Business Process Monitoring and Alignment: An Approach Based on the User Requirements Notation and Business Intelligence Tools

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Abstract

Monitoring business activities using Business Intelligence (BI) tools is a well-established concept. However, online process monitoring is an emerging area which helps organizations not only plan for future improvements but also change and alter their current ongoing processes before problems happen. In this paper, we explore how monitoring process performance can help evolve process goals and requirements. We elaborate an approach that uses the User Requirements Notation (URN) to model the goals and processes of the organization, and to monitor and align processes against their goals. A BI tool exploiting an underlying data warehouse provides the Key Performance Indicators (KPI) used to measure the satisfaction of goals and process requirements. Feeding this information into the URN modeling tool, we can analyze the consequences of current business activities on desired business goals, which can be used for process and business activity alignment thereafter. We illustrate the approach with a case study from the healthcare sector: a hospital discharge process.

1. Introduction

Businesses are subject to a variety of external events that need quick actions and responses to ensure their survival and growth. One of the most important strategies is to make core business processes agile and flexible. Flexibility enables appropriate response time for today's event-driven business environments [5].

In addition, businesses need to establish process monitoring mechanisms to get updated information about their business processes and to improve their decision making capabilities [16].

According to Rudden [27], over 1,400 Chief Information Officers identified business process improvement as one of their companies' top priorities. Business process improvement reduces costs, increases revenues, motivates employees, and satisfies customers.

In this paper we introduce a new method for improving processes and evolving their goals and requirements. This method combines business process modeling and activity monitoring concepts. It takes advantage of the User Requirements Notation (URN) [1][14] to express and reason about business goals and process performance requirements. This method also enables organizations to align their processes with their business goals. Key Performance Indicators (KPI) are used to measure how well processes satisfy their goals, and a URN tool combined to a commercial business intelligence tool support the automation of the monitoring.

Basic concepts and previous work related to business process management and URN, with an emphasis on healthcare processes, are first recalled in section 2. The core of our new method, with concepts, steps, and KPIs integrated to URN models, is introduced in section 3. To illustrate and (to some extent) validate this approach, the implementation and results of a monitoring system for a realistic healthcare case study (hospital discharge process) are presented in section 4. Conclusions and items identified as future work are discussed in section 5.

2. Literature review

2.1 Business process management and tools

In [4], a *business process* is defined as a "coordinated chain of activity intended to produce a business result." In addition, it can be considered as a "repeating cycle that reaches a business goal" [8]. A process usually has several steps that are performed by multiple individuals across an organization.

Simple processes usually target a single functional unit of an organization. End-to-end business processes, however, can go from one department to another and from one business partner to another. Businesses and their supportive software applications (e.g., Enterprise Resource Planning, Customer Relationship Management, and financial software) are usually structured into different functional units and are hardly capable of integration with other included parties [4]. This is due to the legacy mindset of arranging organizations around functions and departments. This cannot be the case for today's agile enterprises, whose focus is on customers and on closer cooperation with business partners in their value chain [22].

Business Process Management (BPM) is the understanding and management of diverse and cross-organizational processes which link humans and automated system together. If BPM has been around for some time, *Business Process Management Systems* (BPMS), used to automate processes and to provide process monitoring and improvement capabilities [2], represent a revolutionary way of using technology in the business environment [4]. Recent studies show that most information technology executives consider BPM as the most important technology that help them achieve their business goals [2].

Business Activity Monitoring (BAM), usually considered one of the components of a complete BPMS, is gaining more popularity in the industry these days. According to Gartner, "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" [9]. Having business process management and automation systems increases the need for process monitoring and introduces new redesign and improvement opportunities [12].

Using performance monitoring tools, business and process analysts can identify the possible points of improvements and reengineering in each process. In some cases these tools even have the capability of integrating with simulation environments, which allows monitoring of the optimized process based on real life data. Most BPMS provide dashboard creation, as well as key performance indicators monitoring capabilities [4]. According to [16], the principal outcomes of continuous monitoring, controlling and analysis of processes, are improved decision making both in strategic and operational level and process optimization using the information provided by such a system.

BPMS monitoring tools represent a new wave of *Business Intelligence* (BI) tools. While in traditional BI tools there is usually a huge gap between process execution and performance monitoring [21], BPMS tools allow reducing this gap while helping organizations with the continuous improvement of their processes. "Old fashioned" business monitoring tools with limited power like *balanced scorecards* in most cases look at the organization only from a vertical viewpoint. "BI 2.0" is the name given to this new generation of BI tools that provide true insight into ongoing processes in the business. In his book [23], Nicholls talks about BI 2.0 and its ability to track ongoing business behavior. The main problem he observed in current solutions is the latency between a business event and monitoring the effect on business, and subsequently taking action. This problem causes some actions to happen too late to prevent incidents.

Business Process Intelligence (BPI) is another term that is used for the aforementioned functionalities. It is usually implemented as a suite of products including Data Warehouses (DW), a BI tool, and a business process automation and execution engine that supports both business users and information technology users to run and monitor business processes. In addition, BPI can be used to predict unwanted actions, events and exceptions [13].

2.2 BPM and URN

Business process modeling usually involves identifying the roles of users involved in the process, and the definition of activities (often referred to as workflows or services) that contribute to the satisfaction of well-defined business goals [31]. It is common to use requirements engineering concepts, such as scenarios and goals, to model business processes.

The *User Requirements Notation* (URN) [14] is an emerging standard that integrates two main notations that can be used to connect goals, requirements, quality, and business processes: a goal-oriented notation (Goal-oriented Requirement Language – GRL, based on the *i** and NFR frameworks) and a scenario-oriented notation (Use Case Maps – UCM).

