

# Compliance Analysis Based on a Goal-oriented Requirement Language Evaluation Methodology

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## Abstract

*In recent years, many governmental regulations have been introduced to protect the privacy of personal information. As a result, organizations must take a systematic approach to ensure that their business processes comply with these regulations. In the past, we introduced a requirements framework that mapped regulations documents and goals to goal and scenario models of organizational processes. The intent was to help organizations document and manage the compliance of their processes in the face of evolutionary changes. In this paper, we extend our framework by incorporating regulation scenario models and by adding the notion of contribution link level to the compliance link types. These extensions result in a framework that is more aligned to the needs of an organization when it must evaluate and ensure the legal compliance of its organizational processes.*

## 1. Introduction

Governments have introduced many new regulations in order to protect the privacy of personal information. As a result, organizations have to update their policies and business processes in order to align them with these regulations. The new regulations are complex, and unfortunately are still fairly volatile in terms of amendments and updates. In order to manage the complexity and continuous evolution of both regulations and organizational business processes, a systematic methodology with tool support would be beneficial in order to ensure compliance on an ongoing basis. Furthermore, organizations would like to be able to track overall compliance of the organization with regulations as well as line item by line item compliance for individual business processes. Being able to measure the degree of compliance, quantitatively or qualitatively, would also be useful in order to measure progress towards complete compliance and to evaluate risk.

Approaches based on requirements engineering methodologies have been used to model law and document compliance [1][2][3][4]. Such work has concentrated on complete compliance in which the links document a compliance relationship. None of these approaches have provided support for a quantitative or qualitative analysis of the degree of compliance to the law. We introduced a compliance framework in which both the organization and the relevant laws are modeled and compliance links are drawn to show the relationship between the law and the organization.

In this paper, we extend our previous compliance framework [3][4] to show how such support can be added to the framework based on the User Requirements Notation (URN) standard [5]. We do this by extending the link type between two models in our framework to support either a quantitative measure of the “degree of impact” or a qualitative measure of this degree of impact (i.e. *make, help, some positive, none, some negative, hurt and break*). The concept of degree of impact is identical to that supported for the contribution link type used in the Goal-oriented Requirements Language notation (GRL), a sub-language of URN [5]. The use of these types of links makes it possible to find out to what degree the organization satisfies the law, that is, to differentiate between satisfied and partially satisfied goals or requirements in the law. With this new addition, it becomes possible to customize a model of the law that applies to an organization by specifying a set of rules to which a company must comply. Our framework therefore supports three different types of goal model analysis, namely quantitative, qualitative and hybrid.

In addition to partial compliance, we also extend our framework to support Use Case Maps (UCM), another sub-language of URN, for the modeling of legislation. This enables the modeling of an explicit sequence of activities, in the cases where the legislation specifies procedural constraints. URN is one of the few languages for requirements modeling which

supports Use Case Maps, but we had not taken advantage of it for our legislation model in our previous framework.

This paper is structured as follows: Section 2 discusses work related to legal modeling and analysis and their effect on business processes. In Section 3, we explain the requirements management framework including its new extensions and meta-model. Then, in Section 4, we demonstrate the framework using three case studies from a research hospital in Ontario, Canada. Section 5 compares our extended framework with other approaches. Finally, in Section 6, we present our conclusions and future work.

## 2. Related Work

Much research has been done recently to improve the comprehensibility of legislative texts and to integrate them with software requirements and organizational policies. Breaux *et al.* in [6][7] introduced a systematic method and tool support for extracting rights and obligations from legal documents. In addition, they introduced a requirements management framework [8] which combines delegation and refinements in a distributed system to help managers and system administrators achieve compliance. They use the UML notation for their framework.

LRI-Core [9] is used to organize legal concepts by describing a legal layered ontology. LRI-Core is mainly based on the idea that a law is driven by common-sense concepts. It combines notions of agents, actions and organizations with legal concepts.

Legal modeling has been addressed in several approaches with the help of requirements engineering concepts. These methodologies are based on the similarities between regulations and requirements. In [1], Rifaut and Dubois use goal models to capture compliance requirements. More specifically, they use the case of an ISO/IEC 15504 standard to provide a framework as an *i\** goal model in order to analyze business process compliance against imposed regulations. Darimont *et al.* apply KAOS to model objectives extracted from legal texts [10]. The normative *i\** framework [2] provides an intentional framework for modeling laws that integrates legal requirements with system requirements.

Recently, we also implemented a requirements management framework [3] to help organizations document their compliance and more particularly to manage the evolution of laws and business processes [4]. In our framework, we use the same modeling notation, namely URN, to model both laws and organizations. We introduce a set of compliance links between this

pair of models in order to manage the traceability between the two.

## 3. Requirements Management Framework

Our updated requirements management framework is shown in Figure 1, with our extensions shown with dotted lines and dotted boxes. Compliance is tracked with links between artifacts at three levels:

1. Official source documents that define the legislation on the one hand and organizational structure, policies and processes on the other.
2. Goal models, using the Goal-oriented Requirements Language (GRL) supported by the URN standard, that capture the objectives and requirements of both the organization and the legislation.
3. Business process models, using the Use Case Maps (UCM) supported by the URN standard, that define the business processes that implement organizational policy as well as representing the steps mandated by legislation.

