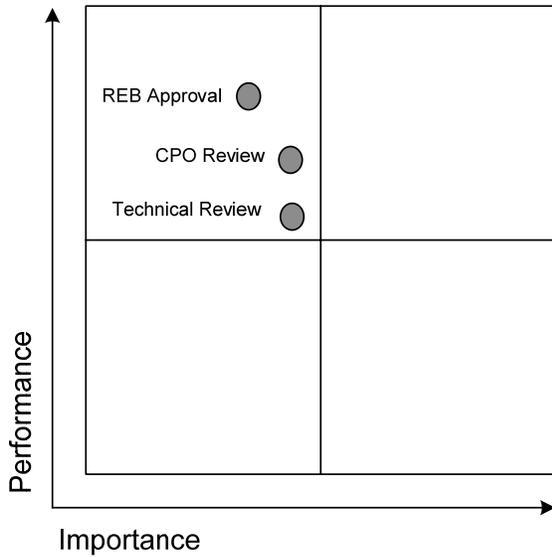


Figure 21: Initial process portfolio view

DW stakeholders start to send in various types of complaints. The *type* dimension defined for complaints KPI allows one to categorize the complaints based on their type. The number of complaints about DW efficiency is the highest, but we also have some privacy complaints.

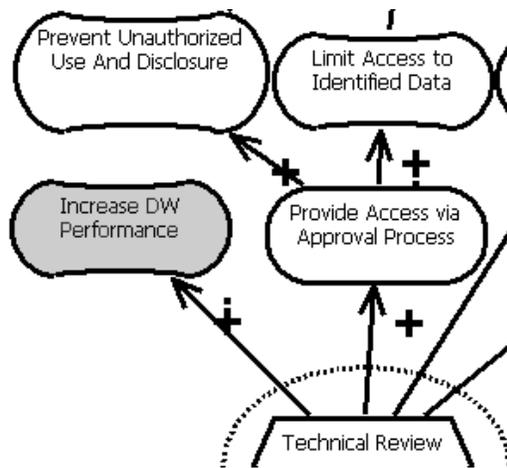


Figure 22: Revised technical review goal model

After having experienced inefficiencies in the DW, the number of users starts decreasing once more and the hospital realizes that efficiency contributes significantly in encouraging users to use the DW.

As a result, Figure 19 is updated to Figure 22, and Figure 20 to Figure 23. The process portfolio view changes to Figure 24. Such modifications to the goals inevitably lead to changes in the business processes in order to bring the process portfolio back to a sweet spot performance-wise and satisfy stakeholders and the organization.