A GRL model captures business or system goals, alternative means of achieving goals, and the rationale for goals and alternatives. GRL includes concepts such as *intentional elements* (goals, softgoals, tasks and beliefs), *actors*, *contributions* (with levels/weights), *decomposition*, and *dependencies*. Given a set of initial satisfaction levels associated to some of the intentional elements (which define a *strategy*), the satisfaction levels of the other elements in the model can be evaluated by propagating the initial values through the various types of links.

A UCM model depicts scenarios as causal (sequence, alternative, concurrent) flows of *responsibilities* representing something to be performed (operation, action, task, function, etc.). Responsibilities can potentially be allocated to *components*, which are generic enough to represent software entities (e.g., objects, processes, databases, or servers) as well as non-software entities (e.g., actors or resources). Complex models can be decomposed via *stubs*, which are containers for sub-UCMs (called *plug-ins*).

Although URN was traditionally applied to telecommunication systems [1], it is general enough to support business process modeling in a variety of contexts. For instance, URN's scenario notation was used to elicit requirements by identifying the different responsibilities and the demands on spatial resolution associated to the actions of each administrative unit in a health information system [24]. URN's goal notation was also used to model agent relationships and improvement alternatives to assist in the analysis and redesign of the patient discharge process in three major Canadian hospitals [7].

A more integrated use of both views (GRL and UCM) not only enables one to answer the *where*, *what*, *who*, and *when* questions of process models, but also *why* an activity, or particular sequence of activities is performed. Early work exploring such relationships was done for an information system (Web-based training system) [18]. A more integrated view, better supported by tools, was further explored for the modeling, analysis, and evolution of a supply chain management system [31][32]. All these examples and many others have demonstrated the suitability of URN and its sub-views to model and reason about business processes, goals, and requirements.

3. Methodology

3.1 Conceptual view

In this methodology, we use *Key Performance Indicators* (KPI) to monitor, measure, and evaluate business processes. In other word, we consider indicators as means of measuring how well business goals and performance requirements are satisfied.

Figure 1 illustrates a high level view of the methodology. In this method we get the real-time value of KPI and after comparing those with target values based on business goals the necessary actions are taken.

The bi-directional iteration arrow shows that this could be an iterative and continuous process. In other words, businesses can monitor their processes to improve them based on their goals, and their goals could also be improved based on their achievements. Consequently, the main reason for monitoring is not only process improvement but also goal improvement.

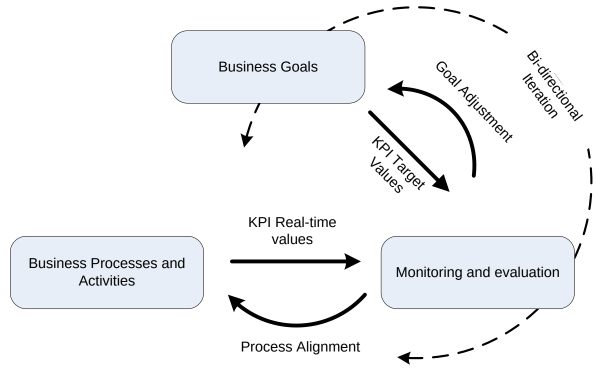


Figure 1. Methodology - conceptual diagram

To achieve this objective, process-oriented KPIs which enable us to get conclusions about effectiveness and efficiency of the processes [16] are monitored using the data gathered from the business activities and the execution results of process instances. There are four main dimensions of indicators that we will monitor and investigate in order to evaluate the required actions on processes: time, cost, quality, and flexibility. These dimensions have been described as the *devil's quadrangle* [3], showed in Figure 2. For example, we obviously try to improve the execution time of a process, while decreasing its cost and increasing its quality and flexibility. However, since these indicators usually affect each other, we cannot usually improve all of them at the same time. Often, increasing the number of available resources decreases execution time but increases cost. In Table 2, discussed in the conclusion, we specify how process-redesign patterns affect these indicators.

Based on the types of processes and the decision maker's goals and priorities, key performance indicators for each process and their target values will be defined. After monitoring and measuring, an appropriate redesign pattern that has a positive impact on the monitored indicator and is applicable to the case will be selected.

Longo and Motta indicate that "a process design is good if it allows good performance on the whole range of performance measures. Further, the process design is sustainable if it allows good performance for the various actors involved in the process, who are regarded as process stakeholders" (management, customer, operator, etc.) [20]. In our method we try to address different ranges of performance measures for different stakeholders through combining the KPI model concept and GRL strategies.

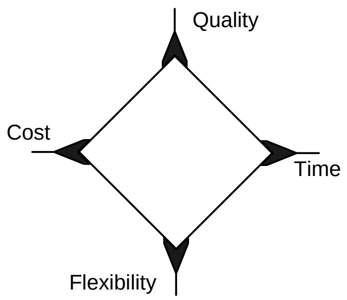


Figure 2. The devil's quadrangle

3.2 Steps of the methodology

The methodology steps (Figure 3) are generalized based on our experience with case studies as well as on lessons learned in other cases [17][21] and other methodology guidelines [8][13][19][21][30].

The first and necessary step is to model the required business processes or update the existing models. Only by having processes modeled can we define the required performance indicators and metrics. When outdated or artificial, a business process model does not help improve the actual process [17].

After specifying the business process, high-level business goals and their relationships to business processes through KPI models should be modeled. During this phase, the indicators and metrics expected by top and middle management are defined, selected and attached to goals and processes [20][21].

After having modeled the processes and the associated KPIs, the required and appropriate DW should be developed to enable information gathering in an effective and efficient manner [20][21].

Next, the required systems and tools, including operational databases, DW, BI tool, and process modeling and monitoring tool, should be integrated. This task usually requires detailed engineering and technical work due to the diversity of systems and heterogeneous infrastructures that are involved in execution of end-to-end processes [17].

Once all required components are in place, we can start monitoring our processes to find out the possible improvement opportunities in processes and/or goals in an iterative and continuous manner.

