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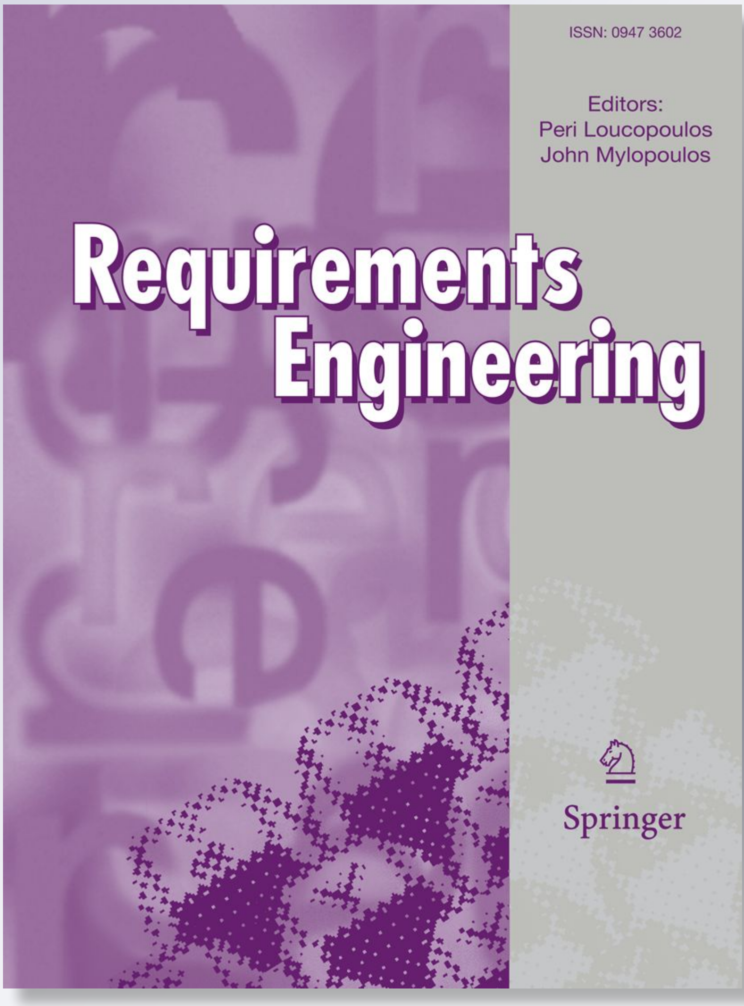

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ORIGINAL ARTICLE

Modeling stakeholders for information systems design processes

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Abstract In the software engineering area, stakeholders play a significant role in requirements elicitation and validation. Moreover, all the project management is integrally affected by stakeholders' perspectives and their participation. This effect is strengthened when projects involve several organizations. Thus, a clear and explicit representation of the stakeholders and their attributes is required in order to achieve their effective management. The integration of this representation with other models capturing the knowledge of engineering design processes can be of great utility in software development projects. In this sense, this article describes the construction of an integrated model for representing stakeholders in information systems design processes. This proposal considers diverse attributes related to stakeholders and gives information for performing quantitative calculations about their interest and influence over the project. Thus, more inclusive experiences of the information systems development can be supported, even more if contexts with the participation of several organizations are considered.

Keywords Information system design processes · Stakeholders modeling · Interest · Influence

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1 Introduction

Diverse changes of perspectives in organizational management and engineering areas are taking place by these days. Several issues have been modifying the way business is done and managed. Now, organizations tend to cooperate and create links among them due to several reasons, such as globalization, changes in consumers' requirements, new market trends, and dynamic development of new technologies, to name but a few. Information and Communication Technologies (ICTs) play a crucial role in this change, not only reducing distances but also supporting operations and interchanges among organizations. Moreover, the turbulence of business contexts, diversity and multiplicity of stakeholders, as well as evolution of information infrastructures, invites research to reflect on the dynamics and complexities involved in this area [5].

A noticeable change has taken place in design processes in the engineering area, more precisely in the design area. Under the influence of social sciences, design processes that have been centered for years only on users are now tending to focus on more participative experience. Diverse approaches exist to represent and store all the knowledge generated during engineering projects, considering actors as entities related to the project activities [35]. However, no additional information related to stakeholders is registered. Thus, these approaches do not consider stakeholders as the main requirements and validation source.

In the engineering area, also, a new perspective has arisen. There is a growing tendency to consider the integration between "technical" and "human" elements in design processes [22]. This change of perspective is based on the shift from design FOR users to design WITH users, where new ways of thinking and working are required. Participative design is not a simple method or set of methodologies, but an attitude which focuses on the premise that everyone which is involved in the design process can collaborate. Thus, their representation must be considered in new tools for supporting activities related to design.

Several authors promote this approach. Among them, Sanders [37] states that people want and wish to express themselves and take part directly in the design process. Therefore, the great challenge is the creation of tools and infrastructure to support and enable design processes considering users' experience. Meanwhile, Olphert and Damodaran [30] recognize that systems require the successful integration of the values, interests, and needs of different stakeholders if they are going to function well. Also, Bryl et al. [15] pose the need for a socio-technical perspective for requirements engineering in order to allow the modeling and analysis of the interaction of hardware and software components with human and organizational actors.

In design processes of information systems (IS), more specifically in requirements analysis, *stakeholder* concept is fundamental. Stakeholders are the primary source of requirements for software projects [9]. They are defined as any group, individual or organization that must take part in a project because they are affected by its activities or results [33]. Each stakeholder has a unique view on the system, so they must be involved in its analysis and design. By means of their coordinated efforts, the system is conceived, created, and maintained. Therefore, stakeholders' perspectives must be explicitly represented in the models required to develop an IS [16, 29]. This does not only make the process more easily understandable but also supports the shared activities required for its development. Then, stakeholders' activities can be linked, their needs and perspectives can be considered from earlier design stages, and their achieved degree of satisfaction can be tracked.

Moreover, Olphert and Damodaran [30] recognize that direct engagement with potential stakeholders provides designers and developers with a sound and extensive knowledge base about their needs and characteristics. Furthermore, genuine dialogue with stakeholders reveals the diverse objectives, aspirations, needs, and characteristics of different groups and enables the definition and validation of requirements specifications. At a later stage in the design lifecycle, design prototypes and simulations can be tested with relevant user groups, thus attaining early feedback on stakeholder responses. Feedback gained before a system is built can be used to make improvements that would be impossible or extremely expensive if flaws were to be discovered at a later stage of the design.

Thus, stakeholders' management is one of the key factors that must be addressed in engineering projects [2]. If a project cannot effectively identify, connect to, and interact with stakeholders, it is difficult to discover software requirements and their practical use [28]. Moreover, information about them (needs, roles, interests, influence, etc.) must be considered all over a project. In order to make this information effectively accessible to participants, organizations, and project stages, it needs to be defined, classified, and related in a well-defined terminology shared by all the participants.

Models are commonly used to organize and represent knowledge. They provide a way to manage the knowledge and the relationships between involved concepts, promoting the communication between users. Therefore, a model for organizing and integrating the information related to stakeholders is required. Considering this latent need, this article proposes a stakeholder model to be used in the IS design process. Thus, a description of the stakeholders and their attributes is achieved in order to reach a more complete comprehension of the design process and its management. This is a great advance in the integration of the social and technical areas that coexist in design processes but are not adequately supported by the existing techniques and tools.

This proposal also describes several ways to quantitatively measure important stakeholders' attributes. Taking into account that managers must appropriately conduct the different project stages, they should make decisions based on proper criteria. The proposed model admits the assessment of stakeholders' characteristics in order to achieve an effective project development. In particular, the interest and influence attributes are studied and analyzed.

