

A NEW FORMALIZATION OF DECISION-MAKERS' NEEDS

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ABSTRACT: The development of a BI project goes through several phases. The analysis phase remains an upstream phase, which requires further investigation to overcome the major problems that arise during this phase and to anticipate the resolution of other problems that may arise in the other phases for the development of these BI projects. The complexity of the formalization of the decision-makers' needs (DN) is one of the problems that has been tried to be solved by proposing a new version of the meta-model of the formalization of informational goals, which have been implemented with models. This new version of the meta-model will facilitate to the analyst-designer the identification of decisional data from a set of decision-makers' goals, from which the facts' and dimensions' parameter of the star schemas can be extracted. In the remainder of this paper, the first part provides a state of the art of the DN formalization approaches and their models of representation, then the second part presents our new version of the meta-model of the goals' formalization, and, finally, this work is completed with the conclusions and a future work part.

Keywords: *Decisional information systems, Decision-makers' needs formalization approaches, Decision-makers' requirements engineering, Start schema, Semantic model.*

1. INTRODUCTION

In the enterprises, decisional information systems (DIS) have become indispensable to help in making the decision. According to earlier studies, about 60% of the errors in the projects of system development come up during the Requirements Engineering (RE) phase [1], a relatively young field of research: until the end of the 80s was still referred to as "analysis" to qualify the upstream phase of system design; the analysis phase is essential to produce the specifications of the system to be developed. This engineering, also named decision-makers' needs engineering, is defined by Nuseibeh and al. [2] and Bourque and al. [3], as a discipline that takes care of : elicitation, analysis, specification, validation and management of needs and constraints for the construction of a system phases; otherwise in conventional information systems, RE is presented by Rolland and al. [4] as a process that derives the requirements through the exploration of the actors' objectives and the activities to reach these latter.

Several approaches have been proposed to analyze the decision-makers' needs. These approaches are oriented by a process formed by a set of phases which are broken down into a set of steps; this process is accompanied by models of representation of the needs during the analysis phase (Fig. 1).

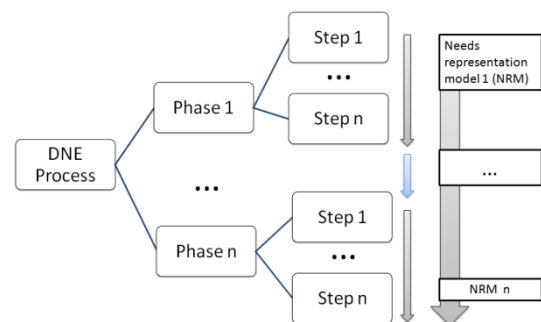


Fig.1 Decomposition of DNE process

Among the phases of this process, the phase of the formalization of the informational goals that are already processed and validated during the previous phases, and which are ready to be formalized, in order to facilitate the production of the decisional data table in the last phase of this DNE process, knowing that the current models of formalization of needs still have a gap between the formalization of the decision-makers' needs and the multidimensional representation of the data in the star schemas in the second phase of the development of the DIS, namely the design phase.

In the formalization of decision-making needs (DN), the vast majority of DNE approaches are based on the following concepts: goal or scenario. These two concepts are the source of three types of approaches: Scenario-Oriented Approaches, Goal-Oriented Approaches and approaches generated by the couple: goals and scenarios at the same time.

The remainder of this paper is decomposed into four sections: Section 2 presents a state of the art of the approaches of the DN analysis. In Section 3, we present our new conception of the formalization of the DN. Section 4 contains an example of implementation and illustration. This work will be completed by conclusions and future works in section 5.

2. RELATED WORKS

For The success of the NE project relies heavily on the success of the NE process, which typically consists of the following phases:

1. Elicitation of the needs: A phase that helps to understand the organizational situation and the expression of needs [5], [6], [7], [8], [9].
2. Specification: Defines the relation between the business objective and the functional and non-functional components of the system [10], [11], [4], [12].
3. Negotiation: The phase in which the deliberation context of the whole process is defined [13], [14].
4. Validation: phase of validation of the system specifications with regard to the needs expressed/expected by the users [15], [16].

To ensure the quality of this process, it is essential to have appropriate techniques, approaches and tools; the choice of these three elements influences the quality of the resulting

needs.

The next section provides a look at the Goal-Oriented Approaches, followed by a review of the approaches that combine goals and scenarios.

2.1 The Goal-Oriented Approaches

According to Ben Achour [17], a goal is defined as "Something that someone hopes to achieve in the future". In other works, a goal can be defined as "an objective to be achieved in the future system" [18]. In other words, a goal is an image of an intention, which is subsequently operated on by a set of objectives that are planned to be realized in a precise duration, without specifying how they can be reached. It is associated with a result that we want to have and materialize by a set of object states.