Although we could have used other goal modeling notations, GRL has the benefit of being linkable to the UCM scenario notation, suitable to represent business and legal processes. In addition, GRL is scalable since it is possible to have multiple diagrams/views of a same model with different levels of granularity. GRL, UCM and their relationships are additionally well defined as part of the URN standard [5]. The metamodel of this framework has been explained in [3] and [4].

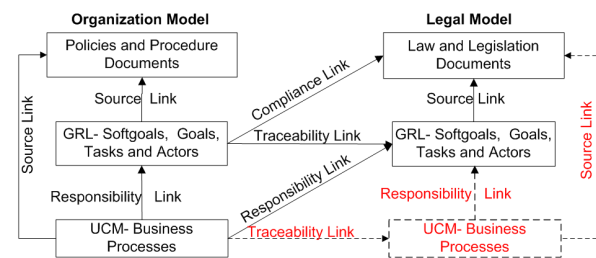


Figure 1 – Framework overview and extension

Four types of links are used to document compliance:

1. Compliance links map directly from goal models to the source legislation.
2. Source links map the goal and business process models of the legislation and of organizations back to their source documents.
3. Traceability links map the correspondence between organizational models and legislation

models (either at the goal model level or the business process model level).

4. Responsibility links document which business processes implement or are responsible for what parts of the goal model.

In our original framework, the links between the two models were static and without any degree of impact. In this new extension, we integrate both quantitative and qualitative values for traceability, compliance, responsibility and source links and extend the GRL qualitative and quantitative analysis algorithms to provide a method to indentify the satisfaction or denial level of goals and softgoals in the legal model. This concept of contribution types already exists for contribution links in the GRL. Quantitative values for contribution type range from -100 to 100 while qualitative values are *make, help, some positive, none, some negative, hurt* and *break*.

The quantitative and qualitative analysis algorithms we used have been influenced by previous work on the propagation of goal satisfaction values. In [11][12] for example, the authors proposed qualitative and quantitative algorithms for analyzing a single goal model. Unlike most algorithms, GRL's propagation algorithms compute goal satisfaction across multiple diagrams, can combine qualitative and quantitative contributions and satisfactions, allow cycles in models, consider actor dependencies in propagation, and also compute overall actor satisfaction [5].

In this GRL analysis, values defining initial degrees of satisfaction are first assigned to a set of lowest-level intentional elements (which are mainly tasks) in the model as part of a *strategy*. Satisfaction values are propagated towards higher-level intentional elements (i.e. tasks, goals or softgoals) through links connecting them. Decomposition links are first evaluated (e.g., maximum for OR, minimum for AND), followed by contribution links (weighted sum of input contributions), and then dependency links (a constraint that ensures the satisfaction value of an intentional element is not higher than the value of an intentional element it depends on). A single satisfaction value is hence computed for each intentional element in the model. The satisfaction of an actor is computed from the satisfaction and importance of the intentional elements it contains. The algorithm details are provided in [13].

Depending on the goals and interests of the analyst, the compliance analysis can be quantitative, qualitative or hybrid. The qualitative degrees of satisfaction are *denied, weakly denied, weakly satisfied, satisfied, conflict, unknown, none* and the quantitative degrees of satisfaction range from -100 to 100. A qualitative analysis is used when the contribution types and de-

grees of satisfaction are both qualitative whereas a quantitative analysis is when both are quantitative. The hybrid analysis exploits the combination of both qualitative and quantitative values.

In the extended GRL analysis algorithm which is used in our framework, values for all contribution and compliance links are defined and a set of low-level intentional elements with relevant degrees of satisfaction from the GRL model of the organization (a GRL strategy) are selected. Then, the degrees of satisfaction are propagated to the intentional elements in the GRL model of the law.

## 4. Case Study

In this section, we define three examples from a case study to illustrate and demonstrate the benefits of this new framework extension. In all of the following case studies, we use Ontario's Personal Health Information Protection Act (PHIPA) [14] as the basis for the legal model and a research hospital's privacy policy document as the basis for the organizational model.

We use relevant portions of PHIPA's part IV (*Collection, Use and Disclosure of Personal Health Information*) as a basis for the GRL legal model, shown in Figure 2. In the act, it says that the Personal Health Information (PHI) custodian can disclose the PHI (shown with the *goal Use or Disclose PHI*) only if the disclosure of data is required or permitted by law, or it is needed for payment or funding or to contact relatives. Collecting PHI (shown with the *goal Collect PHI*) can only be done if the data is for carrying out research, providing healthcare, or investigating a breach. Individual consent (shown with the *task Get Individual Consent*) is also usually needed. If the disclosure targets researchers, (shown with the *goal Disclose to Researcher*) these researchers need to submit some documents to the PHI Custodian (shown with the *task Submit to Custodian*) and they need to get to an agreement (shown with the *task Get to an Agreement*). The various types of documents (i.e. a research plan, an application and a copy of the Research Ethic Board (REB) decision) are linked as sub *tasks* to the *task Submit to Custodian* through *AND* decomposition links.