This article is structured as follows. Section 2 introduces an integrated model for representing and managing stakeholder-related concepts in the development of an information system. This section analyzes several stakeholders' attributes (interest, influence, etc.) and proposes concrete expressions to systematically assess them. These attributes have been previously analyzed from a qualitative point of view. So, this approach reduces the existing gap between the *problem domain* and the *solution domain*, from the modeling of requirements associated with the sources (stakeholders) and their influences. Section 3 describes a case study that exemplifies the ideas previously presented. In order to discuss the proposal, a general context is presented where several organizations take part in the IS development. Then, some lessons learned are presented in Sect. 4. Finally, the conclusions and future steps are described in Sect. 5.

2 Stakeholders' model for IS design

Hummel et al. [23] affirm that design processes can be greatly improved through the use of methods supporting and managing the knowledge from all those involved in the project, so that diverse multifaceted factors can be analyzed. In the same sense, Oostveen and van den Besselaar [31] demonstrate the usefulness of involving multiple stakeholders in an e-government project. Thus, in order to attain a successful information systems design and development, stakeholders and their attributes along the project have to be considered and managed.

Modeling stakeholders' issues is essential since, by definition, their characteristics and needs are likely to be different. Further, the design process itself draws participants into a social process, sharing not only knowledge but also the generation of ideas. This process must be dynamically considered and represented in design models in order to evaluate the achievement level and the relations with product goals. Therefore, a holistic vision is required in order to manage all the involved criteria, considering as many perspectives and interests as possible. The resulting system should be developed taking into account all stakeholders' demands.

Bergman et al. [8] affirm that the organizational and political context surrounding design fails to be so easily understandable. They call this surrounding context "*design ecology*". They also define it as consisting of functional and political elements: (1) what system(s) can be built and delivered within the given environment and (2) how stakeholders' interests align with proposed designs to mobilize willingness and resources. Therefore, stakeholders' modeling helps design products being effectively embedded in design ecologies. Thus, as the authors describe, significant improvement in systems design practice can be achieved, which will help to mitigate against failures that result from a poor understanding of how design artifacts relate to stakeholders and their interests. Moreover, designers will be able to discover and coordinate multiple stakeholders' needs or other stakes and then create solutions that will meet their preferred needs with the minimal time and cost, possibly with the maximal benefit.

Figure 1 presents an integrated UML class model [11, 36] for representing and manage stakeholders, which considers diverse concepts related to them in system design processes. Diverse analyses, interpretations, and assessments required by ISs projects can be supported by the model and are described in subsequent subsections.

The model includes required information for supporting the quantitative assessment of stakeholder attributes, in particular the interest in the project and their influence on it. Although this article describes in detail these stakeholders' characteristics, this model can be extended to support others' attributes. Thus, an effective stakeholders' management can be implemented during the project development.

Information related to stakeholders, their attributes, and their relation with product requirements are key concepts that must be considered since early stages of the development process. In the following sections, these model elements are described.

2.1 Stakeholder sub-model

Such as Ballejos and Montagna [6] describe, a stakeholder is *any individual, group, or organization that can affect or be affected (positively or negatively) by the system under study and that have direct or indirect influence on its requirements.* Considering this concept, the sub-model in Fig. 2 describes every *stakeholder* as an *individual*, a *group,* or an *organization*. A *group* is a set of two or more individual, which share some particular characteristic without a defined structure as occurs with an organization.

An *organization* is composed by one or more *stakeholder individuals*, *groups,* or *organizations* with a defined structure.

Several conclusions can be derived from Fig. 2:

- A *stakeholder individual* is always a leaf node in the stakeholder abstraction: there is not any aggregation relationship where *stakeholders* are members of the *stakeholder individual*, so a *stakeholder individual* cannot contain members.
- A *stakeholder individual* cannot have parts, since there is not any aggregation relationship indicating that *stakeholder individuals* can be *part* of him.
- A *stakeholder organization* or a *stakeholder group* cannot be leaf nodes in the stakeholder hierarchy, since these are not atomic concepts, such as the *individual* concept.
- The aggregation relationship between a *stakeholder organization* and its members (*member* relationship) is transitive: all stakeholder members of an organization are also members of any organization from which the first one is member.

A stakeholder can be also related to other stakeholders through the *member* or *part* relations shown in Fig. 2. For example, a *stakeholder individual* can be *part* of various *stakeholder groups*.

2.2 Stakeholders, actors and roles

According to Pfahl [32], the *actor* concept defines responsibilities between agents and activities of particular processes. Nevertheless, a subtle difference between the terms *actor* and *stakeholder* exists. Stakeholders have some interest in the process and will be affected positively or negatively by the results to be obtained. Thus, the set of stakeholders of a particular process is more numerous and, at the same time, includes the set of actors of that process.

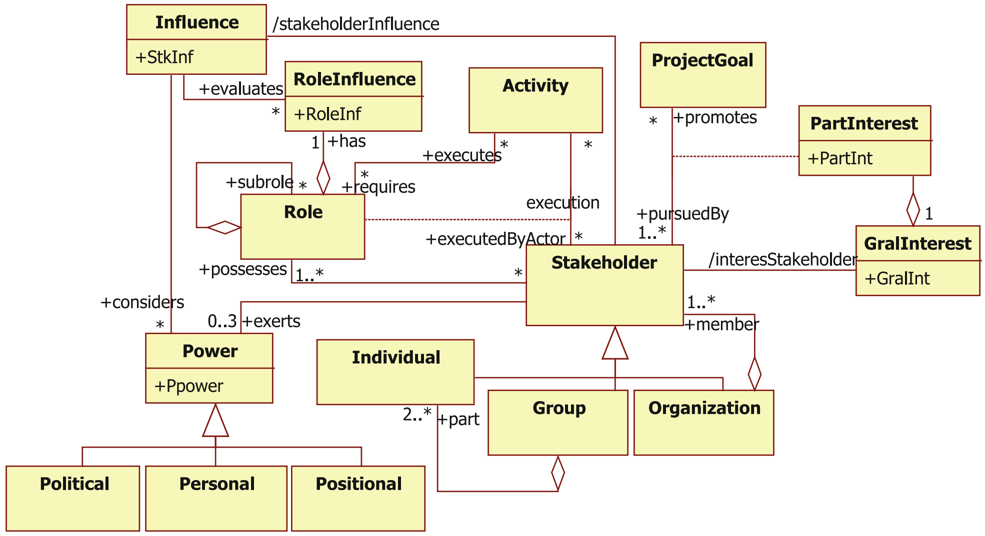

Fig. 1 Integrated model for the stakeholder representation

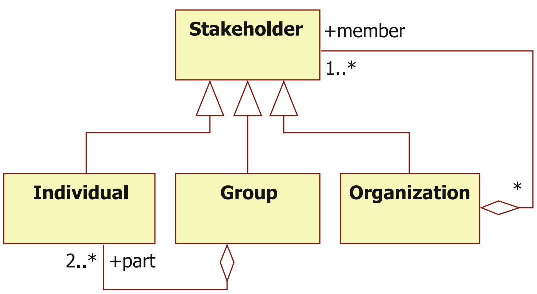

Fig. 2 Stakeholder sub-model

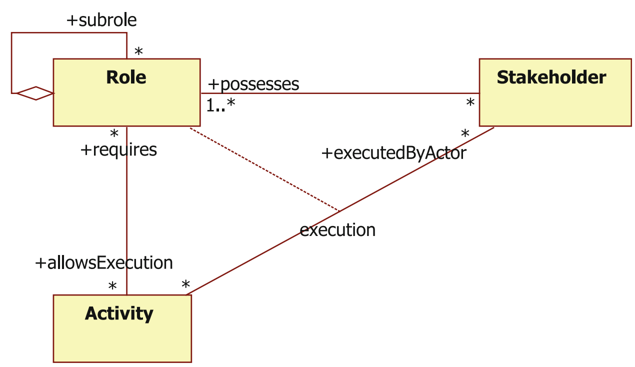

Fig. 3 Stakeholders, activities and roles integrated model

Nowadays, IS projects often affect many more stakeholders than when IS participation theory was first proposed, where only users were considered [27].

