Goal-oriented dashboard's requirements with i*: a case study

Requisitos de un Dashboard orientado a metas con i: un caso de estudio*

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ABSTRACT

This paper aims to present a Business Intelligence dashboard with a goal-oriented approach. A case study was developed taking as context of analysis a Cuban college. The requirements of the dashboard were modeled by using aspects of social modeling and the language i*. The models obtained allowed analyzing the goals, tasks and resources necessary to accomplish the requirements of the dashboard, as well as to align the metrics of the dashboard with the goals of the decision-maker. The resulting dashboard allowed visualizing and monitoring the performance of students to support decision-making at a tactical level. The contribution of this paper is a goal-oriented approach for modeling the requirements of dashboards and for extracting the metrics of dashboards aligned with the goals of decision-makers.

Keywords: Business intelligence dashboard, goal-oriented requirements, i*.

RESUMEN

Este documento tiene como objetivo presentar un dashboard de inteligencia de negocio con un enfoque orientado a metas. Fue desarrollado un caso de estudio tomando como contexto del análisis una universidad cubana. Los requisitos del dashboard utilizan aspectos del modelado social y el lenguaje i. Los modelos obtenidos permitieron analizar las metas, tareas y recursos necesarios para cumplir los requisitos del dashboard, así como para alinear las métricas del dashboard con las metas del decisor. El dashboard resultante permitió visualizar y monitorear el desempeño de los estudiantes para el apoyo a la toma de decisiones a un nivel táctico. La contribución de este trabajo es el empleo del enfoque orientado a metas para el modelado de los requisitos y la extracción de las métricas de un dashboard alineadas con las metas de los decisores.*

Palabras clave: Inteligencia de negocio, dashboard, requisitos orientados a metas, i.*

INTRODUCTION

Dashboards allow decision-makers to visualize and monitor the Key Performance Indicators (KPIs) of an organization to support decision-making [1-2].

A Business Intelligence (BI) dashboard is a term that refers to a dashboard built upon BI technology [2-3]. Although dashboards were originally thought for executives [4], they are widely used for users at all levels at the organization: operational, tactical

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and strategic [3, 5-6]. An operational dashboard is used by the lowest-level employees to monitor their daily operations [7]. A tactical dashboard is used by middle-level employees in the organization to monitor a particular office [7]. Finally, a strategic dashboard is intended for top executives to have a clear idea of performance of strategic goals [7]. The key for developing an efficient dashboard is to understand the needs of users, as well as their roles and responsibilities from a decision-making perspective [3]. One of the main challenges remaining when developing a dashboard is to find the information to be presented to the decision-makers, i.e. the metrics of the dashboard. This issue remains because the metrics of a dashboard depend on the goals of each particular decision-maker, as well as the resources and goals of the organization [5]. The requirements of a dashboard are the basis to extract the metrics and depend on the goals of decision-makers within the context of the organization. Current literature focuses on performance management (what to measure) and Information Systems (how to display the measures) [1, 2, 8], but rarely addresses the fact on how to model the needs of decision-makers and the requirements of a dashboard following a goal-oriented approach. In [9] a goal-oriented approach is proposed to conceptualize, model and specify KPIs in Business Strategy. However, the proposal is not intended to model the requirements of a dashboard. Lempinen in [2] proposes a framework for constructing performance dashboards. A set of guidelines and principles are presented to guide the development of a dashboard based on a case study [2]. However, neither methods nor models are proposed to extract the metrics of the dashboard aligned with the goals of decision-makers or to model the requirements of the dashboard from a goal-oriented perspective.

Social modeling [10] adopts the capture of requirements from a different way other methods [11] do, i.e. by seeing intentions and reasons behind a behavior [12]. The modeling language i* [10] takes as foundation aspects of social modeling to represent the requirements of a system following a goal-oriented approach [10]. Goal-oriented models support formal reasoning schemes during requirements engineering [13]. A goal-oriented model helps to manage changes and allows evaluating alternatives of solutions by showing strengths and weaknesses [13-14].