The partial GRL model of the hospital's organization focusing on the access to information for research purposes is shown in Figure 3. In this model, we have separated the goals of collection for the hospital from the use and disclosure so that it is easier to understand the model. That is why there are two separate containment circles (actor references) in Figure 3, both labeled "Hospital". There is only one hospital actor,

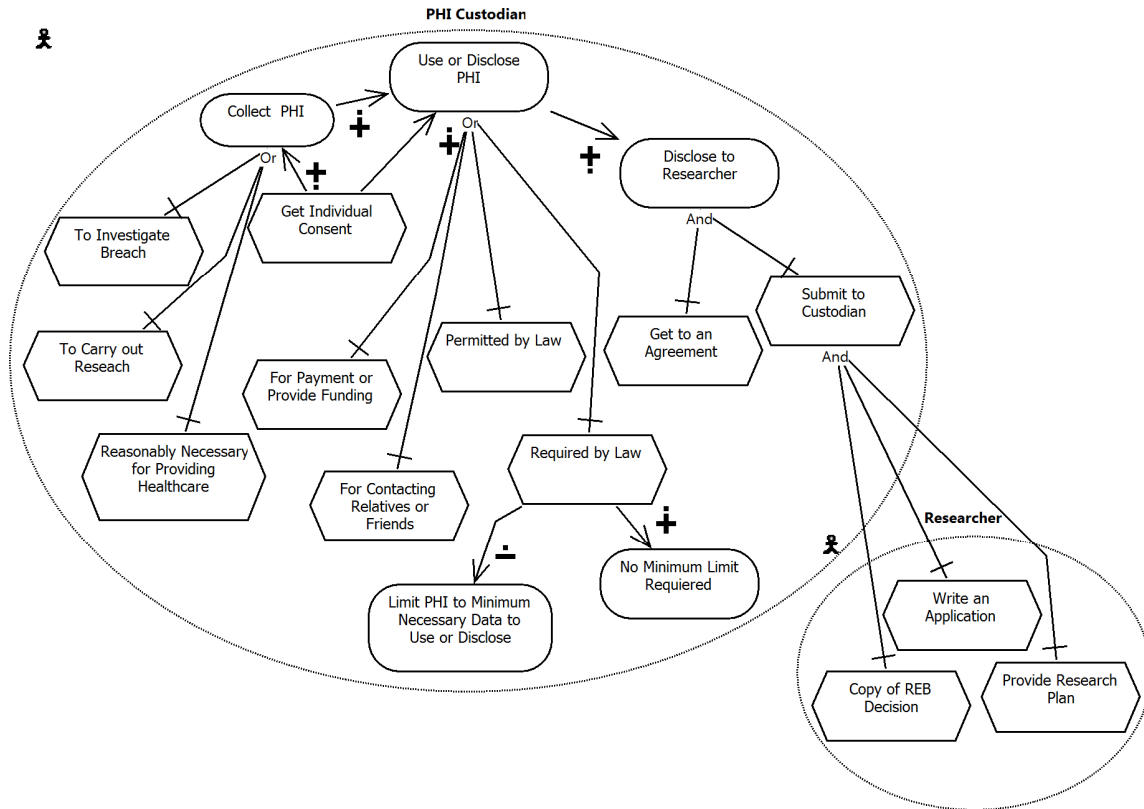


Figure 2 – PHIPA legal model - GRL view

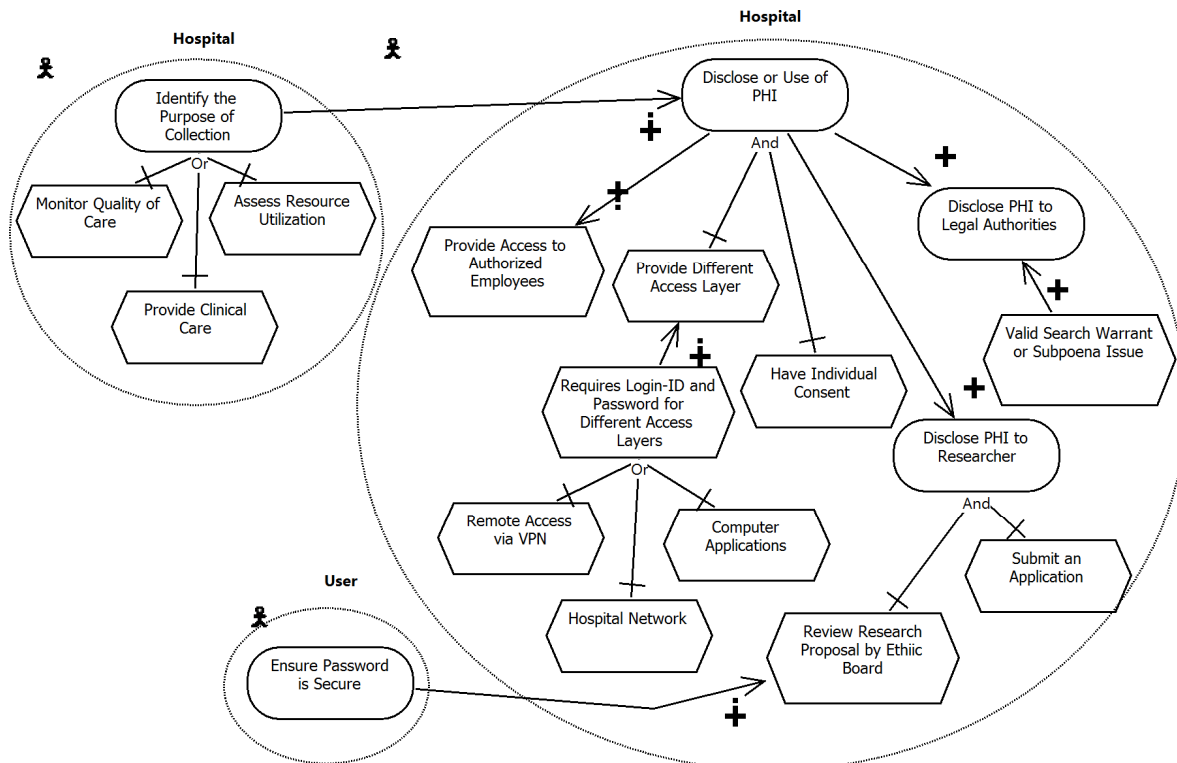


Figure 3 – Hospital organization model – GRL view

which owns the two sets of goals. GRL permits multiple references to the same actor definition in the same diagram or in different diagrams of a model, for scalability, reuse, and readability. In the hospital, to disclose PHI (shown as the *goal* Disclose or Use of PHI in Figure 3), individual consent is required and the hospital can disclose the PHI for the same reasons as it was collected (shown as the goal Identify the Purpose of Collection with the *tasks* Monitor Quality of Care, Assess Resource Utilization or Provide Clinical Care).

### Case 1 – Qualitative Analysis of Goal Models

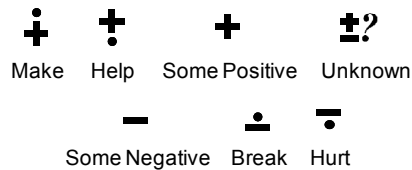
In our first example, the Hospital organizational model is analyzed against the PHIPA legal model in a *qualitative* way. With a simple scenario, we check whether the organization model satisfies the legal model by analyzing the satisfaction level of each goal as well as of each actor. In this scenario, we test the situation where a researcher needs Personal Health Information (PHI). As shown in Figure 3, in order to give PHI to researchers (i.e. Disclose PHI to Researcher), the hospital needs to make sure that disclosure in general is allowed (i.e. Disclose or Use PHI which requires both Have Individual Consent and Provide Different Access Layer). As the model shows, to provide a different access layer, at least one of the three options

The hospital also provides different access layers for disclosing PHI (shown at the *task* Provide Different Access Layer). In addition, if the hospital is disclosing the PHI for research (shown as the *goal* Disclose PHI to Researcher), then an application has been submitted by the Researcher (shown as the *task* Submit an Application) and there has to be a review of the research proposal by the Ethics Board (shown as the *task* Review Research Proposal by Ethic Board).