In general, process modeling is limited to represent only individuals who will directly execute tasks. Also, in any domain, the execution of activities by actors is restricted to the roles they may play in particular moments.

For ISs development, roles arise from the analysis of the possible interaction types that can exist between a particular stakeholder and the system under development. The role concept avoids personifying the relation between actors (stakeholders) and activities and is a very useful concept to model properties and behaviors of entities which evolve over time in processes models [34]. Zhang and Chen [39] pose that a clear identification of stakeholder roles and participation degree in the design stages are important steps toward the success of distributed and collaborative design.

Figure 3 represents that each *stakeholder* has at least one *role* associated and that a *role* can be played by diverse *stakeholders*. The association-end *possesses* indicates the stakeholder's position in relation to the project under analysis.

The *role* represents the relation between the stakeholder and the system or design process. Usual roles are operator, regulator, responsible, beneficiary, among others. A *subrole* relationship indicates that a *role* includes other *roles*, also involving their relations with *activities*.

On the other hand, *activities* are performed through the assignment and utilization of *roles*. Every project *activity requires* particular *roles* to be executed, and at least a *role* is required for the execution of each *activity*.

Diverse process modeling proposals associate the execution of activities to the possession of certain ability. However, this can be generalized considering the actor concept by Ellis and Wainer [19]: "*an actor is a person, computational program or entity which must play roles to execute, be responsible for, or be associated in some manner with activities and procedures*". Then, other criteria also exist when relating stakeholders to activities, and not only the ability or competency. For example, functions performed, hierarchical level, geographical location, etc. are attributes independent from the ability or the specific knowledge of the individuals. In the model, these specific properties will be materialized through the *role* concept.

Figure 3 also describes that *activities execution* is performed through *stakeholders* and that an *activity* can be executed by diverse *stakeholders*. Similarly, a *stakeholder* can execute diverse *activities*. Nevertheless, a *stakeholder* executes a particular *activity* playing certain *role*. Thus, an association class is needed. This class incorporates attributes about the position that certain stakeholder must have (*possesses* association-end) to execute an *activity* (*execution* relationship). It also includes concepts related to activities management (*requires* association-end) and activities execution (relationship *execution* between *stakeholder*, *activity,* and *role*).

2.3 Interest and influence

Once stakeholders are selected, descriptive attributes must be selected and incorporated to the model. The proposed model supports different stakeholders' attributes. In this article, stakeholder interest and influence are particularly analyzed taking into account the richness of these concepts and their impact on the project development [12]. Nevertheless, this model also allows other characteristics to be added so as to enable effective stakeholder management throughout the project.

The interest is generally derived from the relation between stakeholders' needs and project goals or purposes. On the other hand, influence indicates stakeholders' relative power over the project and over decisions to be made. As Aaltonen et al. [2] consider, stakeholders use versatile strategies or tactics to influence organizations and decision-making processes.

In general, authors who propose methods for stakeholder selection or identification also recognize the importance of discovering in advance interest and influence levels associated with them [6, 13]. Nevertheless, these authors do not give major details for the concrete evaluation of those levels or for their quantitative measurement. On the contrary, qualitative values are commonly used for determining an initial estimation in order to organize subsequent steps without worrying about the execution of detailed assessments. Applegate [4], for example, uses "high" and "low" values to initially estimate the priority associated with requirements. Meanwhile, Bourne and Walker [14] use five values in the range between "very high" and "very low" in order to obtain an intensity index of stakeholders' interest.

As the project advances, greater precision about information provided by stakeholders will be also required. Besides, all the assessments about stakeholder participation should be related with information about the project development. These links are vague and difficult to manage and complications increase when several organizations take part. In order to systematically evaluate these attributes, specific quantitative approaches are proposed that can be supported by the present model. Thus, subjectivity and limitations usually arising when working with stakeholders can be reduced. These advantages are more outstanding in environments where interorganizational ISs are developed and diverse perspectives must be considered.

The following subsections analyze in detail the representation of interest and influence attributes, giving concrete methods to perform their assessments for each stakeholder in the project.

2.3.1 Interest

Figure 4 shows the representation of concepts associated with the particular interest of a stakeholder in the project. This interest is related to the project objectives, determining that a *stakeholder* somehow *promotes* project goals (*projectGoal*) with certain interest value (*partInterest*). Thus, every *projectGoal* is pursued by, at least, one of the selected stakeholders.

Representation and reasoning about project goals, which involves the development of an information system, unavoidably implies the iterative transformation of unclear stakeholders' needs into unambiguous requirements [24]. Thus, the representation of project goals helps in the subsequent clarification of stakeholders' requirements and in their justification. If the requirements engineer does not account for the selection of one clear requirement over others, the subsequent modeling decisions cannot be justified either.

Using the model proposed in Fig. 4, the information required to estimate the degree of the particular interest that a stakeholder has in each project goal (*PartInt* attribute in class *partInterest*) becomes accessible. Thus, there is sufficient data to assess the general interest of a stakeholder, considering all defined project goals. A numeric scale must be used in order to evaluate *PartInt* attributes related to the project objectives that certain *stakeholder* promotes. This scale must be defined by the project team and used along all the project stages. Different alternatives can be proposed. For example, scales of 1..100 or 1..10 can be

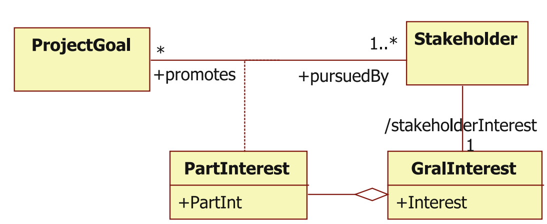

Fig. 4 Interest sub-model

considered, depending on the information detail level. In this article, the latter will be used in the examples to be presented.

Negative values can also be considered in order to assess those project goals the stakeholder is not interested in and, indeed, argues against because these negative *PartInt* values will then negatively affect the stakeholder general interest in the project.

Differences between *PartInt* values of diverse stakeholders denote certain discrepancy between particular interests. This is then translated in requirements misunderstandings and disagreements among stakeholders, which must be managed in later steps of the development project. Kaiya et al. [25] introduce a technique to identify requirements with disagreements among stakeholders by using preference matrices. They affirm that, in order to detect these discords, information regarding stakeholders' understanding and evaluation of a given requirement should be gathered. This opinion supports the proposal described in this article, which considers the evaluation of particular interests related to each project goal.

Taking into account a stakeholder may be related to several goals, a general interest measurement must be defined. Figure 4 also describes that the stakeholder general interest (*gralInterest* class) has an attribute (*Interest*) whose value is estimated from all particular interest values (*PartInt* attribute) of the project goals (*projectGoal*) associated with the *stakeholder*. The stakeholder's general interest (*gralInterest*) in the project is unique.

Figure 4 shows */stakeholderInterest* as a derived association. Derived associations are considered *dependent* or *redundant* since they are directly or indirectly determined through other associations. However, they are incorporated in order to facilitate information search.

Different expressions can be used to assess the interest value (*Interest*), considering the particular interest values (*PartInt*) associated with the stakeholder. Three possible alternatives are proposed in this work:

(a) The project team evaluates all the goals related to a stakeholder with an adequate weighing factor in order to assess questions associated with the objective fulfillment, such as urgency, cost, time, and strategic impact. Thus, the *Interest* attribute for stakeholder *s* can be assessed by the following expression:

$$Interest_s = \sum_{i \in O_s} p_i * PartInt_{is} \qquad (1)$$

where O_s is the set of project goals related to stakeholder s and p_i is the weight assigned by the project team to the particular goal i.