2.1.1 Structure of a goal

In general, the goal is expressed in natural language, and formalized according to a structure composed of a verb accompanied by a set of parameters; each of them has a semantic function and provides in their instances answers to the different questions that are around that verb: who, what, when, how much, how etc.

This structure is proposed at the beginning in the works of Prat [19] (Figure 2) which in turn relies on the grammar of the cases of Fillmore [20] and on its extensions. This goal structure is subsequently improved in other works [21], [22]

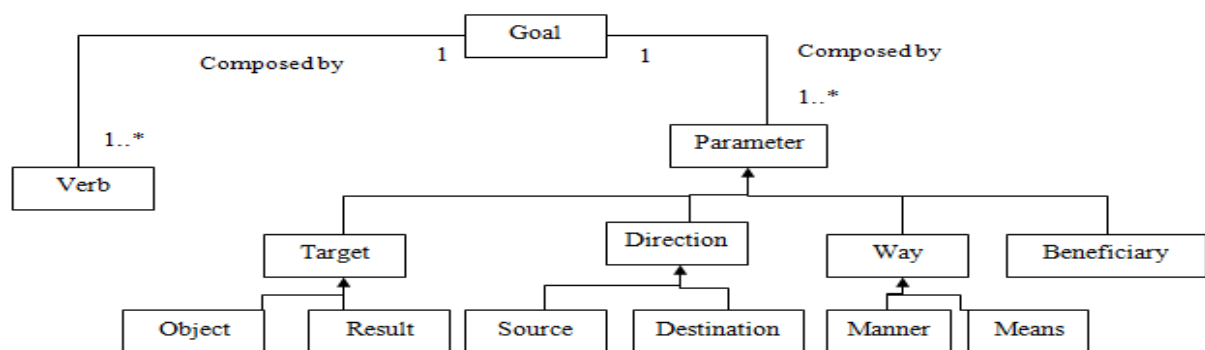


Fig.2 Structure of a goal [Prat, 1999]

In this structure, there are mandatory components to define: the verb and the target, but the other parameters are optional:

- **Target:** The target is a complement to the action concerning the entities affected by the goal. There are two types of targets: the object and the result. The object exists before achieving the goal

and may, eventually, be modified or deleted by the goal; whereas the result is the entity resulting from the realization of the goal designated by the action.

- **Quantity:** it measures the quantity of the object that should be produced.
- **Quality:** This is a property that must be achieved or preserved.

- **Direction:** Contains two types of directions named: source and destination, their role is to identify, respectively, the initial and final locations of the object:
 - ✓ Source: Represents the starting point of the goal (source of information or physical location).
 - ✓ Destination: Represents the ending point of the goal (to whom or to what).
- **Beneficiary:** Expresses the person or group for whom the goal should be obtained.
- **Way:** It consists of two parameters:
 - ✓ The manner: Specifies how the goal can be achieved.
 - ✓ The means: Specifies by what means (tool) can the goal be achieved.
- **Locality:** It positions the goal with regard to space.

- **Time:** It positions the goal with respect to time.
- **Reference:** it is the entity according to which an action, of the fact table, is performed or a state is achieved or maintained.

The advantage of using natural language is to simplify and to facilitate the manipulation of these intentions, which are represented in the form of a linguistic formulation, and their understanding by the different actors/participants in the Decisional Information Systems (DIS) and more particularly in the process of the RE. In Elgoli's work [22], she was inspired by this linguistic formulation and she proposed a new version in the form of a meta-model (Figure 3) expressing the semantics and facilitating automatic exploitation while remaining understandable by the actors.

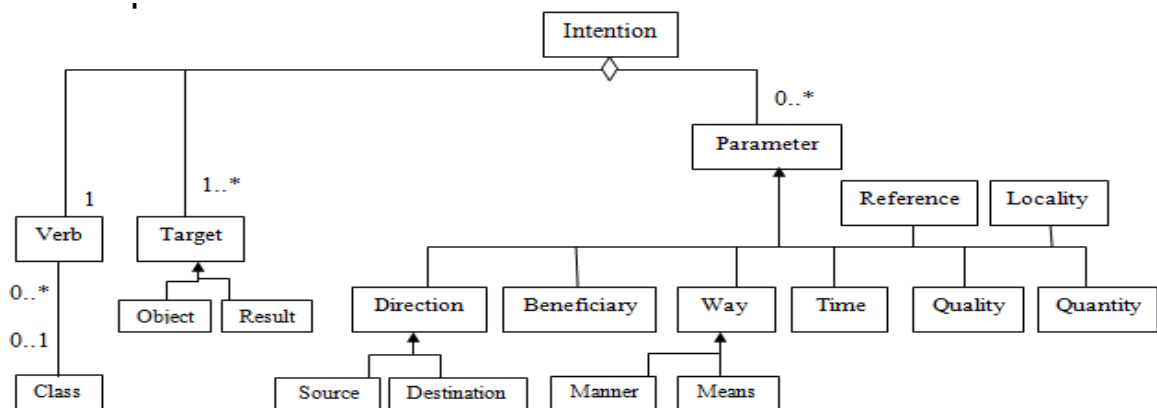


Fig.3 Linguistic meta-model of Intention in UML notation [ELGOLLI, 2008]