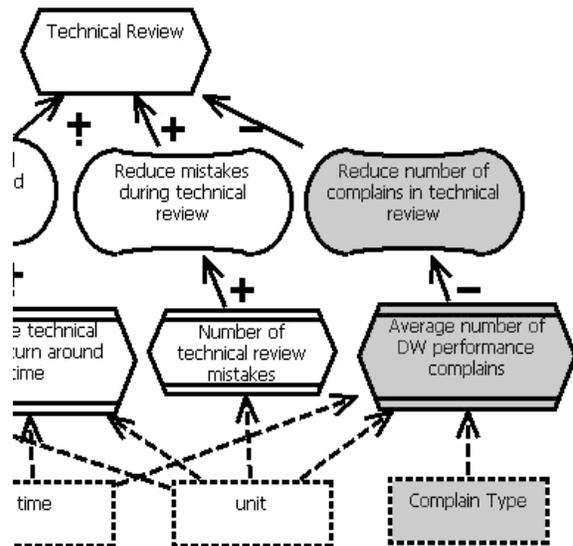


Figure 23: Revised technical review performance model

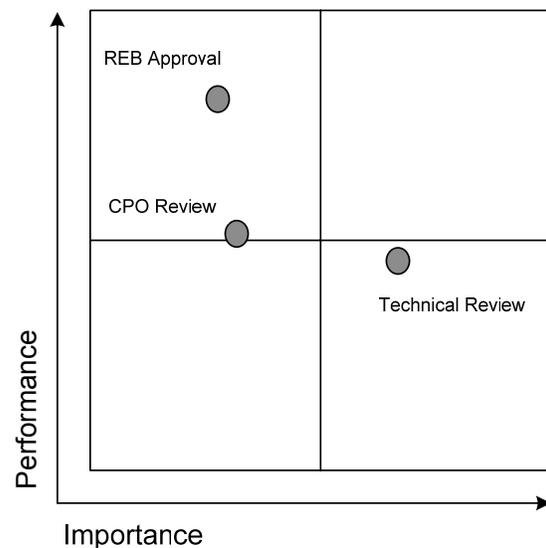


Figure 24: Updated process portfolio view

5. Discussion and future work

In this paper, we have introduced a business process management framework based on the URN modeling notation with integrated tool support through jUCM-Nav. The semantics of the framework is provided by an extensible meta-model designed to support more capabilities as requirements arise.

The focus of this paper was on the business process monitoring and performance management aspects of the framework.

First, we introduced the concept of performance models, derived from business goal models, which

help organizations improve both their processes and goals. Second, a scenario-based technique for performance and impact analysis has been elaborated. This new feature of the framework allows users to filter out the rest of the performance models and only analyze the part of the processes covered according to UCM scenario definitions. Finally, we talked about process portfolio analysis. In this case, we elaborated how a quadrant view of the modeled processes allows one to see the performance of processes and their level of importance for the business. In addition, it allows users to drill down into process hierarchy and find out the roots of the problems.

The framework and its supporting tool can be compared with other similar methods from three perspectives: modeling notation, methodology and integration with tools. One of the most important competitive advantages of the suggested framework is its modeling notation – URN. Using the original URN, we are able to model goals and processes. With the proposed extension, we can also illustrate performance models.

In terms of methodology steps, the proposed approach uses common steps of process improvement methods but also provides some enhancements. First, unlike BPR, it does not suggest radical and revolutionary improvements in all processes. However, at the same time, the methodology does not suggest to focus on small-grained details that cause the big picture to be lost, which is often the case for statistical-oriented improvement methods like six sigma [36]. Instead, the methodology suggests a spiral approach of improvement. After creating the global model, each subsequent iteration deals with the most important processes. Finally, unlike classical improvement methods that have trouble gathering information about processes scattered across an organization [40], our framework provides a data exchange layer capable of obtaining data from different sources including data warehouses and business intelligence systems.

Table 6 briefly compares our URN-based BPMS with other major BPMS in the industry. Relevant criteria include support for process modeling, KPI modeling and evaluation, and goal modeling and evaluation. The table shows that by providing an integrated system based on URN, our solution can provide stronger support for modeling and evaluation across processes, KPIs and goals. Note however that many of the other tools provide more detailed descriptions of business processes and many support process automation.

For future work, we plan to enrich the framework in different ways including: integration with a business process execution engine, automated deployment of the process models, simulation of the processes in real scenarios before deployment, improvement of the processes using business process redesign patterns, and

pattern recognition in business processes using some of the techniques that has been used in Aspect-oriented URN [29]. Integration between jUCMNav and other BPMS will be explored. In addition, during this study, we encountered some limitations of the current GRL propagation algorithm that require contribution links to become completely quantitative. Better handling of negative contributions is also required.

Table 6: Comparison between BPMM tools

	Process modeling	KPI modeling and evaluation	Goal modeling and evaluation
Our URN-based BPMS			
IBM WebSphere Process Integration [16]			
Intalio BPMS [14]			
Appian Enterprise BPM Suite [2]			
Tibco iProcess Suite [7]			
G360 Enterprise BPM Suite [10]			
Lombardi Teamworks BPMS [23]			

■ : Supported via integration

■ : Partial supported

□ : Not supported

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