Although this method could improve both process and business goals, using it like any other BPM methods introduces some difficulties in practice. This kind of problems if not addressed, using relevant best practices, may cause project failure which has been the case for many Business Process Reengineering projects in the past. BPM and BAM methods are generally tend to be heavy weight methods with lots of corporate efforts involved which require executives' commitment and whole corporate will.[11][29]

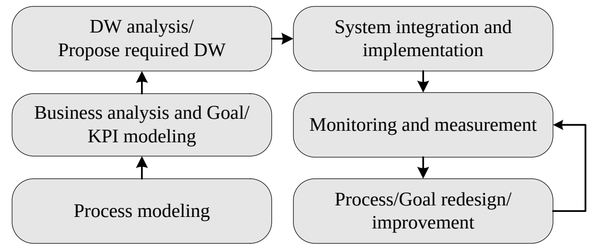


Figure 3: Methodology steps

3.3 Using URN for process modeling

URN has already been used for modeling, analyzing, and evolving business processes [32] and business models [31]. GRL models can include tasks and sub-goals that contribute to achieving high-level goals. Tasks are goal/softgoal operationalizations that are granular enough to be quantifiable. In addition, the UCM view is used to describe process activities, their actors, as well as causal and responsibility relationships. UCM can be used at different levels of abstraction (e.g., business or system) and complex models are decomposed hierarchically.

Traceability between the UCM view and the GRL view and its usefulness has been discussed in the literature. This is one of the main reasons for using URN as the notation of choice for our business process monitoring methodology. We can hence see the effects of processes on business goals and monitor them in a visual manner using the jUCMNav Eclipse plug-in [26]. In addition, from a completeness standpoint, these capabilities help us find the goals without corresponding operational elements and vice versa [1].

3.4 Integrating KPI models with URN

In order to fill the gap between business goals and business processes, and to relate KPI to both aspects, we use a concept called *KPI model*. As depicted in Figure 4, the KPI model is a GRL model that is connected to a business goal component on one side and to a monitored part of the business process on the other side. This model is developed based on the four dimensions introduced in the devil's quadrangle. Defined KPIs are linked to the appropriate dimensions through contribution links.

A KPI model shows how defined KPIs that help monitor processes contribute to connected business goals. The defined contribution links between used KPIs and the target business goal model component help to set the initial evaluation level of this component, which is otherwise often set arbitrarily and without proper justification. Contributions may have various degrees of impact on linked intentional elements (positive, negative or neutral, and sufficient, insufficient or unknown) and hence this evaluation level may affect the whole business goal model.

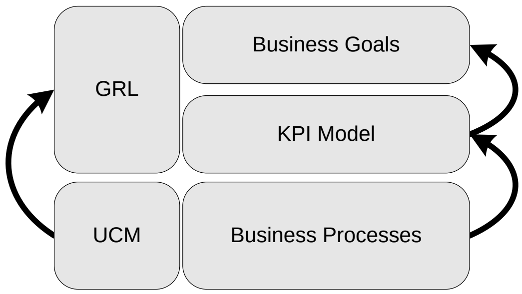


Figure 4. KPI model with GRL and UCM

Even if the KPI model could be depicted in the same GRL model as the business goals, we prefer to separate it into another model to prevent any confusion. In other words, we keep our business goal model clean and clear, and at the same time we can elaborate the effects of KPIs on a given business goal model component as much as we want.

As discussed earlier, one process might have more than one stakeholder, and in order to measure the performance of the process, all stakeholders' measurement factors must hence be considered [20]. To enable the definition of different KPIs for different stakeholders, or the same KPI but with different targets, thresholds, and contributions, we define individual KPI models for each specified stakeholder. This method allows us to evaluate the processes from stakeholders' individual perspectives or all together. As an example, the average lead time might have different target values from different viewpoints: managers, operators, and customers. Organizations often consider different weights of opinions for different stakeholders (e.g., the manager's opinion may weight more than the operators'). Using GRL contribution links and contribution levels, we also support this factor.

Section 4.3 further elaborates on KPI model concepts with a case study. The next sections discuss relationships between KPI, GRL, and UCM models.

3.5 KPI model definition in GRL

Currently, the URN/GRL metamodel does not include KPI concepts. To be able to use GRL in our proposed methodology, we have to integrate KPI model concepts with URN. This integration and its associated metamodel are shown in Figure 5.

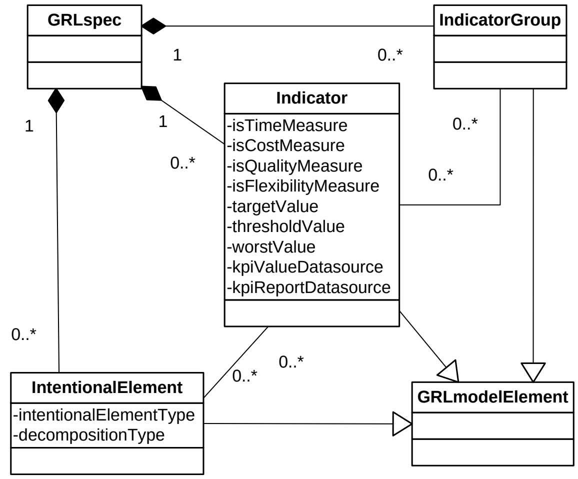


Figure 5. KPI in GRL metamodel

Indicators can be specified in four dimensions: time, cost, quality, and flexibility. An indicator can belong to more than one dimension because, in many cases, these dimensions have some effects on each other. For instance, quality is often measured by means of time, therefore lead time for processes with external stakeholders can not only be considered as a time dimension but also as a quality dimension [3].

An indicator group, as modeled in Figure 5, is used for usability features like filtering, and for providing different views and perspectives to users. In addition, it can be used for KPI aggregation, which we are going to use in the context of process monitoring in our future work.