(b) The project team evaluates stakeholders' interest with the greatest particular interest associated with each one. Thus, distortions that can be introduced by (1) are avoided. For example, when a stakeholder with many goals of low value is assessed with a general interest greater than a stakeholder with a unique goal of high impact. In this case, the calculation might be done through the following expression:

$$Interest_s = \max_{i \in O_s} (PartInt)_{is} \qquad (2)$$

(c) The project team can balance the effect of several goals by averaging particular interest values. In this way, the calculation of the interest associated with stakeholder *s* takes the following form, where weighing factors are also considered:

$$Interest_s = \frac{\sum_{i \in O_s} p_i * PartInt_{is}}{\#O_s} \qquad (3)$$

where $\#O_s$ indicates set O_s cardinality.

Any of the previous expressions can be used depending on project team criteria. All of them are supported by the model proposed in Fig. 4.

2.3.2 *Influence*

Influence indicates the relative power of the stakeholder on the project and the decisions that must be taken. That relative power can be assessed from two information sources. The first one is the set of roles associated with the stakeholder in the project and the relative influence of those roles. The second source for estimating the influence is determined by the origin of his/her power [14].

This section proposes the influence assessment considering both sources through a quantitative and systematic analysis. Thus, previous approaches based on qualitative points of views are overcome. This proposal is flexible since it supports obtaining a global value over both sources: roles and powers associated with a particular stakeholder. Besides, appropriate weighting factors are introduced in order to adjust more valuable sources.

2.3.2.1 Role influence Stakeholders play critical roles, which further underscores the importance of achieving the correct level of stakeholder involvement and representation in modern software development practices [10].

Stakeholders' roles in a project are somehow related to the stakeholders' decision power over the project. This power is independent from who plays the role. The degree of influence of the role over project decisions can be deduced by analyzing the roles commonly used in ISs development projects, their responsibilities, and participation stages. For example, the *responsible*, *decision maker*, and *regulator* roles have greater influence than the *operator*, *consultant*, and *functional beneficiary*, due to their more significant responsibilities.

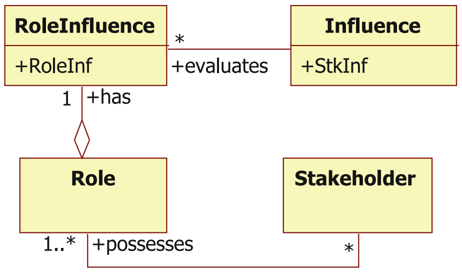

Fig. 5 Influence model using roles

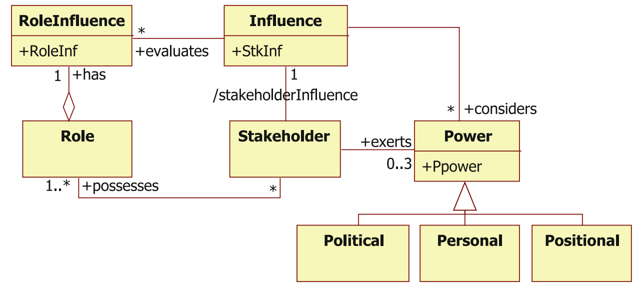

Fig. 6 Influence sub-model

Table 1 Stakeholder roles and associated influence values

Role	RoleInfluence
Beneficiary	10
Functional	3
Financial	7
Political	6
Sponsor	8
Negative	5
Responsible	8
Decision-maker	10
Regulator	3
Operator	2
Expert	7
Consultant	4
Developer	3

The analysis of each role in relation with its possible influence on the project gives information for the generation of a new attribute (*roleInfluence*). From Fig. 5, it can be deduced that each role must be associated with a unique influence value (attribute *RoleInf* from *roleInfluence* class). Table 1 shows influence values associated with each role in the case study. They are estimated using a 1..10 range.

In the case of the *beneficiary* role, certain stakeholder can be associated with this general role (obtaining a *RoleInfluence* value of 10) or, it can be associated with some of the beneficiary subroles, obtaining different *RoleInfluence* values in each case.

2.3.2.2 Power sources Yukl [38] defines three possible power sources for stakeholders (Fig. 6):

– *Positional power*, derived from authority (e.g., organizational) and related to control and formal aspects.
– *Personal power*, derived from influence on human relationships or specific features such as experience, charisma, loyalty/friendship, etc. when the stakeholder is an individual. When the stakeholder is a group or organization, this attribute might be analyzed as the group/organization motivation, charisma, etc., in order to collaborate with the project and pursue its success (for example, by trying to persuade other stakeholders to take part in the project).
– *Political power*, derived from control positions over decision processes related to the particular project.

Other power types can be added to the model in Fig. 6 as specializations of the power concept. The diverse power types are associated with quantitative values represented by *Ppower* attribute. This attribute, inherited by all power types from *Power* class, describes the value each type has for a particular stakeholder. According to the model, a *stakeholder* can exert none to three-type *power* (0..3 cardinality).

2.3.2.3 Influence model and its assessment According to the previous descriptions, the influence associated with a stakeholder will be related not only to the influence of his/her roles but also to the power types associated with him/her. In order to schematize this situation, Fig. 6 also represents all concepts involved in the influence assessment. In this figure, as well as in Fig. 4, the */stakeholderInfluence* association is a derived association.

Figure 6 graphically describes that *stakeholder influence* on the project is unique. Also, the influence value (*StkInf* attribute from *influence* class) is calculated over the influences of roles related to the stakeholder (*RoleInf* attribute from *roleInfluence* class) and over the values assigned to power types exerted by the stakeholder (*Ppower* attributes). Thus, diverse combinations can be considered in order to evaluate stakeholder's influence. The weighting factors ω_r and ω_p will be used in the calculation to weight the considered elements: *roleInfluence* and *power*, respectively. These weights depend on the significance assigned to each element, on the information availability, on the project team sensibility, etc. The following general expression is proposed:

$$StkInf_s = \omega_r * f_s(RoleInfluence) + \omega_p * f_s(Power) \qquad (4)$$

where $f_s(RoleInfluence)$ is a function related to the values of roles influences associated with stakeholder s and $f_s(Power)$ is a function related to the values of power types associated with stakeholder s.

Although this model supports different expressions for calculating the influence for a particular stakeholder *s*, some suggestions are subsequently presented.

(a) Function $f_s(\boldsymbol{RoleInfluence})$ can be represented by some of the following expressions:

(a.1) The project team might consider the weighted addition of the roles influences associated with each stakeholder, as follows:

$$f_s(RoleInfluence) = \sum_{r \in R_s} p_r * RoleInf_r \qquad (5)$$

where R_s corresponds to the set of roles associated with the stakeholder *s* and p_r represents the weight assigned to a particular role.

(a.2) The influence values for stakeholder roles can be evaluated considering the greatest value, as it is shown in the following expression:

$$f_s(RoleInfluence) = \max_{r \in R_s}(RoleInf_r) \qquad (6)$$

(b) Function $f_s(\boldsymbol{Power})$ can be represented using the following expressions:

(b.1) The project team might consider the weighted addition of values of power for a particular stakeholder, assigning greater importance to types more relevant for the project or for some particular stage:

$$f_s(Power) = \sum_{t \in T_s} p_t * Ppower_{ts} \qquad (7)$$

where T_s represents the set of power types associated with the stakeholder *s* and p_t represents the weight assigned to a particular power type.

(b.2) The stakeholder power can be evaluated from the greatest value associated with some of the power types the stakeholder exerts:

$$f_s(Power) = \max_{t \in T_s}(Ppower_{ts}) \qquad (8)$$

3 Case study

In order to exemplify the models previously introduced, a real example in the public health area of an Argentinean province is presented.

Problems that arise from inefficiency in medicine distribution, usually due to poor information integration, have encouraged the formulation of a project aimed at solving them. An interorganizational information system will be developed to manage all interactions and relationships involved in production, supply, and access to medicines and information across the interorganizational network. The main goal is to transform the current operation of separated organizational systems into a global and integrated one.