of Remote Access via VPN, Hospital Network or Computer Application has to be performed. Then the hospital also needs to ask the Research Ethics Board (REB) to review the proposal.

Note that the Hospital actor from the hospital model in Figure 3 corresponds to the PHI Custodian actor in the legal model in Figure 2, and the User actor from the hospital model in Figure 3 corresponds to the Researcher actor from the legal model in Figure 2.

GRL's seven levels of satisfaction are described by the symbols shown in Figure 4. The analysis process starts with giving a satisfaction value to a subset of the intentional elements as well as an importance value to intentional elements of an actor. The qualitative importance value can be *High, Medium, Low* and *None*.



(a) GRL Contributions Types



(b) GRL Satisfaction Levels

**Figure 4 – GRL notation for qualitative analysis**

In this case, based on the hospital requirements to disclose PHI for research, we can select five tasks from Hospital actor (Have Individual Consent, Remote Access via VPN, Submit an Application, Review Research Proposal by Ethics Board and Provide Clinical Care) as the initially satisfied elements. In the organization GRL model, through contribution and decomposition links, these initial values propagate to the other intentional elements of the model and as a result, the goal Disclosure PHI to Researcher and the actor Hospital are satisfied. Since there are traceability links between two models with the same impact level of contribution links, the satisfaction values from the organization model *also* propagate to the legal model. The goal Disclose to Researcher in the legal model has a

goal Use or Disclose of PHI (in general) and two tasks Submit to Custodian and Get to an Agreement. Submit to Custodian is also decomposed into three low level tasks. Figure 5 shows the result of this analysis, which was automated using jUCMNav, an Eclipse-based tool for modeling and analysis with URN that also integrates with a requirements management system to handle traceability to source documents [15].