Defined indicators can be assigned to GRL intentional elements, and each intentional element can have multiple indicators. For the purpose of evaluation and mapping of KPIs to GRL strategies, the following properties have been defined in our KPI metamodel:

Target Value is used to specify users' expectations about improvement. The expectations can be adjusted based on the KPI real-time value.

Any value between *Threshold Value* and target value will be treated as acceptable. The threshold value, and as the result the acceptable range, will be decided and defined by the user.

Any value between threshold and *Worst Value* is considered as an unacceptable value. This range could specify how serious the condition is. It is obvious that any number below threshold will be unacceptable, however to specify the degree of dissatisfaction as well as to align with GRL satisfaction levels we need to define such a range.

GRL model elements use an evaluation level property to measure the impact of qualitative decisions on the level of satisfaction of high-level goals [1]. Although this value could be considered in any required range, in our case it is between -100 and +100 as in jUCMNav's default conventions [26]. As shown in Figure 6, to be able to display a KPI real-time value as an intentional element's evaluation level, the defined target value is mapped to +100, the threshold value to 0, and the worst value to -100. Based on Formula 1 and Formula 2, the associated evaluation level of a KPI real-time value will be calculated. If KPI's performance value is above the threshold:

$$\frac{V_{kpi\ evaluation\ level}}{100} = \frac{|V_{kpi} - V_{threshold}|}{|V_{target} - V_{threshold}|}$$

Formula 1. Mapping KPI value to KPI evaluation level-above

If KPI's performance value is below the threshold:

$$\frac{V_{kpi\ evaluation\ level}}{100} = -\frac{|V_{kpi} - V_{threshold}|}{|V_{threshold} - V_{worst}|}$$

Formula 2. Mapping KPI value to KPI evaluation level-below

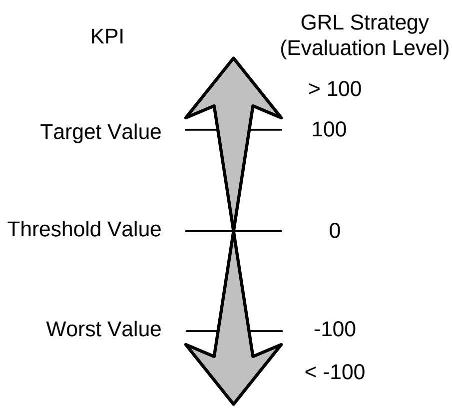


Figure 6. KPI value and GRL evaluation level

Since the jUCMNav tool currently uses a color coding scheme that is only able to show two ranges (i.e. 0 to 100 and 0 to -100) via shades colors (i.e. from green to red, via yellow), if the real-time value exceeds the defined target value or fall behind the worst value, then this will not be different visually than the target and worst values. We plan to enhance the tool to handle these two situations by adding additional colors to the current color scheme (e.g., turquoise and purple).

For the purpose of integrating the business process monitoring tool to external resources, two KPI Value/Report Data Source properties have also been defined in the KPI metamodel. *KPI Value Data Source* is used to connect our tool to external BI tools and data sources. Since many BI tools use the scorecard method to "organize, communicate, and measure performance" [30], we are going to use information and capabilities provided by BI technologies to measure KPIs and visualize their effects on GRL models.

Although GRL strategies and associated KPIs show the effect of processes on business goals, they do not provide enough information to users about the underlying information. KPIs represent aggregated results of some quantifiable data. As global results, if they are the only values considered for monitoring purposes, then they could easily become a misleading factor as opposed to a helpful one. As demonstrated in Figure 7, although the KPIs' real-time values for two distribution curves are equal, their standard deviations and variances are different. The curve with a larger variance could show us symptoms of process instability. Therefore, having a KPI within the desired value range does not necessarily mean that our process is an optimized and a healthy one. In addition to using KPIs for evaluating processes, we should assess the validity of KPIs themselves by providing users deeper insight through other reports. These reports and evaluation methods can help users during more detailed investigations. For example, histograms or scatter diagrams could contribute to the understanding of the issues.

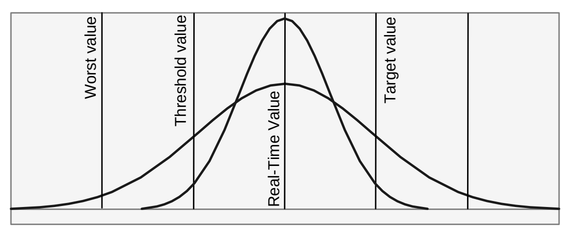


Figure 7: Distribution Curve

To allow users to investigate issues in more details, we provide the capability of fetching reports related to each KPI from external resources for the users through *KPI Report Data Source*. The architecture and implementation method will be discussed latter in this paper.

3.6 Connecting KPI and UCM models

The links between GRL elements and UCM elements can be used to specify the relationships between KPI models and business processes. As shown in Figure 8, links can be assigned between Indicators and UCMmodelElements (e.g. maps, components, and responsibilities) through URNlink. In business processes modeling with URN, UCM maps represent business processes, components represent business actors or roles, and responsibilities capture business activities [32]. Consequently, the performance of business processes and their effects on business goals can be measured and monitored.

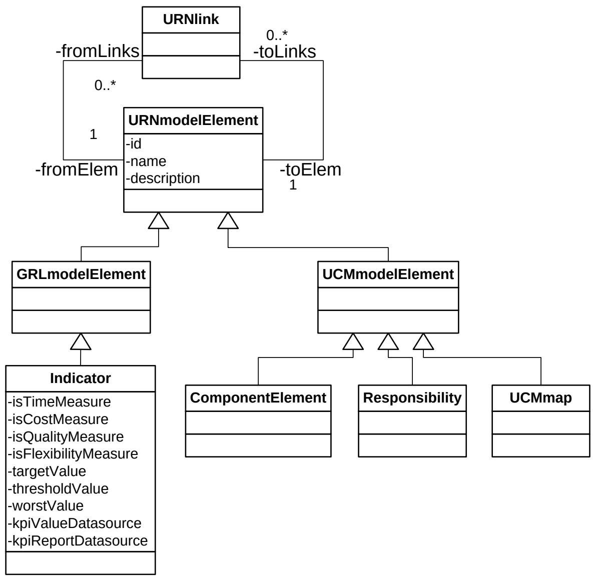


Figure 8. KPI in URN/UCM metamodel

4. A goal-oriented business process monitoring system: Tools and case study

In this section, we provide a proof-of-concept architecture that supports the methodology described in the previous version. We prototyped this architecture by combining the jUCMNav tool with a commercial BI tool and we illustrate the approach with a hospital discharge process. A replica of a real hospital data warehouse is used to provide process measures. Note however that the data reported in this paper is fictitious because of confidentiality and privacy constraints.