This paper aims to present a tactical BI dashboard. The requirements of the dashboard were modeled by following a goal-oriented approach with i* and the models proposed in [15]. The research method used was a case study [16]. The context of analysis was the development of a dashboard to measure and to monitor the performance of students in the Faculty of Information Engineering at CUJAE (Instituto Superior Politécnico José Antonio Echeverría) in Cuba. The models obtained allowed extracting the requirements of the dashboard by analyzing the goals of the decision-maker as well as available resources and dependency-relations among actors involved into the context of the business and the context of the system. Furthermore, the metrics of the dashboard were aligned with the goals of the decision-maker to assure the usefulness of the dashboard.

THEORETIC ANALYSIS

Goals in requirements engineering

Requirements is the first stage when developing a software [17]. During this stage, software analysts collect and analyze the needs of stakeholders in order to obtain a first description of the system. The result of this stage are the goals of the system (why is the system necessary) and the constraints on how the requirements must be designed and implemented [18]. Requirements might be considered as one of the most important stages when developing a software [19]. Social modeling adopts requirements with a goal-oriented approach [12]. An analysis of goals reveals desires, which allows seeing expectations or conflicts. A goal-oriented model may help to manage changes. Goals provide criteria and guides to evaluate possible solutions [13-14] and have been widely used and discussed in literature. For instance, in [20] and [21] a goal-oriented approach is used for capturing the requirements of Data Warehouses (DWs) [22]. In [9] goal-oriented models are used to conceptualize and specify KPIs in business strategy. In [18] an approach is proposed to extract quality software requirements based on goals decomposition. Examples of how goal-oriented models have been used in real projects might be found in [12].

The modeling language i* introduces aspects of social modeling on requirements stage [10]. In i*, actors are seen as intentional, i.e. they have beliefs, goals, abilities and commitments. Thus, the analysis focuses on capturing the goals of each actor, given

the relations between the human actors and the system. This analysis may lead to set the strategic interests of actors [10]. In *i** the requirements stage is divided into two stages: Early Requirements and Late Requirements [10]. Early Requirements stage consists of identifying the actors involved in the domain of the problem, as well as their needs and intentions. Late Requirements stage consists of modeling what the future system should do as clear as possible [10].

In addition, *i** uses two models, each one with a different level of abstraction: the Strategic Dependence model (SD) and the Strategic Rational model (SR). In the SD model, dependency-relations existing among social actors are represented [10]. Figure 1 shows an example of a SD model by using the tool TAOM4E [23]. In the SR model dependencies among objects within an actor are represented [10]. Figure 2 shows an example of a SR model.

Requirements of a dashboard

The concept of dashboard is not clearly defined in literature [1, 6]. From a technological point

of view, a BI dashboard is a technology used to display metrics and KPIs for users at the organization [2-3]. In a broader sense, a dashboard is a tool that allows analyzing and monitoring business activities for users at all levels at the organization [6]. In this paper, a goal-oriented approach is introduced in the concept. Therefore, a BI dashboard is defined as a goal-oriented Information System (IS) based on BI technology that allows visualizing and analyzing metrics for users at all levels at the organization.

The requirements of a dashboard are divided into four categories [2]:

- Information scoping: The dashboard should provide relevant information to the user.
- Information management: The quality, quantity and correctness of data must be ensured.
- Functions: The dashboard should provide functions that fit the needs of decision-makers to improve decision making.
- User interface: Information should be presented to the decision-maker in a graphical way.

This paper proposes to add one more category concerning to the goal-oriented approach:

- Goals-oriented: The dashboard should be intended to achieve the goals of decision-makers. Thus, the metrics of a dashboard must be aligned with the goals of decision-makers.