As shown in Figure 5, only two of the tasks in the legal model (Copy of REB Decision and Write an Application) have links from tasks in the hospital model (Review Research Proposal by Ethic Board and Submit an Application). The task Provide a Research Plan does not have any link from the hospital model, and therefore its value does not change from the initial *none*.

Consequently, the value propagated to the task Submit to Custodian will also remain *none* (by definition of the *AND* decomposition links). In addition, the task Get to an Agreement does not have any link from the hospital model. Since the only non-null contribution is a satisfied Help contribution (positive but insufficient) from Use or Disclose PHI, the value of the goal Dis-

close to Researcher changes to *weakly satisfied*. This means that this goal cannot be satisfied by the current hospital model.

However, the PHI Custodian actor gets a *satisfied* value because the goal Use or Disclose PHI has a *high* importance value with a satisfaction value computed as fully satisfied.

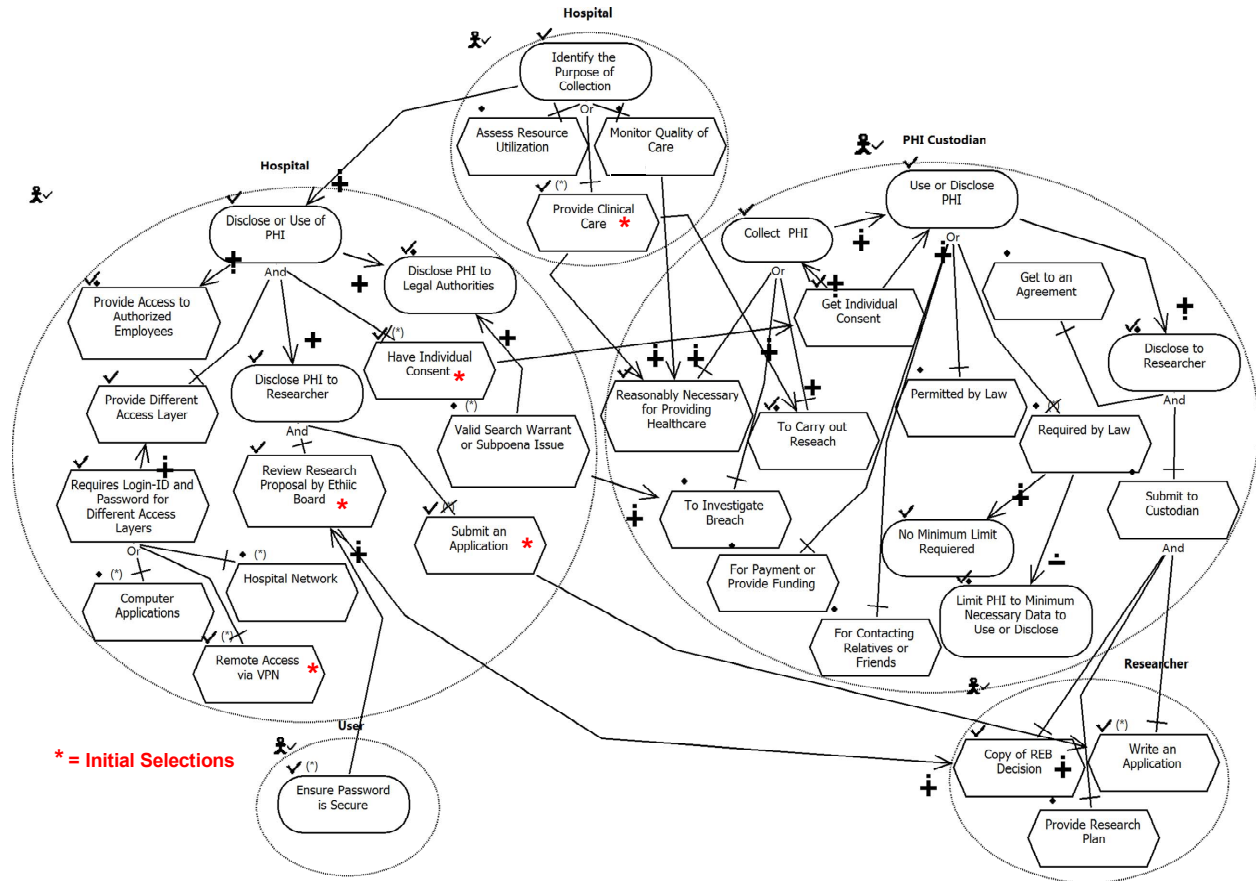


Figure 5 – Qualitative analysis

### Case 2 – Quantitative Analysis of Goal Models

In this example, we use the same scenario and analyze the satisfaction degree of goals in the legal model *quantitatively*. In this case, we also analyze the satisfaction degree of the goal Disclose to Researcher in the legal model when all of the possible tasks in the hospital model are chosen and the hospital goals are almost satisfied. As was done in the first example, after assigning satisfaction values to the lower-level tasks in the hospital model and quantitative importance values to the elements in both goal models, the degrees of satisfaction are propagated to top goals and tasks of the hospital model through contribution and decomposi-