4.1 Conceptual architecture

As illustrated in Figure 9, the monitoring system is composed of a business process monitoring tool, various business information providers, and monitoring services. The business process monitoring tool is the core part of the system, which requests data from various information providers through the monitoring services. The business information providers could be single or multiple resources that record, store, and analyze real-time and/or history business activity information. The monitoring services, which extract, clean, organize, and format information from providers, offer a standard interface to the monitoring tool, and hence can be used as a convenient and extendable way to facilitate communication between the monitoring tool and the information providers. The services could be provided in various ways including Web Services, RMI, tool's Plug-ins, etc. according to available programming interfaces and recourses.

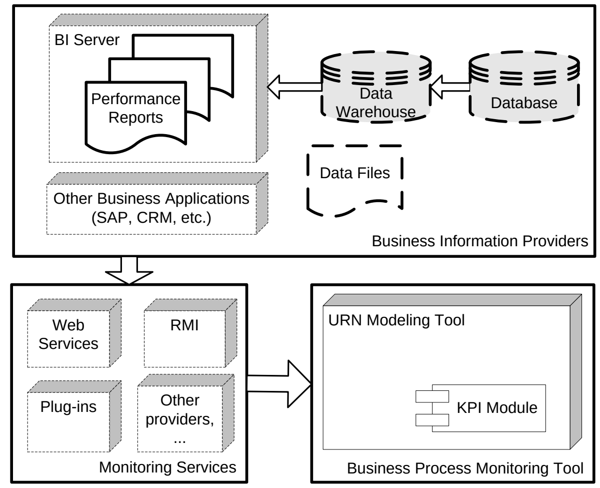


Figure 9. Conceptual architecture

4.2 Implementation

Based on our methodology and conceptual architecture, a modeling tool is extended to support KPI and then combined with Cognos 8 BI [6], which acts as the information provider, and JBoss Web Services [15], which acts as the monitoring service, to implement the proposed architecture.

The business process monitoring tool is based on the jUCMNav URN modeling tool. Being open source, jUCMNav allowed us to integrate the required features into it. To support the functionalities discussed in sections 3.4, 3.5, and 3.6, a KPI module has been developed and added to the tool.

Cognos 8 BI is an enterprise business intelligence solution with integrated reporting, analysis, scorecarding, and event management capabilities [6]. This web-based environment contains several components including Metric Studio, which helps users manage the performance of the organization by monitoring and analyzing metrics at all levels. Another component, Report Studio, supports sophisticated multi-page/query reports against multiple data sources. Cognos Framework Manager is used to build BI models based on backend data warehouses while Metric Studio is used to generate metric values for evaluating KPIs. Also, Report Studio can be used to generate more detailed reports that provide deeper insight around KPIs.

JBoss Web Services (JBossWS) is an open source implementation of J2EE compatible web services running on the JBoss application server. Monitoring web services are deployed on the JBossWS platform to offer a standard interface to the monitoring tool. It communicates with the BI server on one side and with the monitoring tool on the other side.

For performance consideration, a data buffer can be used to store pre-generated KPI data. This buffer will be refreshed periodically. Figure 10 depicts one typical usage of this process.

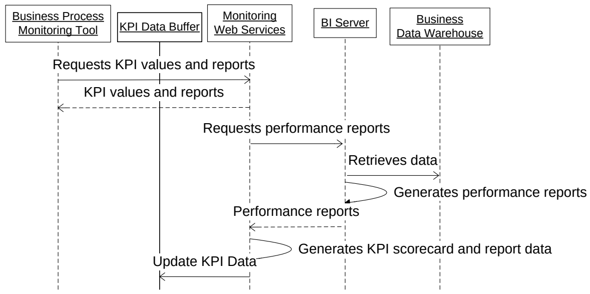


Figure 10. Real-time BP KPI extraction

4.3 Healthcare case study: discharge process

Continuous traceability and monitoring of all healthcare activities is deemed mandatory by Staccini *et al.* [28] in order to reduce variations in practices, and to detect, measure, and prevent adverse events occurring during healthcare delivery. In the healthcare sector, the *discharge process* is a key process that starts with the very first point of patient entry at the hospital and ends with patient discharge. Such a process can indeed be linked to many delay issues as well as damaging adverse events [10].

We modeled the existing discharge process of a Canadian hospital in a hierarchical manner with Use Case Maps. Figure 11 shows the top-level view of the process. Recall that UCM stubs (diamonds) are containers for sub-maps (our hierarchical model contains a total of 36 such maps). As indicated, after a patient enters the hospital through one of the usual channels (e.g., Admin Department or Emergency Department) she gets accepted into the appropriate unit. Since we had access to the organization's General Medicine (GM) unit, we focused on the discharge process of this unit. However, this process is not limited to GM.

Figure 12 elaborates the General Medicine process in more details. The first step is patient administration, which is done for each patient visit by GM physicians. In the second step the care plan for each patient is established, followed by the implementation of the plan. The result of patient care is evaluated, which may cause care plan re-establishment if required. The actual patient discharge is the last step. A patient might go to other external entities for extensive care or, because of resource limitations, she might stay in a waiting place to get admitted by external entities. Meanwhile, exceptions like patients death might happen, causing changes to the process flow.