By following the same approach, Sabri [23] in her work, extended this work of Elgoli [22] by trying to make appear the facts' parameters and the dimensions' parameters at the moment of the semantic representation of the informational goal (Figure 4), to facilitate the way for the operational actors of the DIS to develop the decision data dictionary on which we will base to build the multidimensional star schema.

2.1.2 Levels of goal abstraction

In general, a goal is decomposed into sub-goals. The treatment and decomposition of a goal into sub-goals have been studied in several works that can be decomposed according to three categories:

- The first category: includes AND / OR [11], [24], [25], [26] and [27] reduction graphs which have inspired this method of artificial intelligence [28].

A goal 'A' can be decomposed into several sub-goals: A1, ... An

If an AND relation is associated with goals {A1 AND A2}, {A1 AND A3} ... implies that all of these goals must be achieved to achieve the desired result of goal A and that one cannot replace the other.

In this case, the satisfaction of one goal (A1 for example) ensures the satisfaction of the other (A2).

- The second category: several approaches have extended the method used in the first category, with some variations from one approach to another; there are those that have adopted a new hierarchical organization of goals based on the relations AND, OR and REFINED BY [29]; this last link "Refined by" is deduced when the two goals share a syntactic part of the goal and are complementary, but do not aim at the same result.

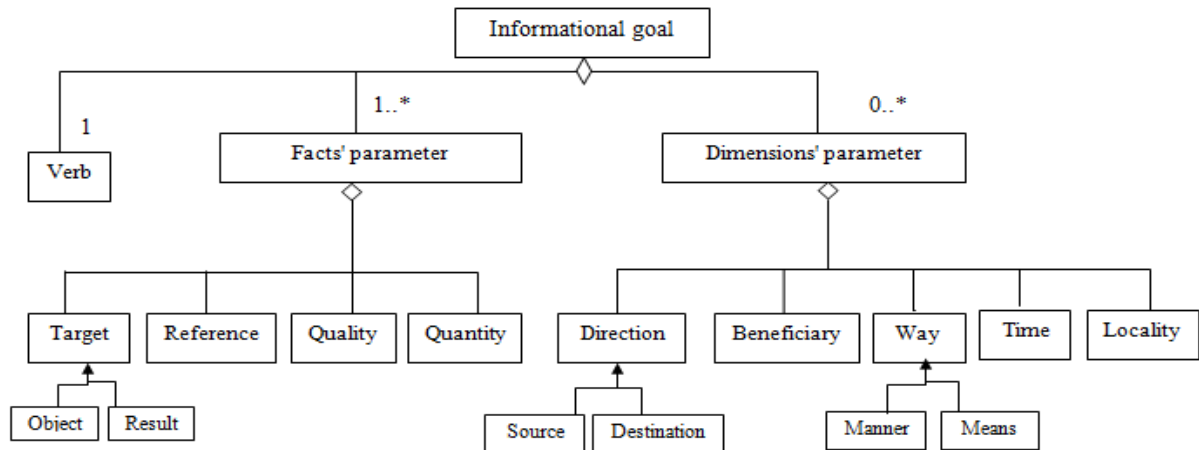


Fig.4 Semantic model proposed to represent an informational goal [Sabri et al., 2015]

In other works, another type of "complemented" link is used to represent a particular case of the OR relation; this link is used to express a relation between two goals that share a syntactic part and the two syntaxes are complementary and aim to achieve the same result [23].

2.2 Goal-Scenario directed approaches

The objective of these approaches is to discover the needs of the system by coupling each discovered goal with a scenario that illustrates the behavior of the system to achieve the goal.

A goal is "intentional" while a scenario is "operational". Therefore, it is possible to combine the two concepts. Each goal can be attached to one and only one scenario (which operationalizes it), and each scenario describes the steps and constraints of achievement (describes a possible behavior of the system to achieve the goal) of one and only one goal. The couple <goal, scenario> is named a fragment of need [33] (Figure 5) and explains a part of the specification of the system to be realized. The fragments of needs can be classified at various levels of abstraction: the contextual level to which the services rendered by the system in the context of the organization are identified, the level of interaction in which the behavior of the system is described and the interactions which must carry out with its users, and the physical level in which the behaviors of the internal objects of the system are described.