Participating entities are shown in Fig. 7. The organizations enclosed in a rectangle are the members originally considered in the network. Outside the rectangle, several organizations are also included taking into account they affect medicines supply. Full lines correspond to material flows, and dotted ones represent economical flows.

The main organizations involved are:

- *Pharmaceutical Industrial Manufacturer (PIM)* elaborates generic medicines at a low cost, to be provided to the population in public health centers. Its unique customer is the Central Pharmacy.
- *Central Pharmacy (CP)* depends on the Provincial Health Department (PHD). Its goals are to plan,

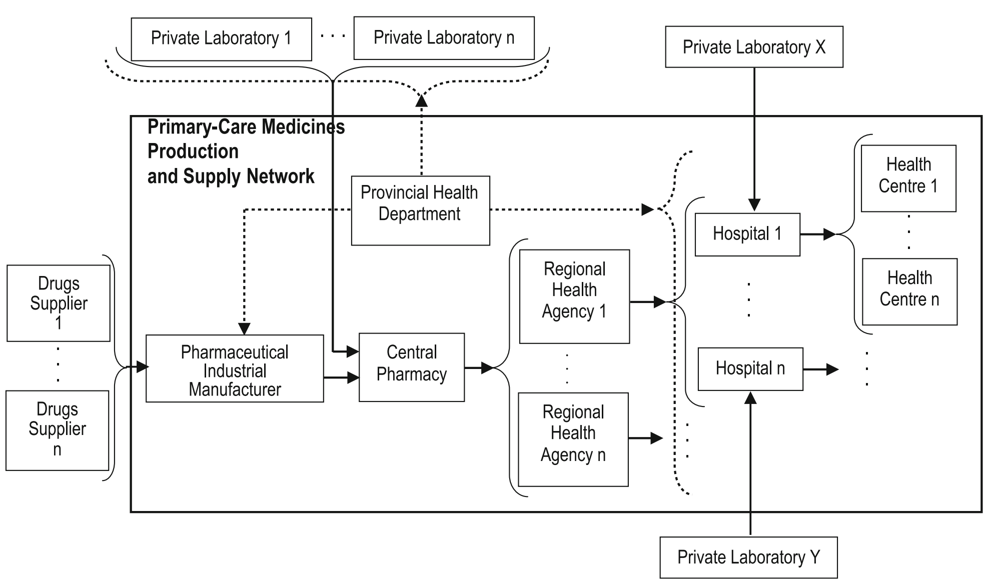

Fig. 7 Interorganizational network for medicines production and distribution

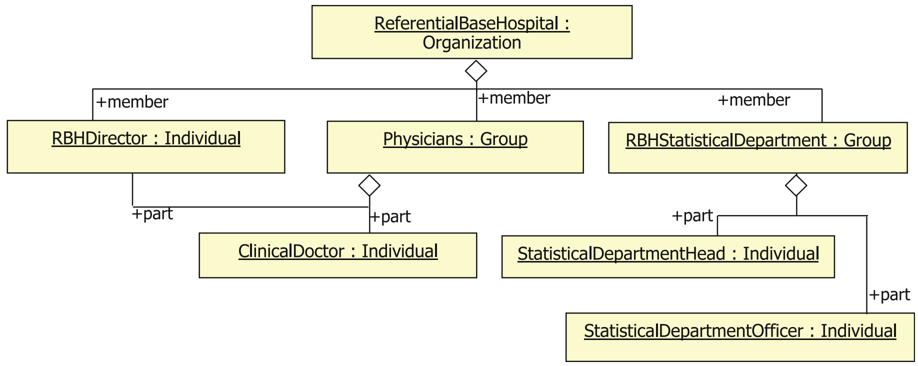

Fig. 8 Example of stakeholders' relationships

coordinate, and control the supply of medicines required by health centers. The PIM is one of its principal suppliers. Private pharmaceutical companies also provide medicines to the CP.

– *Regional Health Agencies (RHAs)*. The province is divided into 9 RHAs that are responsible for medicines distribution to hospitals and their depending health centers. Each of them has a warehouse and a pharmacist for medicines quality and storage conditions control. They receive medicines from CP and redistribute them according to specific orders from hospitals.
– *Referential Base Hospitals (RBHs or Hospitals)* deliver medicines to minor health centers and patients that depend on them. Each of them also has a warehouse where small levels of medicines stocks are managed. There exists at least one for each RHA.
– *Health Centers* depend on base hospitals and are smaller.
– At external level, drugs and medicines suppliers, private pharmaceutical companies, patients, other government areas are some of the entities that will interact with the network members.

3.1 Stakeholder types

In the example, the Provincial Health Department is an *organization stakeholder* as well as Referential Base Hospitals, RBHs being members of the first one and Referential Base Hospitals Directors forming a *group stakeholder*. Figure 8 shows that the recursive decomposition of a stakeholder in *members* and *parts* in Fig. 2 derives in a graph structure, more than in a tree structure. This is due to the existence of the *part* relationship that can occur between *individual stakeholders* and *group stakeholders*.

3.2 Stakeholder interest

Central Pharmacy Director (CP Director), *Pharmaceutical Industrial Manufacturer, Technical Director (PIM Technical Director)* and *Referential Base Hospital Pharmacy Department Head (RBH Pharmacy Department Head)* will be considered to show the assessment of their interest values and analyze the differences between the expressions proposed.

The following basic goals have been identified. Although they do not specify the totality of the goals pursued by the project, they are sufficient to assess the interest of the stakeholders previously named:

– Minimize operative costs.
– Reduce stock levels.
– Use equipment efficiently.
– Minimize production overtime.
– Avoid changes in production planning.
– Reduce the medicines dispatches (i.e. trips) to hospitals and health centers.
– Reduce medicines stockouts in hospitals and health centers.
– Avoid erroneous forecasts.
– Reduce cycle time from order to delivery.

Great differences among diverse stakeholders' interests have arisen from the interviews carried out. In order to represent this situation and perform the assessments of the interest attribute, a value scale with range from 1 to 10 is used. Then, the object models associated with each stakeholder are shown in Figs. 9, 10, and 11. They represent the interest calculation for each stakeholder considering their particular interests and using (3) with weighting factor $p_i = 1$ for all the project goals. Comparing them, it can be deduced that the stakeholder *Central Pharmacy Director* has the greatest interest in the project, taking into account the goals analyzed.

In order to analyze the different expressions previously proposed, they are applied to the *Central Pharmacy Director* and *PIM Technical Director* stakeholders. Thus, the differences between the diverse values obtained can be discussed. The project goals and particular interests shown in Figs. 9 and 10 are considered.