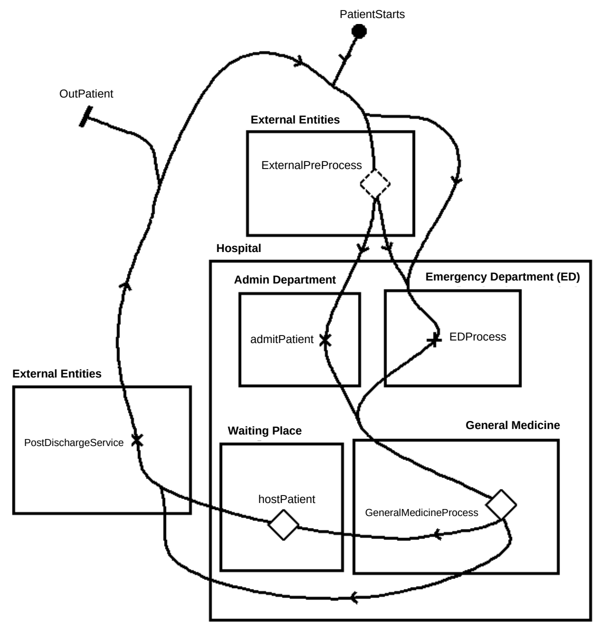


Figure 11. Discharge process

Investigating care plan implementation in more detail, Figure 13 shows that after performing some processes based on different group of patients, which include some tests (e.g. lab tests, radiology test, etc.) and other care processes (e.g. consultation, medicating, etc.), the patient condition is evaluated. This evaluation helps physicians to decide about patient discharge. In this step the patient either will be discharged or the care plan will be re-established based on her condition.

Based on the patient's needs, there might be different discharge sub-processes. We have hence used a *dynamic stub* (which contains multiple sub-maps) in Figure 12 to elaborate these discharge sub-processes. One of these sub-maps (Figure 14) describes the condition by which the patient will be discharged to an external entity based on her needs. In this case, if the patient, in the first place, has come from the same external entity, then there would be no waiting and admission process involved, otherwise the patient should wait until she gets the admission and required facilities to be transferred. In the final step, and before completing the patient transfer, additional sub-processes should be performed, as depicted by the "patientDischarge" stub. The complete list of sub-maps for this stub is given in Table 1. In this paper, we only elaborate the *dictate process* (Figure 15) in more details and use our method to monitor this sub-process with the help of a BI tool to get KPI measures.

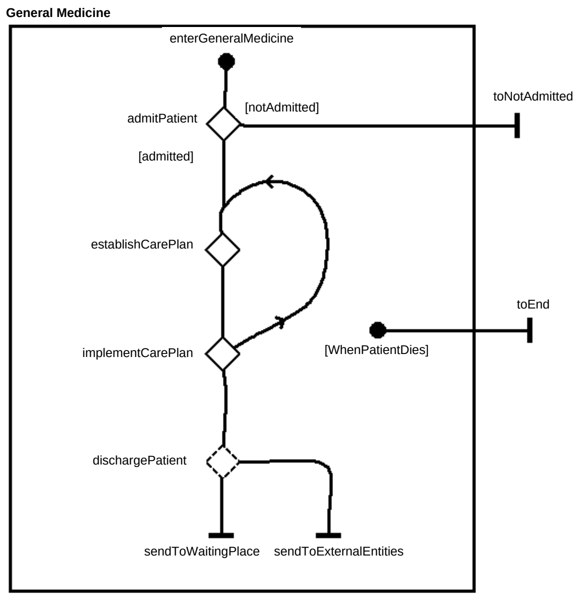


Figure 12. General Medicine process

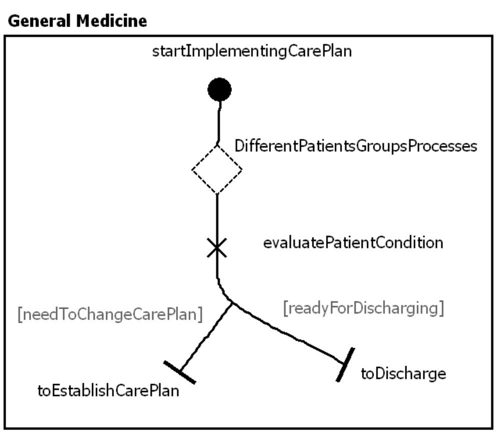


Figure 13. Care plan implementation

As depicted in Figure 15, this sub-process mainly covers dictate discharge summary, transcription, and transmission in the GM boundary. The main issue in this process is *time lag* between these tasks. Although these tasks can be done sequentially very quickly, due to some physicians' time constraints or deviations from the process, in reality there is a huge delay between them. In some cases, some parts are even done weeks or months after the patient's discharge [10]. This can introduce serious risks and problems for the patients and can reduce the quality of care and affect other goals of the discharge process, which we discuss in the context of Figure 16 and Figure 17.

In the GRL model of Figure 16, the top level goals identified for the discharge process are to reduce the rate of readmission and the length of stay and to improve patient safety. These goals are all affected by adverse events that either occur during patient hospitalization or post-discharge.