Mazon et al. in [20] propose a goal-oriented approach for extracting the requirements of DWs based on the goals of stakeholders. They propose to divide the goals of stakeholders in three categories [20]:

- Strategic goals: Represent the main objectives of the organization. This type of goal might be thought as changes that occur in the organization to improve the current status.
- Decision goals: Respond how to achieve strategic goals.
- Information goals: Try to respond how to achieve a decision goal in terms of required information.

This paper uses these categories to represent the Goals-oriented requirements of a dashboard. Furthermore, these categories are adapted and used as a method to extract the metrics of a dashboard, as explained in [15].

Figure 1. Example of SD model.

Figure 2. Example of SR model.

RESULTS

In this section, a case study is presented. The research question formulated was the following: how goal-oriented models allow capturing the requirements of a dashboard and aligning the metrics of a dashboard with the goals of decision-makers? The context of analysis was the Faculty of Information Engineering at CUJAE, Cuba. The unit of analysis was the development of a dashboard integrated to a BI tool that allows measuring and analyzing the performance of students. This dashboard is intended for a tactical decision-maker, i.e. the Vice teaching dean. During the dashboard development, two fundamental activities were performed.

Activity 1: To model the requirements of the dashboard with i*.

During Early Requirements stage, the requirements of the user were modeled following a goal-oriented approach. Furthermore, the following activities were performed:

1. To identify and to model social actors within the business context. By following the recommendations proposed in [15] a first set of social actors was identified. Nevertheless, other actors appeared due to the context of analysis itself. All the actors modeled are presented in Table 1.
2. To represent dependencies among actors in an SD model.
3. To identify and represent the goals of each actor in SR models. In the SR model of the Vice teaching dean, a goal hierarchy was represented by using the strategic, decision and information goals categories, as explained in [15].

In Figure 3 are represented the SD and SR models obtained during Early Requirements stage. The

Vice teaching dean has one strategic goal: “To control the teaching process”. This goal contributes positively to achieve the intention “To increase promotion of students”. The strategic goal can be divided into four decision goals: “To control evaluation cuts”, “To control final evaluations”, “To control the MAP” (Methodological Activities Plan) and “To control the process of giving classes”. The decision goals are divided into seven information goals: “To control evaluation cut 1”, “To control evaluation cut 2”, “To know the state of evaluations”, “To know the fulfillment of controls to classes”, “To know the state of methodological meetings”, “To know the state of missing classes” and “To know the state of changed classes”. To achieve the information goals the following plans are modeled: “To control evaluations cuts”, “To analyze the state of evaluations”, “To monitor delivery of evaluations”, “To monitor the fulfillment of controls to classes”, “To monitor the state of methodological meetings” and “To analyze the state of classes”. This hierarchy of goals and plans allowed extracting a first set of metrics, which are presented in Table 2.

In order to achieve the strategic goal, the Vice teaching dean depends on the actor Dashboard designer to accomplish the goal “To build the dashboard”. The plan “To design visual interface” represents a mean to achieve the goal “To build the dashboard”. Furthermore, the resource “Software” is needed to design the visual interface of the dashboard.

To build the dashboard, the Dashboard designer depends on the actor Dashboard analyst to accomplish the goals “To obtain the metrics of the dashboard” and “To obtain the requirements of the dashboard”. The goal “To obtain the requirements of the dashboard” is divided into four goals: “To obtain visual interface requirements”,

Table 1. Social actors identified in Early Requirements.

Social actor	Description
Vice teaching dean	Represents the decision-maker. Monitors and analyzes the performance of students.
Dashboard analyst	Extracts the requirements of the dashboard by analyzing the goals of the decision-maker.
Dashboard designer	Designs the visual interface of the dashboard.
SIGENU	Represents an OLTP (On-Line Transactional Process) system used to manage data about students and employees.

Figure 3. SD and SR models of Early Requirements.

Table 2. Metrics identified per task.