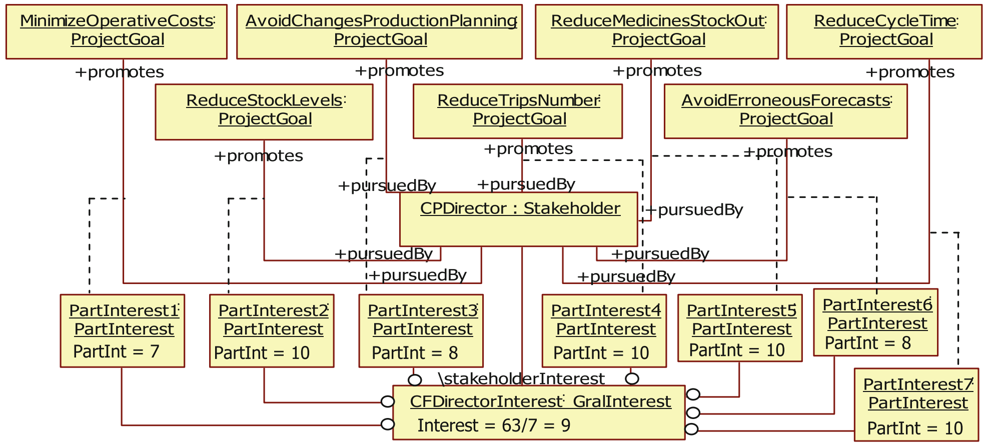

Fig. 9 Central pharmacy director interest model

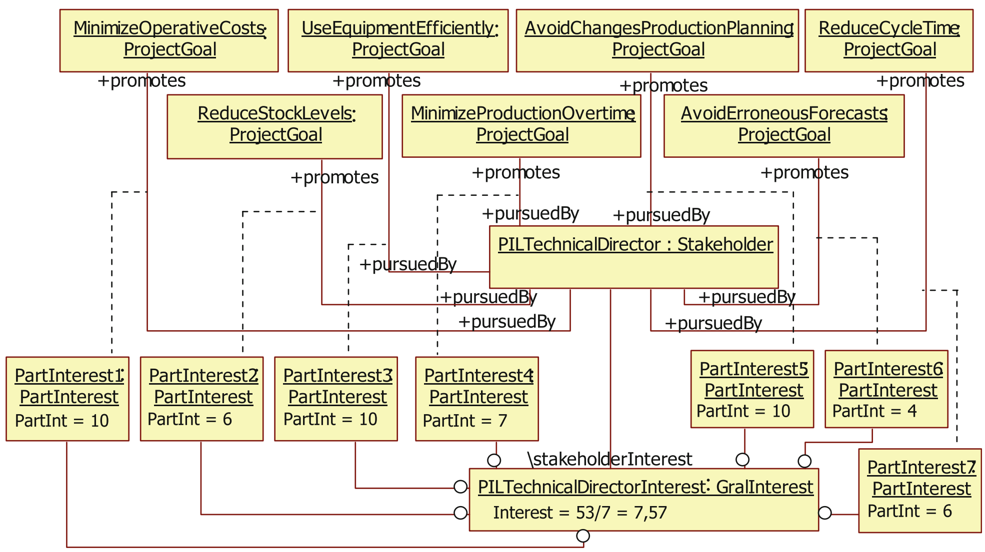

Fig. 10 PIM technical director interest model

(a) The following expression describes the calculation using the (1) with weighting factors $p_i = 1$ for all goals:

$$Interest_{CPDirector} = \sum_{i \in O_{CPDirecttor}} p_i * PartInt_{iCPDirector}$$
$$= \sum (7, 10, 8, 10, 10, 8, 10) = 63$$

$$Interest_{PIMTechnicalDirector}$$
$$= \sum_{i \in O_{PIMTechnicalDirecttor}} p_i * PartInt_{iPIMTechnicalDirector}$$
$$= \sum (10, 6, 10, 7, 10, 4, 6) = 53$$

(b) Also, the maximum value associated with the particular interests of the stakeholder can be considered using (2), as is shown below:

$$Interest_{CPDirector}$$
$$= \max_{i \in O_{CPDirector}} (PartInt)_{iCPDirector}$$
$$= \max(7, 10, 8, 10, 10, 8, 10) = 10$$

$$Interest_{PIMTechnicalDirector}$$
$$= \max_{i \in O_{PIMTechnicalDirector}} (PartInt)_{iPIMTechnicalDirector}$$
$$= \max(10, 6, 10, 7, 10, 4, 6) = 10$$

(c) Figures 9 and 10 use the following calculation based on (3):

$$Interest_{CPDirector} = \frac{\sum_{i \in O_{CPDirector}} p_i * PartInt_i}{\# O_{CPDirector}}$$
$$= \frac{\sum (7, 10, 8, 10, 10, 8, 10)}{7} = \frac{63}{7} = 9$$

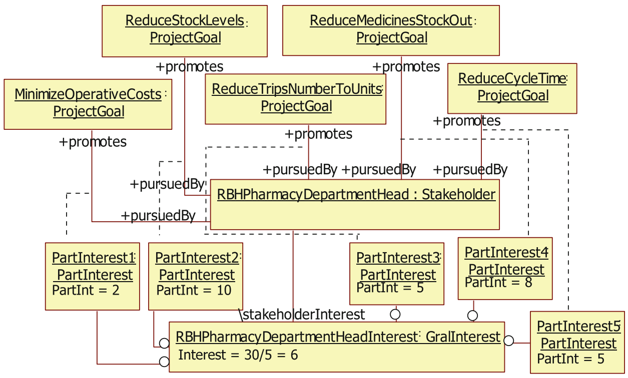

Fig. 11 RBH pharmacy department head interest model

$$Interest_{PIMTechnicalDirector} = \frac{\sum_{i \in O_{PIMTechnicalDirector}} p_i * PartInt_i}{\# O_{PIMTechnicalDirector}} = \frac{\sum(10,6,10,7,10,4,6)}{7} = \frac{53}{7} = 7{,}57$$

From the described examples, it can be noted that results vary. In expression (b) both stakeholders have the same interest meanwhile expressions (a) and (c) show different results for the interest of both stakeholders. Thus, the project team must select the appropriate equation that best fits to the pursued goals. Also different weighting factors can be proposed to remark their importance in the project.

As previously mentioned, another alternative for the numeric scale to evaluate the interest can include negative values to represent particular interests against the established goals. These negative values assess those project goals in which the stakeholder not only does not have any interest but also objects them.

For example, Fig. 12 shows the RBH Pharmacy Department Head interest model considering the goals "*Eliminate extraordinary orders*" and "*Automate order management*" for the project, with a scale from −10 to 10.

The interest sub-model supports various alternatives depending on the considered scenarios. In Fig. 12, the new goals considered were negatively evaluated by the RBH Pharmacy Department Head. For example, the elimination of extraordinary orders removes the procedure used when erroneous forecasts were considered, limiting the alternatives to fulfill the required demand.

Thus, the example in Fig. 12 introduces negative values in the numeric range to assess different goals. Moreover, other examples can be analyzed by selecting diverse numeric scales taking into account the scenario to be represented. This will depend not only on the specific project where the model will be instantiated but also on the importance or priority of the evaluated goals.

3.3 Stakeholder influence

Using the *Central Pharmacy Director* example and the power types detected for some stakeholders in the case study from Table 2; Fig. 13 shows the resulting object model for the calculation of his influence on the project. *RoleInf* values were extracted from Table 1. Considering the power types from Table 2, they are numerically evaluated in the range from 1 to 10. Thus, the *Central Pharmacy Director* stakeholder has been assessed 3 for *positional* power type and 5 for *personal* power type.

In order to apply consistent criteria, the formula used for the calculation of *StkInf* attribute in Fig. 13 combines the *Option 2* for both the role influence function, $f_s(RoleInfluence)$, and the function associated with power types exerted by the stakeholder, $f_s(Power)$. Nevertheless, the results of both functions

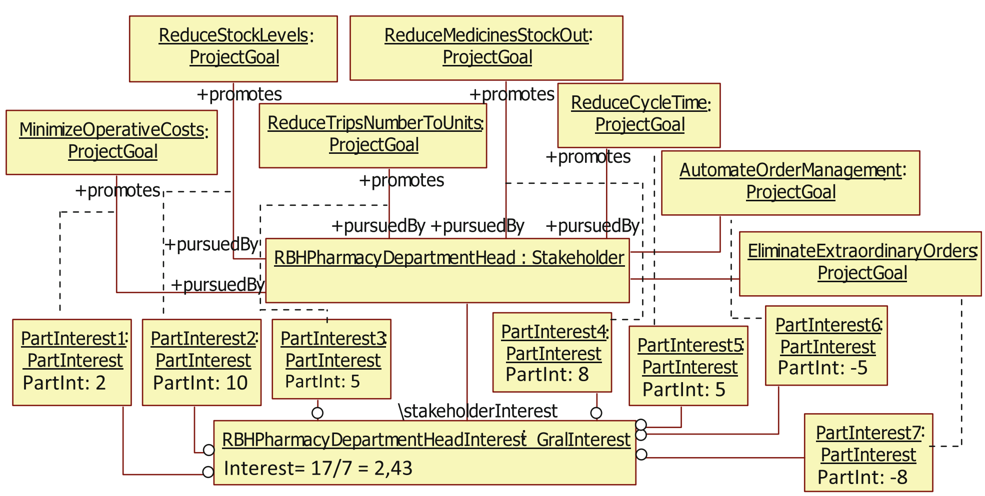

Fig. 12 RBH pharmacy department head interest model considering a scale with negative values