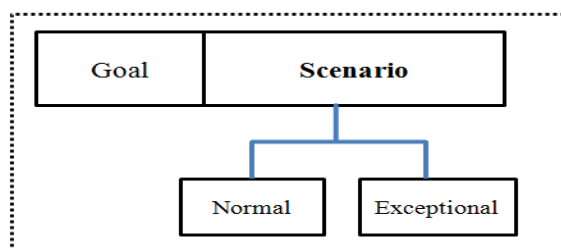


Fig.5 Need fragment

This approach was evaluated through four different experiments:

I) Workshops [33],

II) Case study [29]: Four characteristics that contribute to the satisfaction of the discovery of the needs of the system: 1. The notion of a fragment of need is defined as the couple <goal, scenario>. 2. The hierarchical organization of needs is based on the relations AND, OR and refined by, between fragments of needs. 3. The elicitation process is based on a bidirectional movement between a goal and a scenario. For a given goal, a scenario is written to illustrate its realization. 4. A methodological help, in the form of semi-automatic rules, is implemented by the software The'Ecritoire,

III) Empirical studies [52],

IV) CREWS-Ecritoire project [34].

The results obtained by these experiments validated the applicability and effectiveness of this approach. The ECRITOIRE approach [53] is the software application of the CREWS approach [34]. It interprets and transforms a scenario to ensure its consistency, completeness and conformity to the goal. It proposes: 1) methodological guidelines for writing textual scenarios (written in the natural language) and software tools to check their correction; 2) scenario analysis rules helping to discover variants, exceptions and complements of a given scenario; and (3) a formalization of the process while guiding its development.

3. PROPOSAL

To introduce our new formalization, an activity diagram has been developed (Fig. 6) that illustrates our approach to the DN analysis, to which this work has been applied. This approach can be done

in five main processes. The first one consists in the collection of the DN to define all the actors' expectations using the natural language. The second allows to classify the decision-makers' needs into three types of goals (strategic, tactical and informational) by specifying the compositional relationship between the strategic goals and the tactical goals and between the tactical and the informational goals; also the analyst - designer by attending a business expert can decompose each strategic goal into other tactical goals and each tactical goal into several informational goals. The third process details the treatment of identified needs in the form of goals, and for this step, several rules have been developed and implemented in a proposed algorithm [33]. The fourth is related to the formalization of the informational goals that are treated during the previous processes. The remainder of this paper will detail this process and how to move on to the fifth process that is intended for the production of the decision data table.

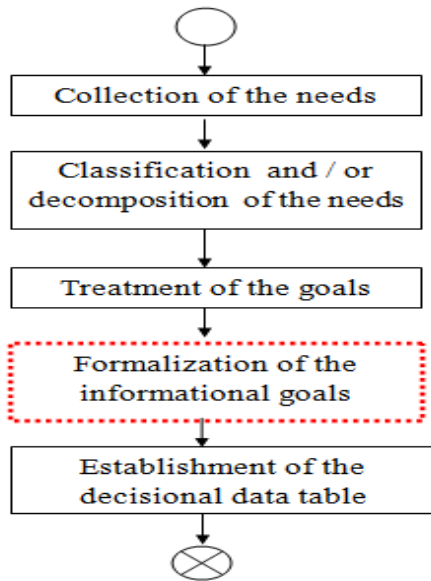


Fig.6 Process of the DN analysis

The decision-makers' goals are classified into three levels of abstraction. In the formalization of the goals, the interest is in the last level of abstraction which contains the informational goals, since they represent the source of the decisional data that make it possible to establish the multidimensional schema. This part of the paper represents, on the one hand, the levels of abstraction of the decision-makers' goals, and on the other hand, our semantic meta-model of an informational goal.

3.1 Levels of the decisional goal abstraction

In the decisional field, a strategic goal (level 1) does not offer an operational view and must be decomposed into tactical goals, this level (Level 2) does not yet give us the possibility to deduce our facts and our dimensions; thus we move on to the third level (level 3), which is operational, by dividing each tactical goal into a set of informational goals (Figure 7)