tion links. Then, through traceability of contribution and decomposition links, these values are propagated to the legal GRL model. As shown in Figure 6, there are some tasks related to Disclose to Researcher in the legal model which still have a value of zero. These tasks do not have any links from the hospital model. As a result Disclose to Researcher is weakly satisfied with a value of 25 while Use or Disclose PHI is fully satisfied with a value of 100. In terms of actor satisfaction, the Hospital's and User's satisfactions are at 100 each but the Researcher's satisfaction is 67 while the PHI Custodian's satisfaction is 78. The reason for this partial satisfaction is the tasks which are missing in the hospital model.

Note again that the Hospital and User actors from the hospital model corresponds to the PHI Custodian and Researcher actors in the model of the law.

By supporting this kind of analysis, we can easily discuss the degree of compliance of organizations to laws. In this case study, we can conclude that the hospital model is partially in compliance with the model.

However, some of its main goals are fully achieved and some are partially achieved. For example, the hospital is in compliance when it needs PHI for providing clinical care (Provide Clinical Care) but it is not in compliance regarding the disclosure of data to researchers (Disclose PHI to Researcher).

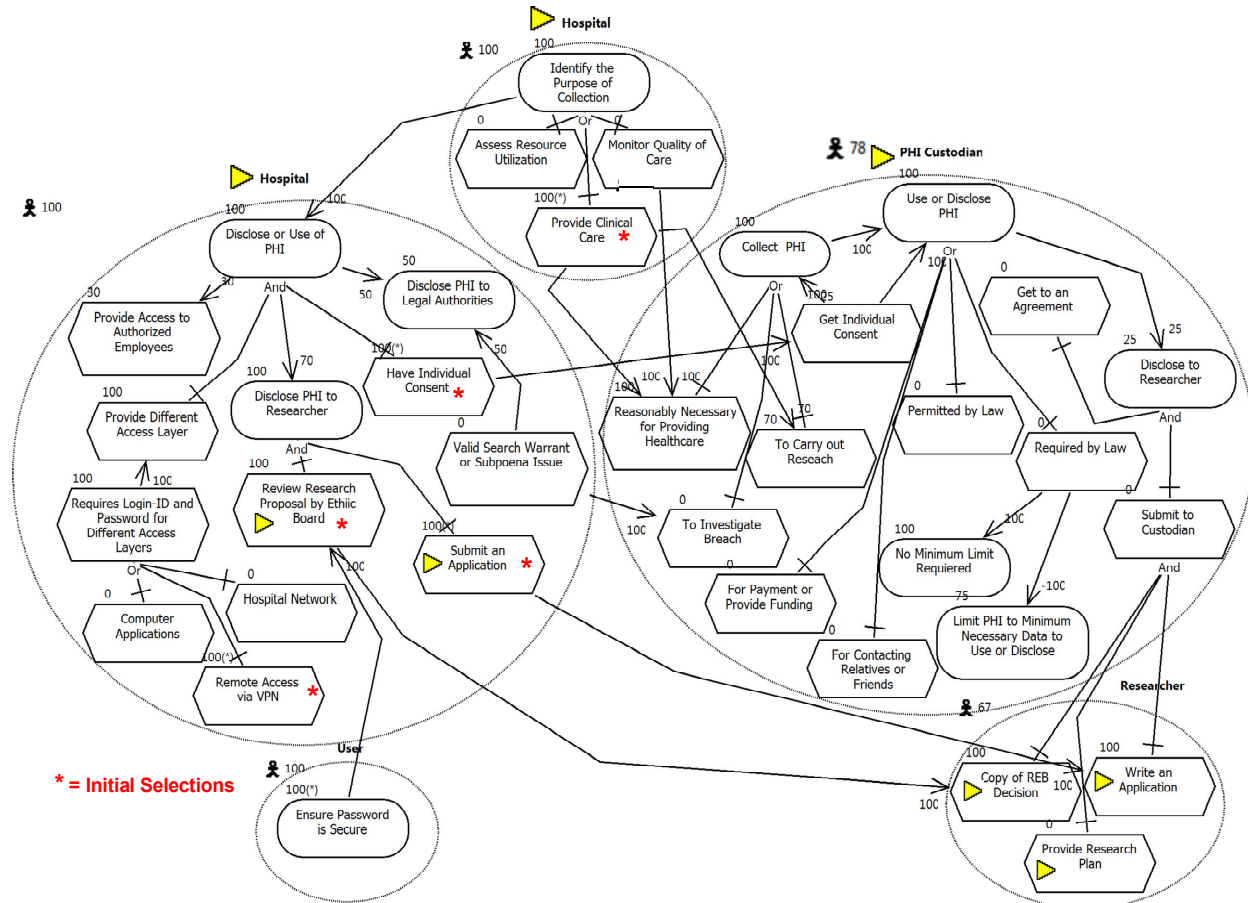


Figure 6 – Quantitative analysis

### Case 3 – Effect of the GRL Model on the Business Process of the Law and Organization

In our framework, we mentioned that it is necessary to have business processes (Use Case Maps) in the legal model as well as the hospital model with traceability links to goals and tasks (GRL) as indicated by the small triangles (▶) in Figure 6 and Figure 7. Having such business processes in the legal model helps us to better analyze the hospital business processes and find potential improvements. It also helps us model the parts of the law that impose processes or parts thereof. In this case study, we analyze business process com-