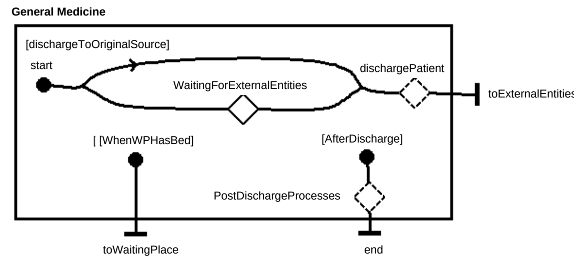


Figure 14. Discharge to other places

Table 1. List of patient discharge processes

Patient Discharge Processes
EducatePatient
BookFollowUpVisits
WriteDischargePrescription
WriteDischargeLetter
CallCareProvider
BookFollowUpTests
EnterPatientInoFollowUpPhoneSystem
ActivateHomeCare
FinalAccessment
EnlistFamilySupport
DictateProcess

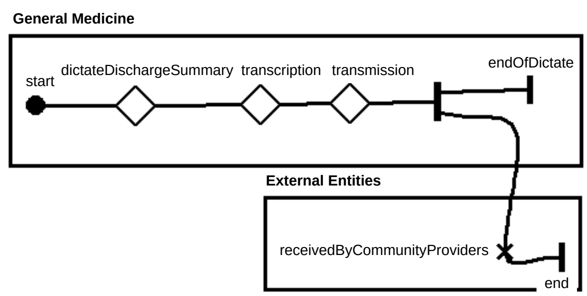
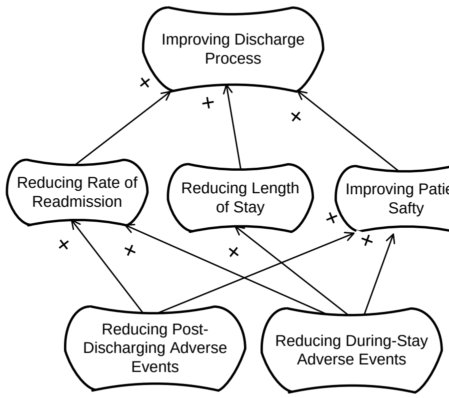


Figure 15. Dictate process

Figure 17 details additional goals down to the task level. These tasks can be found in the process UCM as well. In other words, we have decomposed the high-level goals to the point where the low level tasks can be linked to UCM maps or responsibilities. We are now in a position to evaluate the contributions of the tasks to the high-level goals.

Figure 18 focuses on a portion of the model in Figure 17. The "Sharing Treatment Plan" task contributes to "Adequate Communication" which in turn helps reducing post-discharge adverse events. This task is composed of two sub-tasks "Dictate Discharge Summary" and "Transcription". We can now use our KPI model concept to calculate the evaluation level of these tasks.



+: some positive contribution

Figure 16. Discharge process top level goals

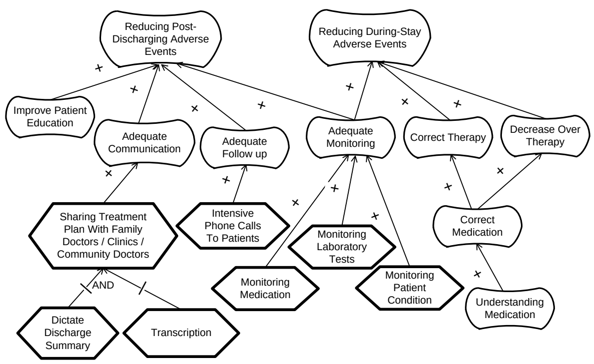


Figure 17. Discharge process detailed goals/tasks

Figure 19 shows the KPI model defined for "Dictate Discharge Summary" from the hospital perspective. For this task, the goal for service time is evaluated by "Average time lag between discharge and dictation" KPI while another goal for service quality is evaluated by "Percentage of preventable and ameliorable adverse events due to ineffective dictation" KPI. Finally, the values of KPIs are propagated to higher levels in the business goal model to evaluate "Adequate Communication".

Figure 20 shows the KPI's target value, threshold value, and worst case value. In addition, this model demonstrates how the system specifies the evaluation level of KPI using information provided by the BI tool. For example, the current average time lag between the time when patients are discharged and the time when discharge summary is written is 21 days, which is between the threshold value 14 days and the worst value 60 days. After drawing mapping functions based on Formula 1 and Formula 2, the KPI gets an evaluation value of -15, which means the objective is not met and process alignment may be required. Calculating such KPIs and feeding them to the GRL model allows us to make global assessment about how well high-level goals are met.

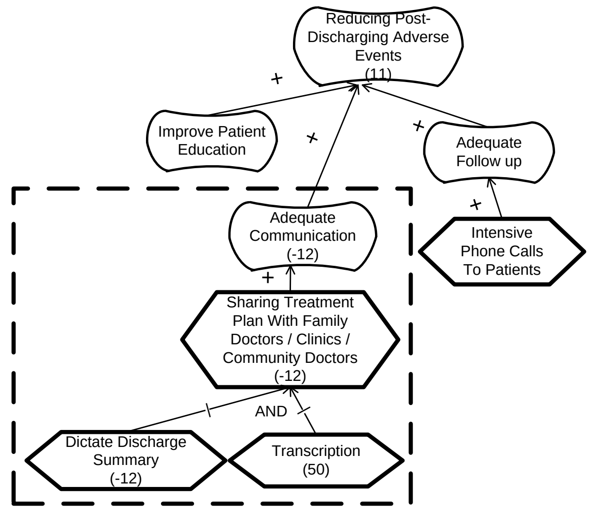


Figure 18. The task "dictate discharge summary" in the discharge GRL diagram

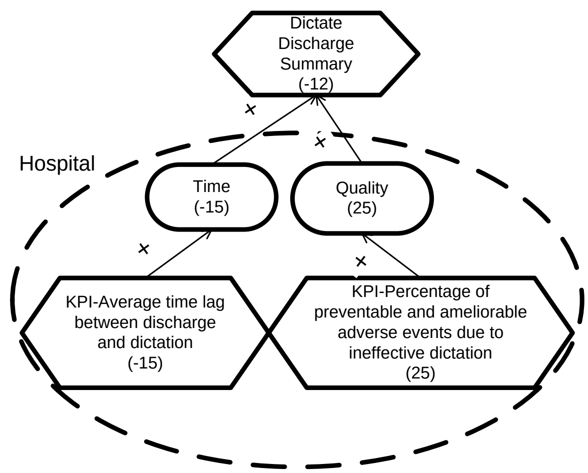


Figure 19. The KPI model defined for the task "dictate discharge summary"

Using our prototype integration, the various reports can also be accessed and visualized in the context of the business process UCM model via Cognos's web portal, as illustrated in Figure 21.