Table 2 Power types for stakeholders in the case study

Stakeholder	Power types
RBH pharmacy department head	Personal
Central pharmacy (CP) director	Positional
	Personal
Inputs planning department head	Personal
Health center assistant	Personal
Provincial health department director	Political
Regional health agency (RHA) coordinator	Positional
	Personal
Patient	Personal

have the same importance for the assessment of *StkInf* value, so ω_r and ω_p are both 1. Thus, the expression applied is:

$$StkInf_s = \max_{r \in R_s}(RoleInf_r) + \max_{t \in T_s}(Ppower_{ts}) \quad (9)$$

From Fig. 13, the information required to perform the calculation of a stakeholder's influence on the project is available, considering associated power types and evaluating the influence of his/her roles.

Alternative results can be derived for the calculation of influence using the different expressions presented, as it is shown afterward for the *Central Pharmacy Director* case.

(a) *f*(***RoleInfluence***) function can be represented by the following expressions:

(a.1) The addition of influences values of the roles associated with the stakeholder, with weighting factors equal 1 in this case:

$$f_{CPDirector}(RoleInfluence) = \sum_{r \in R_{CPDirector}} RoleInf_r = \sum(3, 8, 8, 2) = 21$$

(a.2) The maximum value of role influences associated with the stakeholder generates the following expression:

$$f_{CPDirector}(RoleInfluence) = \max_{r \in R_{CPDirector}}(RoleInf_r) = \max(3, 8, 8, 2) = 8$$

(b) *f*(***Power***) function can be described by the following expressions:

(b.1) The addition of power types exerted by the stakeholder (personal and positional in this example); in this case, with weighting factors equal to 1:

$$f_{CPDirector}(Power) = \sum_{t \in T_{CPDirector}} Ppower_{tCPDirector} = \sum(5, 3) = 8$$

(b.2) The maximum value of power types exerted by the stakeholder (personal and positional in this case), as follows:

$$f_{CPDirector}(Power) = \max_{t \in T_{CPDirector}}(Ppower_{tCPDirector}) = \max(5, 3) = 5$$

3.4 Stakeholders integrated model

Figure 14 describes the objects that result from the instantiation of the model in Fig. 1 applied to the example of the Central Pharmacy Director stakeholder, integrating partial models presented in the previous sections. The object *CPDirector* corresponding to the *Stakeholder* class appears duplicated in order to facilitate the figure

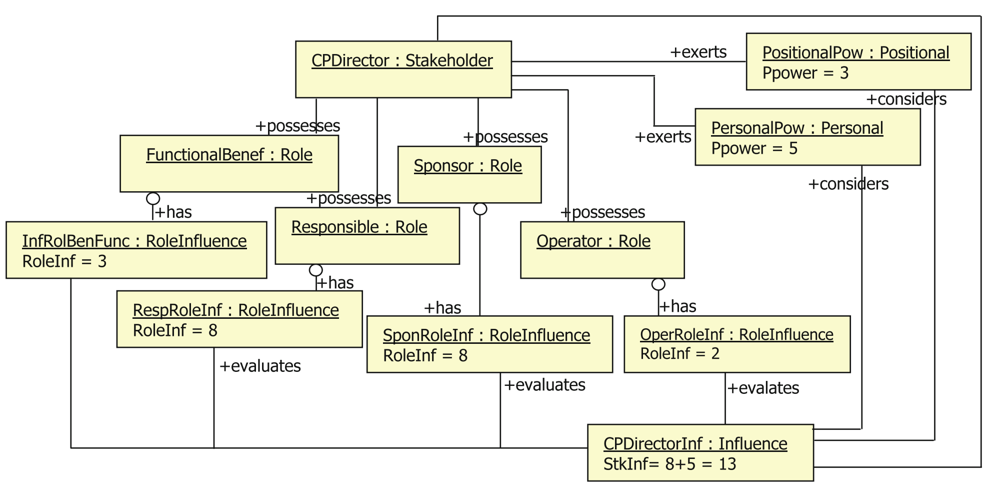

Fig. 13 Influence object model for the *Central Pharmacy Director*

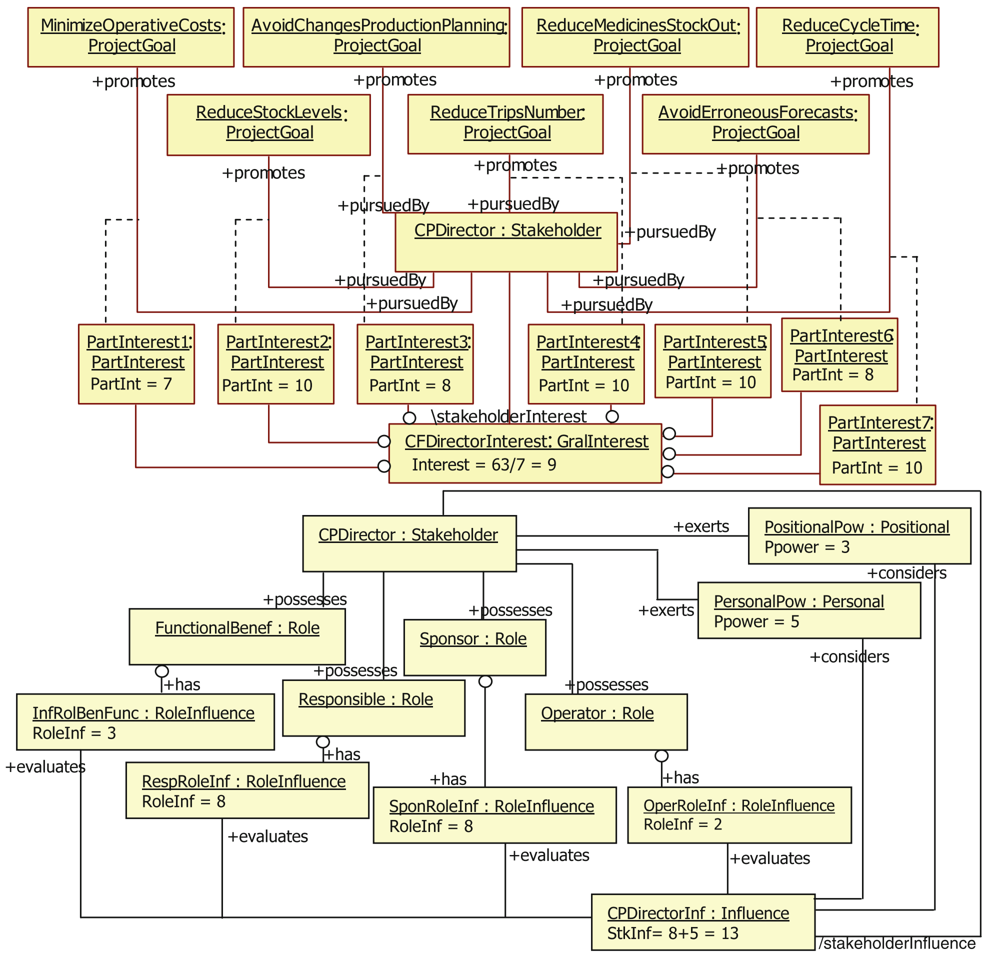

Fig. 14 Object model for *Central Pharmacy Director* stakeholder

comprehension. The model describes the values considered for this stakeholder representation and his associated attributes. This proposal can be systematically and dynamically used along the entire IS design and development project. Modifications occur when stakeholders learn more about the software during design and development or when internal or external conditions for using the software are altered, and thus, some conditions or properties must change in the model supporting the design [28].