pliance against the legal model based on the result of the quantitative analysis of GRL models shown in Case 2. According to the HIPAA legislation, in order to disclose PHI to a researcher, the researcher needs to submit a request (RequestForPHI) that includes an application form, the REB review report, and a research plan to the PHI custodian. Then, the PHI custodian has to review these three documents (ReviewApplication) and, the PHI custodian has to decide to either give permission to the researcher or reject his application. If the PHI custodian allows access to the PHI, the PHI custodian and the researcher need to reach an agreement. The high-level process explained above is shown in Figure 7. On the other hand, in the hospital

business process Access to the Hospital's Data Warehouse by a Researcher, the researcher (who is called User) submits an application and a REB result to the Hospital and the hospital reviews the document (see Figure 8). RequestForPHI and ReviewApplication, represented as *diamonds* in both Figure 7 and 8, contain two sub-processes that are defined in other Use Case Maps. Figure 9 and Figure 10 show the UCMs for the sub-processes RequestForPHI and ReviewApplication as defined in the PHIPA legislation. By linking different elements of a Use Case Map to their corresponding elements in GRL, the satisfaction levels of the elements in GRL are determined by the satisfaction levels of the linked elements from the Use Case Maps. These numbers help us to identify responsibilities, sub-processes and components in the business process which do not have a satisfaction level of 100 and need improvement.

In Figure 7, PHI Custodian and a Researcher have yellow triangles beside them, which indicate the presence of links from these components to their corresponding GRL elements (i.e. actors PHI Custodian and Researcher) in the legal model. The numbers next to Researcher and PHI Custodian indicate the level of satisfaction of each of these components. In this example, Researcher and PHI Custodian have satisfaction levels of 67 and 78 respectively, which can be a sign of non-compliance. In addition, two responsibilities in Figure 7, GetToAnAgreement and SignAnAgreement, which are linked to the task Get to an Agreement in Figure 6, have a satisfaction value of 0, which means there is no such responsibility or task in the hospital model (see Figure 8). The UCM diagram of the legal model shows the high-level process for disclosing PHI. Therefore, to find which activities and sub-processes are not in compliance with PHIPA, we need to look at the sup-processes and the activities in other maps.

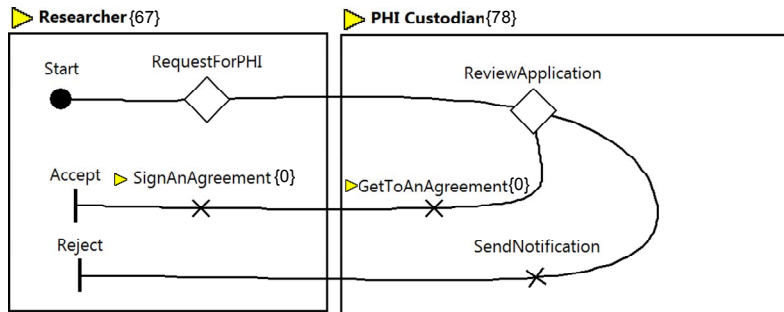


Figure 7 – Disclose PHI to researcher (legal model)

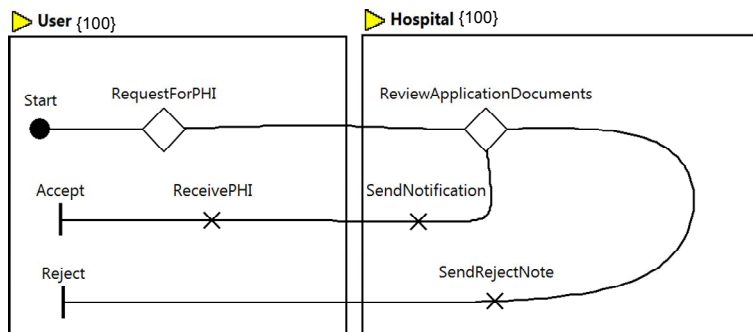


Figure 8 – Access to the hospital data warehouse by researcher (hospital model)

The RequestForPHI sub-map in Figure 9 includes links between responsibilities (shown as X's) to their corresponding goals and tasks. These three responsibilities are performed in parallel (or more likely in any order). In Figure 9, SubmitAnApplication has a link to the task WriteAnApplication and SubmitREBResult has a link to the task Copy of REB Decision in the legal model. In Figure 6, these two tasks have the value 100.