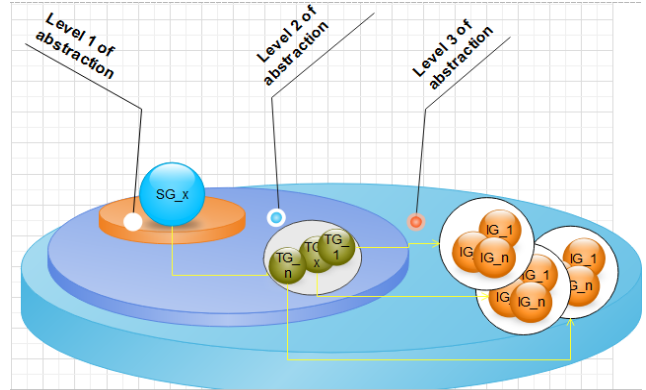


Fig.7 Levels of the decisional goal abstraction

Therefore, each decisional need (n) is decomposed into a set of strategic goals (SG) and each strategic goal i is presented as a set of tactical goals (1 to n), thus:

$$DN = \sum_{i=1}^n SG_i \quad (1)$$

$$\text{Such as } SG_i = \sum_{j=1}^n TG_j \quad (2)$$

And for every tactical goal j of the strategic goal i, it is, itself, presented as a collection of informational goals (from 1 to m), we have:

$$TG_j = \sum_{k=1}^m IG_k \quad (3)$$

In DNE's approach, DNs are classified according to these levels of abstraction. Hence the classification of decision-making goals into three categories: strategic, tactical and informational (Figure 8).

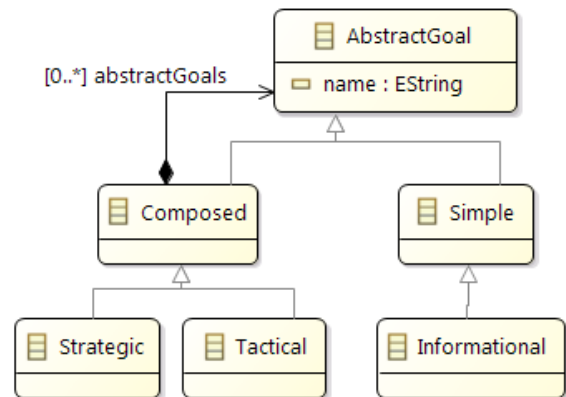


Fig.8 Meta-model of the decision-maker goal' types

The treatment and decomposition of a goal into sub-goals have been studied in several works as mentioned in the previous section. These works, generally, define the relationship between the goals by a relation of composition "AND", "OR" And "Refined by" [12], or in others with "AND", "OR", "Refined by" and "completed by" [11], this type of relationship does not give an exact and a solid criterion for the treatment of goals. This work is generally based on the intentions of the decision-makers and the analyst-designer, the thing that causes several problems. From one analyst-designer to another, one finds a difference in the establishment of these relations because of the ambiguity in the intentional difference between "AND" and "OR". In order to link these goals, one to another, a more appropriate criterion is defined, which will make it possible to unify the different intentional interpretations linked to the treatment of the same goals between different analysts-designers.

Our new formalization of a decision-maker's goal was inspired by the psychological work of Ajzen [34], which treats the origins of an intention, according to the theory of planned behavior, human action is guided by three kinds of considerations: beliefs about the likely outcomes of the behavior and the evaluations of these outcomes (behavioral beliefs), beliefs about the normative expectations of others and motivation to comply with these expectations (normative beliefs), and beliefs about the presence of the factors that may facilitate or impede the performance of the behavior and the perceived power of these factors (control beliefs). In their respective aggregates, behavioral beliefs produce a favorable or unfavorable attitude toward the behavior; normative beliefs result in perceived social pressure or subjective norm, and control beliefs

give rise to perceived behavioral control. In combination, attitude toward the behavior, subjective norm, and perception of behavioral control lead to the formation of a behavioral intention. As a general rule, the more favorable the attitude and the subjective norms are and the greater the perceived control is, the stronger the person's intention should be to perform the behavior in question. Finally, given a sufficient degree of actual control over the behavior, people are expected to carry out their intentions when the opportunity arises. The intention is, thus, assumed to be the immediate antecedent of behavior. However, because many behaviors pose difficulties of execution that may limit volitional control, it is useful to consider perceived behavioral control in addition to the intention. To the extent that perceived behavioral control is veridical, it can serve as a proxy for actual control and contribute to the prediction of the behavior in question. The following figure is a schematic representation of the theory.

The intention is therefore supposed to be the immediate antecedent of the behavior. However, because many behaviors pose performance difficulties that may limit volitional control, it is useful to consider perceived behavioral control in addition to the intent. To the extent that perceived behavioral control is truthful, it can serve as a proxy for actual control and contribute to the prediction of the behavior in question. The following figure is a schematic representation of the theory (Figure 9).

Understanding the origins of the invention, it is proposed to work in a benchmark of two dimensions one of time and the other of place (context or situation).