Plan	Metrics identified
To control evaluations cuts	1. Amount of students evaluated of Bad. 2. Amount of students invalidated.
To analyze the state of evaluations	3. Amount of students promoted. 4. Amount of students absent to exams.
To monitor delivery of evaluations	5. Amount of subjects with registered grades.
To monitor the fulfillment of controls to classes	6. Amount of controls performed to classes.
To monitor and analyze the state of methodological meetings	7. Amount of methodological meetings done.
To analyze the state of classes	8. Amount of missing and changed classes. 9. Amount of teachers per subject.

“To obtain functions requirements”, “To obtain information management requirements” and “To obtain information scoping requirements”. These goals correspond to the categories explained earlier. To achieve the goal “To obtain information management requirements” the plan “To analyze data sources” is required. This plan is very important because it allows the Dashboard

analyst to evaluate alternatives such as building a Data Warehouse [22], represented with the task “To build a Data Mart”. In this case study, to achieve the task “To analyze data sources”, the Dashboard analyst depends on the resource “Database” belonging to the actor SIGENU. The actor SIGENU represents an OLTP (On-Line Transactional Process) system that manages all

data related to students and workers. On the other hand, the goal “To obtain information scoping requirements” constitutes a mean to achieve the goal “To obtain the metrics of the dashboard”. Furthermore, to achieve the goal “To obtain information scoping requirements” the resource “Metrics” is required. This resource belongs to the Vice teaching dean and it is extracted by using the goals and plans hierarchy explained earlier.

During the Late Requirements stage, the requirements of the dashboard were modeled. Furthermore, the following activities were performed:

1. To model social actors within the context of the system.
2. To represent dependencies among actors in an SD model.
3. To represent the goals of each actor in SR models.
4. To model the requirements of the dashboard based on the goals of the decision-maker.

Table 3 shows the social actors identified during Late Requirements stage. In Figure 4 are represented the SD and SR models obtained during Late Requirements stage.

The actor Vice teaching dean remains with the strategic goal “To control the teaching process”. To achieve this goal the Vice teaching dean depends on the actor Dashboard to accomplish the goal “To support decision making”. This goal might be achieved by visualizing the metrics

Table 3. Social actors identified during Late Requirements.

Social actors	Brief descriptions
Vice teaching dean	Monitors and analyzes the performance of students.
Dashboard	Represents the dashboard with the system stereotype of i*.

Figure 4. SD and SR models of Late Requirements.

(represented with the goal “To visualize metrics”) or by analyzing information (represented with the goal “To analyze information”). To achieve the goal “To visualize metrics” the plan “To consult data” is required.

The resource “Data Mart” represents a mean to accomplish the plan “To consult data”. Furthermore, the resource “Metrics” from the Vice teaching dean is also required to achieve the plan. On the other hand, the plans “To provide functions” and “To analyze information” represent means to accomplish the goal “To analyze information”. The plan “To provide functions” might be divided into two plans: “To provide drill-down functions” or “To filter data”. By modeling these plans, the Functions requirements of the dashboard are captured and modeled as tasks to be implemented by the actor Dashboard. The plan “To analyze information” is divided into six plans: “To control evaluations cuts”, “To analyze the state of evaluations”, “To monitor delivery of evaluations”, “To monitor the fulfillment of controls to classes”, “To monitor the state of methodological meetings” and “To analyze the state of classes”. These plans correspond to the plans modeled in the hierarchy of goals and tasks within the SR model of the Vice teaching dean during Early Requirements. By modeling these plans within the SR model of the actor Dashboard, Information scoping requirements are captured and modeled aligned with the goals of the decision-maker. The User interface requirements are modeled as soft-goals, following the recommendations of [15]. In this case, three User interface requirements were proposed: “Web environment”, “Graphical orientation” and “Easy to use”. The way soft-goals affect the accomplishment of the goal “To support decision-making” is also modeled, as well as the way tasks affect the accomplishment of the soft-goals. In this case, the soft-goals “Easy to use” and “Graphical orientation” contributes positively to achieve the goal “To support decision-making”. Nevertheless, the soft-goal “Web environment” might affect negatively the accomplishment of the goals “To visualize metrics” and “To analyze information”, because of issues when using a web application (for instance a failed connection between client and web server). The plan “To provide functions”

contributes positively to achieve the soft-goal “Easy to use”.