Therefore, these two responsibilities also have the value 100. However, the SubmitResearchPlan has a value of 0 since the corresponding task in Figure 6 also has the value 0. This means that the responsibility SubmitResearchPlan is missing in the hospital model. This missing task is the reason for the satisfaction level of 67 for the Researcher in the legal model in Figure 7.

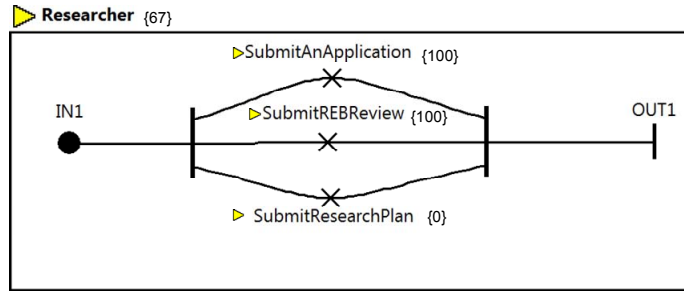


Figure 9 – Request for PHI map (legal model)

The ReviewApplication sub-map in Figure 10 also includes links from UCM stubs and components to the corresponding GRL goals, tasks and actors in the legal model in Figure 6. In Figure 10, REBReview has a link to the task Copy of REB Decision, in Figure 6. Since this task has a value of 100, REBReview also has the value of 100 next to it. Stub ReviewDocuments in Figure 10 has a link to the Disclose to Researcher goal of the legal model in Figure 6. This goal has a satisfaction

value of 25 and as a result ReviewDocuments has the value 25 as well, which means this sub-process is not done properly in the hospital and needs to be improved.

As illustrated in this section, the GRL analysis algorithm can help us find several non-compliance signs in the business processes as well as potential improvements inspired from the legal model.

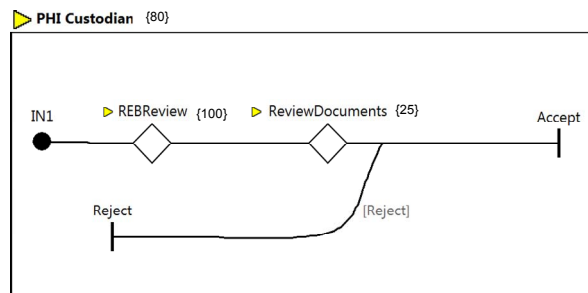


Figure 10 – Review application map (legal model)

## 5. Analysis

In our previous work, we provided a framework to help organizations establish and maintain their compliance with laws and legislation. The framework helped manage, by providing a set of compliance links, the potential changes in laws and it identified which part of a law was not covered by the organization model. However, the framework did not identify exactly which goals are completely achieved and which ones are only partially achieved due to missing sub-tasks or sub-goals. It only could determine whether a part of the law has been addressed or not.

The proposed extension provides quantitative and qualitative analysis capabilities to the framework allowing organizations to determine which goals in the law have been fully or partially satisfied or denied. Therefore, in terms of documenting compliance, this addition enables more precise assessments and diagnoses. This addition also helps us decide what to change, add, or omit from the organization goal model

in order to satisfy the goals of the legal model completely. In addition, providing links between goal models and business processes will help analysts analyze the level of compliance of the business processes to the law in detail and to identify potential or required improvements in these business processes.

Integrating automated goal analysis techniques with legal models is a novel approach as far as we know. In [1], the authors used goal models to analyze business compliance, but they only discuss modeling aspects and they do not perform any automated analysis. Normative  $i^*$  modeling [2] introduces a new version of  $i^*$  for modeling legal texts. However, this method also lacks systematic and rigorous support for model analysis.

One issue that needs further investigation is that of scalability, both in terms of the effort needed by the analyst in order to enter all the quantitative or qualitative assessments of satisfaction for bottom elements for different scenarios as well as the ability of the algorithm to scale for complex goal models. Such scalability

ty has been an issue in  $i^*$  in the past. GRL allows for a model to be decomposed into smaller, more easily manageable and understandable views, which help cope with large models. Also, automated propagation based on GRL strategies and supported by jUCMNav enable rapid analysis of compliance, which again alleviate scalability issues with many interactive analysis approaches seen in the  $i^*$  world. So far we have worked with fairly small models (graphs of up to 50 nodes and 100 dependencies) and have not encountered issues.

## 6. Conclusion

In this paper, we extended our previous requirements management framework by adding support for Use Case Maps to the legal model and adding support for levels of impact to the compliance link set. With this extension, our framework provides for quantitative and qualitative analysis and enables organizations to determine which goals have been satisfied partially and which have been fully achieved. The examples provided from a real-world hospital business process demonstrate the new capabilities, and our analysis describes the benefits.

In our future work, we intend to extend our framework to support multiple laws and different business processes. In addition, we want to extend the concept of level of impact to *source* and *compliance* links which connect the model to source documents. This extension will enable the analysis of the text itself and handle situations that cannot be modeled. We also intend to integrate GRL with deontic modalities to provide a cost analysis method for goal models in the presence of imposed rules and thereby further improve our ability to model laws and policies.

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