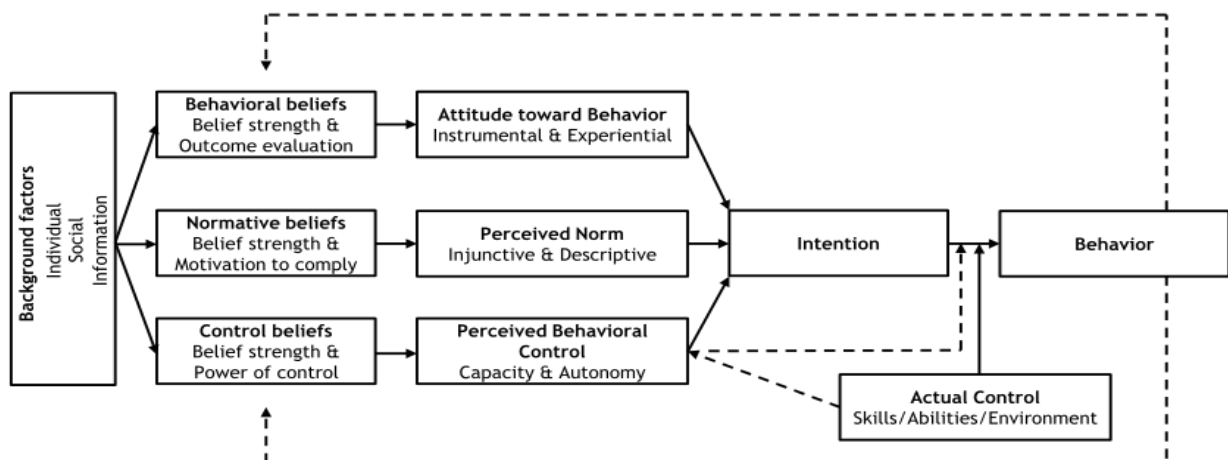


Fig.9 Model of Ajzen's planned behavior theory

This work has been extended considering that any goal, as a representative of an intention, occurs in the form of a behavior; this goal has a "result" (What) to attain and a set of resources (means) to be used to achieve it by following a method (manner) of implementation of these means to arrive at the result of the goal (this is the "HOW to reach it"), these means and manners are called "Canal". Each result is represented in the form of a set of actions and each canal is decomposable into a set of means, and a set of manners that explain the method of implementing the means.

We have :

$$\text{Result} = \sum_{i=1}^n \text{Action } i, \text{ AND}$$

$$\text{Canal} = \sum_{i=1}^n \text{Means } i + \sum_{j=1}^m \text{Manner } j,$$

These relations (4) and (5) are represented in the form of a meta-model which explains our structure of the decision-makers goal as a function of time and context (Figure 10):

This new representation of the decision-makers' goals represents, for all levels of abstraction, a good solution to the problems of the needs processing phases in the analysis process of the DN (Figure 11).

To model the abstraction levels of a decision-makers' needs, the following model has been defined (Table 1)

The analyst-designer can represent the links between the goals of the same type by the relations' matrices between the {Strategic / Tactical / Informational} goals. The link is a combination of {R: same Result, ¬R: Different result} And {C: same Canal, ¬C: Different canal}. Afterward, this matrix is treated with a set of rules that have already been developed according to the possible cases [33].