4 Lessons learned and discussion

In general, during IS design and development processes, there has been a growing awareness of the need to consult with stakeholders. Nevertheless, such consultation has been often limited and confined to particular points in that processes. Thus, research has been required not only to manage and facilitate stakeholders' considerations and involvement in these processes but also to provide a model to represent them.

The presented case study was selected because it is a complete real example, involving the interaction of diverse organizations and stakeholders that must face together an IS design process.

The application of the model in the case study was driven in order to support stakeholders' interests and influences management all over the process, since their participation take place throughout it, not just at specific points. The model helped shaping the planning and implementation of the design process, in whose progress stakeholders were interested and involved and also contributed to the effective project team leadership, organizing stakeholder-related information. Through the stakeholders' modeling, a range of significant issues were revealed that would not otherwise have surfaced until implementation of the system and therefore too late to resolve without major wastage of resources. For example, information regarding the most interested and influencing stakeholders can be checked during the process. These stakeholders are the ones that will be really conducting the process, influencing decisions or, perhaps, making them.

The use of the model significantly increased the chances to guarantee an appropriate and consistent level of stakeholder information representation in the project, since the particular roles and power types of the specific project were instantiated. Nevertheless, the proposal allows the extension of the model to represent other roles and power types explicitly considered in particular projects.

The results presented in this paper demonstrate that stakeholder participation alone is insufficient to guarantee that stakeholders' views are considered in an IS design process. They need to be consistently represented in order to manage changes, relationships to product and project goals, etc. Moreover, the exclusion of any stakeholder perspective, either intentionally or as a result of poorly conceived procedures, will clearly limit the achievement of project goals. It also means that any decision reached by the project team is likely to be based on incomplete information and to have limited political support.

On the other hand, in order to consistently represent the information related to stakeholders, some procedure in order to evaluate and mitigate conflicts and discords between stakeholders' viewpoints and interests must be proposed and applied. Dissension among stakeholders can be originated due to "discrepancies in interpretation" or "discrepancies in evaluation". Discrepancies in interpretation refer to situations where the same requirement may be viewed or interpreted differently by diverse stakeholders, while discrepancies in evaluation refer to differences in preferences of the stakeholders regarding a particular requirement [17]. Although that is not the goal of this approach, any procedure to deal with them requires a previous representation of the stakeholders' attributes with the proposed model. For example, the technique introduced by Kaiya et al. [25] is oriented to detect requirements disagreements among stakeholders using an extended version of a goal-oriented requirements elicitation method. It profoundly analyzes the type of requirement discrepancy (in its understanding or in its evaluation) among stakeholders and, thus, proposes diverse ways to solve this situation. Nevertheless, this type of proposals goes beyond the purpose of this article, which materializes the representation of the final arranged values.

Also, Barragáns Martínez et al. [7] and Coakes and Coakes [18] describe proposals in this area. The former describe proposals in this area and afford disagreements analysis between the diverse stakeholders' points of view. They present a formal methodology to support the evolution of software specifications gathered from multiple perspectives. A viewpoint-based approach is used to explicitly separate the descriptions provided by different stakeholders and concentrate on identifying and resolving conflicts between them. The latter describe a method for modeling the conflicting and competing data with multiple perspectives of participants and stakeholders improving interactivity and conflict management.

Diverse strategies also need to be managed and integrated to the model proposed in order to face stakeholders' pressures and preferences. Pressures take place principally in global projects, where generally, the most demanding stakeholders are the external ones [1]. In order to enhance the implementation scope of the proposed model, the strategies proposed by Aaltonen and Sivonen [3], among others, can be analyzed and represented. With reference to stakeholders' preferences, they must be evaluated and modeled considering diverse evaluation criteria. Kodikara et al. [26] describe a procedure for preferences elicitation and evaluation using the multi-criteria outranking method Promethee and using as application example an urban water supply reservoir system. They select and work with three main stakeholders groups.

A lesson learned from the case study is that for large-scale projects (for example, in the area of e-government), there could be many hundreds of stakeholders, far too many to directly involve and represent them in the process [30, 31]. Thus, some grouping or clustering techniques must be applied in order to find diverse sets of stakeholders with certain similarities or sharing certain attributes, and so, treat them as a sole stakeholder. Fletcher [20] proposes another way to manage many stakeholders in large-scale projects through grouping or clustering. Although it was proposed for coastal management processes, it may be useful for the information systems area. The author promotes the inclusion of stakeholders' views indirectly on a representative basis, in which stakeholder groups nominate a delegate to participate in the process and to express their interest. This constitutes the main goal for future research.

The proposed model must be integrated to the model representing design requirements, in order to integrate changes and evolution of the involved elements. Thus, the complete design process can be managed in order to consistently obtain the desired IS design. In relation to this, for example, Roldán et al. [35] describe a tool for capturing and tracing engineering design processes. They affirm that during design processes, several models are generated, which have different levels of abstraction of the object being designed. Nevertheless, they do not consider in the tool the stakeholder concept in order to take into account important information related to changes in the diverse models that are managed. So, the integration of the model supporting the tool with the model here proposed can result in a more robust application, by incorporating stakeholder-related knowledge.

Furthermore, the model allows the design process to find a feasible set of needs across stakeholders, and then generate solutions that will be understood by, and can obtain support among the stakeholders.

As conclusion, from Gable et al. [21], the relation between IS success and the consideration of multiple stakeholder perspectives is direct. These authors consider the success in an IS development as a formative construct which must integrate different views from diverse stakeholders, since it has not only organizational impact but also individual impact for each involved stakeholder.

5 Conclusions and future steps

The article has addressed an important issue in ISs engineering: the latent need of involving and supporting stakeholders and their perspectives in ISs development processes. A model was proposed for representing stakeholders, their roles, as well as their interest and influence attributes, in order to consider a system development approach that includes and take into account their points of view from early stages. Thus, the existing gap between stakeholders' needs (problem domain) and system requirements (solution domain) is reduced.

The model proposed not only supports the representation of stakeholders but also enables the appropriate management of their attributes, including its assessment. Previous approaches were based on qualitative proposals where stakeholders' attributes were evaluated through subjective recommendations. This model supports the data required to calculate quantitatively diverse attributes based on information related to the project. Though this article emphasizes interest and influence assessment, this approach can be extended to include other stakeholder attributes. Taking into account the available data, several expressions can be formulated in order to fulfill project team requirements. Thus, stakeholder attributes can be managed with a consistent and systematic approach throughout the management of the complete IS development process.

The presented model can be integrated to other IS design processes models, and thus, the social dimension will be appropriately considered. In this way, a new approach based on the design with users instead of the design for users can be attained, taking into account that stakeholder-related knowledge can be represented with new and appropriate tools for supporting design-related activities, including their concerns.

This approach not only helps in the common understanding of the IS design process but also supports the coordinated efforts required for its development. The diverse activities that compose the process will be linked with the stakeholders capable of executing them. Also the satisfaction level is assured, since stakeholders' needs are considered from early design stages. By representing stakeholders in systems models, diverse issues can be analyzed and addressed such as conflicts and disagreements between them, rationale behind requirements, etc.

Nowadays, from the organizational point of view, new structures can be recognized. The proposed approach assumes stakeholders can take part in new organizational forms, including diverse types of interorganizational networks. This perspective has been taken into account, and thus groups and organizations are included and considered as stakeholders in the process. Also, considering that different and opposite goals are feasible in this contexts, this model admits the link between stakeholders, organizations and objectives, allowing their integrated management.

Finally, this proposal is a first step in the integrated management of stakeholders in IS projects. New attributes can be incorporated in order to facilitate changes during the project lifecycle.

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