5. Conclusion and Future Work

We proposed a method to evaluate and monitor the business process against performance requirements and show the effects of ongoing processes on business goals, in a real-time manner. In this method, we want to not only improve our processes but also look for opportunities to raise the target values of our business goals at each improvement iteration.

By introducing a KPI model, we have separated our business goals from the objectives for each task, process, or sub-process, and this helps us to distinguish them from each other. Using a BI tool, we gathered required information from a data warehouse to calculate KPIs and mapped them to evaluation levels of GRL model elements, hence providing reliable and non-arbitrary initial values for GRL strategies. Low-level intentional elements of this GRL model are linked to process activities in the UCM model. The GRL propagation and evaluation capabilities of jUCMNav are used to show the effect of low-level tasks and responsibilities, part of the operational level, on the high-level goals of the organization.

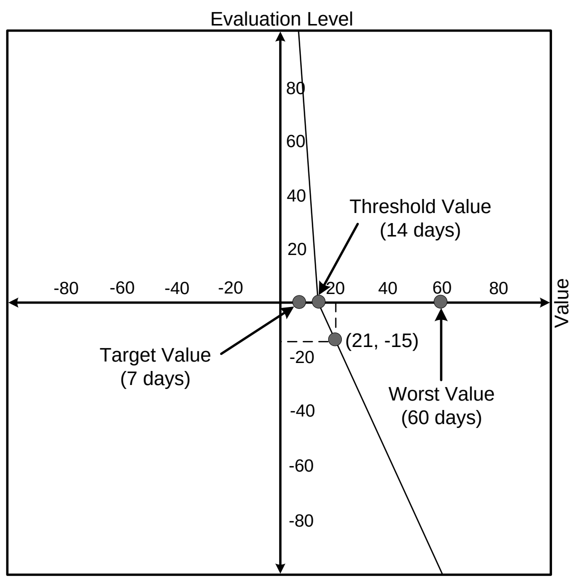


Figure 20. Mapping KPI to evaluation level – Time lag between discharge and dictation

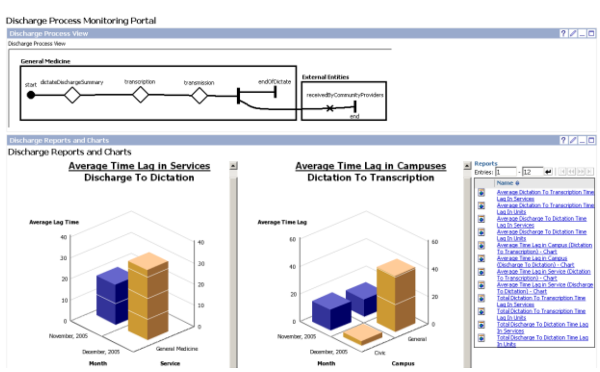


Figure 21. Access to process reports with the BI tool

To be able to test the methodology in a real-life setting, we added KPI functionalities to jUCMNav and integrated this tool with a commercial BI tool through a standard web services interface. The BI tool was also connected to a sample data warehouse of a real healthcare organization used in our case study.

Table 2. Process-redesign patterns

Redesign Patterns	Time	Cost	Quality	Flexibility
Task Patterns				
Task Elimination	↑	↑	⇣	N/A
Task Composition	↑	N/A	⇡	⇣
Task Automation	↑	↑	↑	↓
Routing Patterns				
Resequencing	↑	↑	N/A	N/A
Knockout	⇣	↑	N/A	⇣
Control Relocation	N/A	N/A	↑	N/A
Parallelism	↑	⇣	⇣	⇣
Triage	↑	↑	↑	↓
Allocation Patterns				
Case Manager	N/A	⇣	↑	N/A
Case Assignment	↑	N/A	↑	↓
Customer Teams	↑	N/A	↑	↓
Flexible Assignment	↑	N/A	⇡	N/A
Resource Centralization	⇡	↓	N/A	↑
Split Responsibilities	⇣	N/A	↑	N/A
Resource Patterns				
Numerical Involvement	↑	⇡	⇣	N/A
Extra Resource	↑	↓	N/A	⇡
Specialist-Generalist	↑	⇣	↑	↓
Generalist-Specialist	N/A	⇡	N/A	↑
Empower	⇡	⇡	⇣	N/A
External Party Patterns				
Integration	↑	↑	N/A	⇣
Outsourcing	N/A	↑	⇣	N/A
Interfacing	⇡	⇡	⇡	⇣
Contact Reduction	⇡	⇣	⇡	N/A
Buffering	↑	⇣	N/A	N/A
Trusted Party	↑	↑	N/A	N/A
Integral Business Process Patterns				
Case Types	⇡	⇡	⇣	⇣
Technology	⇡	⇡	⇡	⇡
Exception	↑	⇣	N/A	⇣
Case-based Work	↑	⇡	N/A	N/A

↑ : Positive Impact ↓: Negative Impact
⇡: May positive ⇣: May negative Impact

In the near future, we want to extend this method to prevent undesired events, improve processes, and even make better real-time decisions for each process instances. We will in particular investigate how best to apply business process *redesign* patterns. Current practices rely on humans for finding the applicability of patterns in a requirements engineering context [3]; however we would like to automate this as much as possible. Table 2 is based on Reijers' defined patterns and the discussion about their effects on the dimensions of the devil's quadrangle [25]. These redesign patterns are grouped into six categories that affect processes from various perspectives.

We will use the monitoring tool to make better informed decisions. In addition, the tool could be used to select and adapt processes dynamically during execution time and for each instance of the process, something known as *real-time event processing* [23]. Such approach would require integrating our monitoring system with a business process execution engine.

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