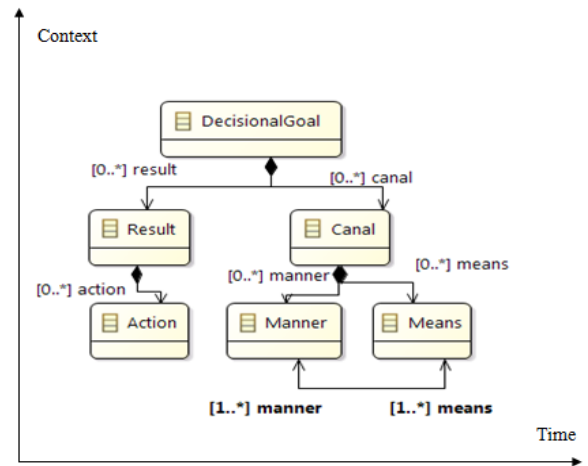


Fig.10 Structure of a decision-maker goal as a function of time and context

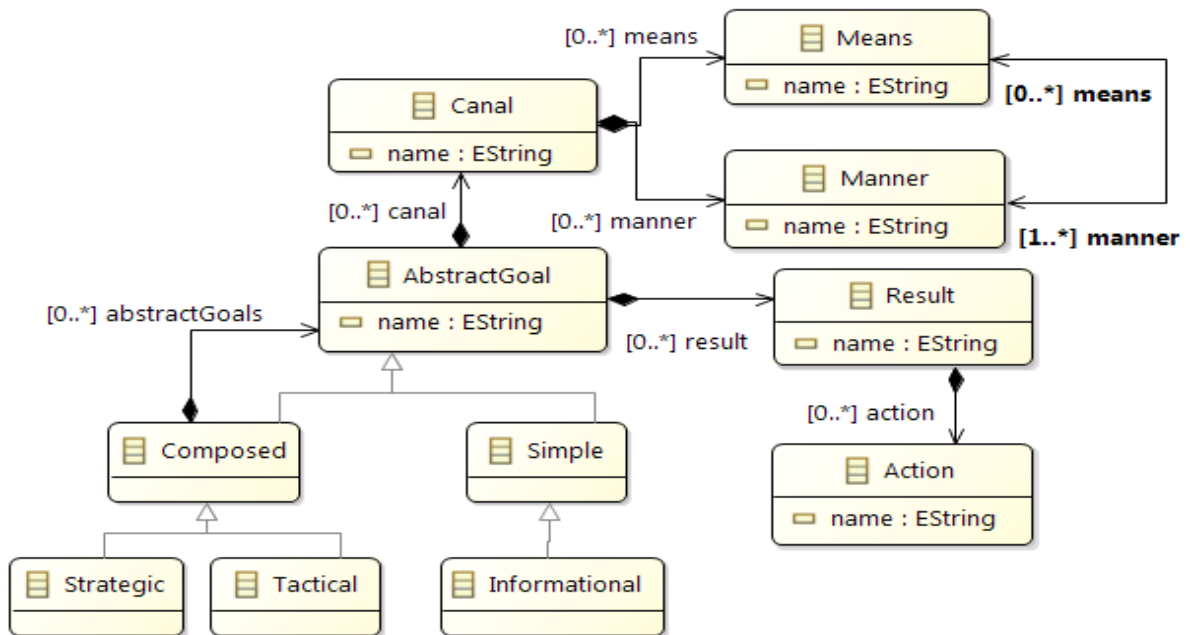


Fig.11 Meta-model of a decisional goal

Table 1 Goal classification model by level of abstraction

Decision-makers need x: DN code.		
Strategic Goal x	Tactical_goal_x _1	IG_x_1_1
		...
		IG_x_1_m
	Tactical_goal_x _n	IG_x_n_1
		...
		IG_x_n_m

3.2 Our semantic meta-model of an informational goal

The informational goals are expressed in a natural language, and they belong to the level 3 of abstraction, which is the operational level; the transition from this level to the extraction of facts and dimensions, to be included in the multidimensional model, is feasible.

To facilitate the extraction of the facts and the dimensions from this meta-model, a new formalization structure of the informational goals has been defined by dividing each one (informational goals) into two sections: the "indicators on the facts" section and the "indicators on the dimensions" section (Figure 12):

We have :

$$IG\ k = \begin{cases} \text{Indicators on the facts} \\ \text{Indicators on the dimensions} \end{cases}$$

From these indicators, the analyst-designer can extract the decision-maker data (<facts,