Activity 2: To design the dashboard.

In this activity, a tool developed by the authors of the paper was used to create the visual interface of the dashboard. The criteria for selecting this tool were mainly two: 1) whether the tool fulfilled the requirements of the dashboard and 2) the experience of the Dashboard designer with the tool.

The selected tool is presented in [24] and consists of a module integrated to a BI suite developed by the authors of the paper as well. As a requirement to use the module, Microsoft Analysis Services (MAS) OLAP (On-Line Analytical Process) cubes need to be created. Therefore, the following activities were performed:

1. To analyze the OLTP system in order to determine whether all the metrics presented in Table 2 had a consistent data source.
2. To perform ETL (Extract, Transform, Load) [25] processes in the data source in order to create a Data Mart.
3. To design MAS OLAP cubes and import them into the BI suite.
4. To design the visual interface of the dashboard based on the User interface requirements.

When analyzing the OLTP data source, there was a lack of information regarding several metrics presented in Table 2. Consequently, only metrics 1, 2, 3, 5 and 9 were identified to have a consistent data source. In order to assure data quality, according to Information management requirements, several ETL processes were performed. As a result, a Data Mart is obtained structured with a Star scheme [22].

When designing the visual interface of the dashboard, graphical components, such as gauges and charts, were used to show the result of the metrics. The graphical orientation corresponds to one of the User interface requirements modeled as a soft-goal within the Dashboard SR model.

As a result, the tactical dashboard is presented in Figure 5.

Figure 5. Resulting dashboard.

CONCLUSIONS

The requirements of a dashboard should be captured by following a goal-oriented approach. In this paper, a case study was presented to develop a tactical dashboard integrated to a BI tool. The requirements of the dashboard were captured and modeled by using the language i* along with the models proposed in [15]. Actors, goals, tasks and resources were represented in these models, as well as dependency-relations existing among actors. The goals and tasks hierarchy represented within the SR model of the Vice teaching dean allowed extracting a first set of the metrics of the dashboard aligned with the goals of the Vice teaching dean. Though no consistent data sources were found for some of the metrics, this hierarchy of goals and tasks allowed modeling Information scoping and Goals-oriented requirements. As proposed in [15], Information scoping requirements were modeled as tasks to be implemented by the actor Dashboard in Late Requirements. To accomplish Information management requirements, an analysis of the OLTP data source SIGENU was performed, represented as a task belonging to the actor Dashboard analyst. Furthermore, several ETL processes were performed to assure correctness of data and to build a Data Mart. Functions requirements were modeled as tasks to be implemented by the actor Dashboard in Late Requirements. Finally, User interface requirements were modeled as soft-goals belonging to the actor

Dashboard. In addition, it was represented how the tasks might affect these soft-goals and how the soft-goals might affect the goals of the dashboard. All this allowed evaluating alternatives of solutions, depending on whether the tasks and soft-goals affected the requirements positively or negatively.

The dashboard presented in this paper is supported by BI technology (Data Mart, OLAP cubes) as explained earlier. The advantage of using BI technologies is that it allowed performing functions (such as drill-down) on data easily due to the structure of the Data Mart, and consequently improving decision-making process. However, goal-oriented requirements as well as the models proposed in [15] are equally useful when developing a non-BI dashboard. Future works will be developed to validate this idea.

Furthermore, the visual interface of the dashboard was built upon a tool developed by the authors of this paper. However, any other BI tool might be used to design the visual interface of the dashboard. The selection of a tool in particular depends on whether the tool fulfills the requirements of the dashboard and the experience of the Dashboard designer with the tool. In this case, the requirements of the dashboard were fulfilled by the selected tool. Also, one of the authors, who played the role of Dashboard designer, had a wide experience using this tool.

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