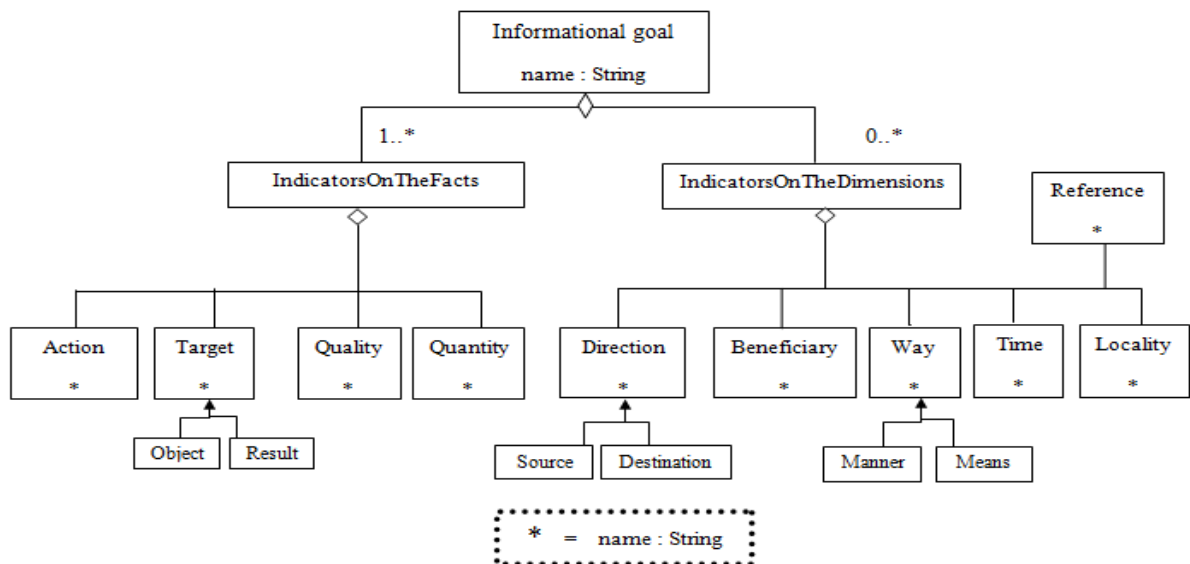


Fig.12 Linguistic meta-model to represent the informational goal

Measurement> ; <dimensions, attributes>) to build the multidimensional star schema, and this will be done directly from the formulated sentences under the form of informational goals, expressed by different DIS actors.

The section of the "indicators on the facts" allows us to determine the fact table and its measurements; this section is related to the section of the "indicators on the dimensions" that allows us to determine one or more dimensions' tables with their attributes.

In comparison to the intention's linguistic meta-model of EL Golli [21], it very interesting to mention explicitly the "indicators on the facts" and the "indicators on the dimensions", which will simplify the discovery of the fact tables and the

dimension tables, hence the deduction of the multidimensional schema. For this reason, the structure of the informational goals has been redefined by introducing the concept of the "indicators on the facts" and "indicators on the dimensions".

The "Indicators on the facts" section contains the parameters that comprise the fact table, and the second section named "indicators on the dimensions" includes the parameters of the dimension tables:

1) "Indicators on the facts" section:

As shown in "Table 2", this section consists of an "action", a "target" and other "indicators". Each indicator plays a specific role in regard to the action. In this structure, the action and the target

are mandatory, and other "indicators" are optional:

- **Action:** It is usually in the form of a verb or a noun that limits the boundaries and the semantic interpretations, and indicates the possible semantic functions for other indicators.

(e.g., Rate (Action), Increase (Action) Calculation of (Action), analysis (Action) ...).

- **Target:** The target is a complement to the action concerning the entities affected by the goal. There are two types of targets: the object and the result. The object exists before achieving the goal and may, eventually, be modified or deleted by the goal, whereas the result is the entity resulting from the realization of the goal designated by the action (e.g., rate (Action) number of clients (Object)).

- **Quantity:** it measures the quantity of the object that should occur (e.g., Increase (Action) Price (Object) by 7% (Quantity)).

- **Quality:** This is a property that must be achieved or preserved (e.g., Stay (Action) the first telecom operator (Quality) at the national level).

2)"indicators on dimensions" section:

This section represents the dimension tables and is composed of a series of indicators which will allow us to build one or more dimension tables with their attributes:

- **Direction:** Contains two types of directions named: source and destination; their role is to identify, respectively, the initial and the final locations of the object:

Source: Represents the starting point of the goal (source of information or physical location). (e.g., establish (Action) the commercial plan (Object) from the established market studies (Source))

Destination: Represents the ending point of the goal (to whom or to what). (e.g., Provide (Action) sales' dashboards (Object) for decision-makers (Destination)).

- **Beneficiary:** Expresses the person or group for whom the goal should be fulfilled (e.g., Ship (Action) the purchasing report (Object) for the CFO (Beneficiary)).

- **Way:** It consists of two parameters:

The manner: Specifies how the goal can be achieved.

The means: Specifies by what means (tool) can the goal be achieved.

- **Locality:** It positions the goal with regard to space (e.g., define (Action) the estimated production plan (Result) for the production unit (Locality)).

- **Time:** It positions the goal with respect to

time (e.g., Sale (Action) every X brand product (Object) in seven months (time)).

- **Reference:** it is the entity according to which an action, of the fact table, is performed or a state is achieved or maintained (e.g., Adjust (Action) the SMS price (Object) to the minimum price of the competitors (Reference)).

To retrieve the fact table and its measurements associated with the indicators on the facts, two types of indicators are to be considered:

- *Indicators on the fact table:* The name of the fact table can be inferred from the "Action" indicator and the "object" element of the "Target" indicator.

- *Indicators on the measurements:* These indicators constitute the measurements of the fact table: the "Quantity" indicator which represents the "How many/much" of the things and the "Quality" indicator that represents the "How".

Table 2 defines the structure that will be adopted for the formalization of the indicators on the facts:

Table 2 Formalization model of the indicators on the facts

F.I I.G	Action	Target		Quality	Quantity
		Object	Result		
IG i	What to do?	What?		How is it?	How many?

To infer the dimensions of the fact table, they need to be extracted from the indicators on the dimensions. These indicators are split into two categories:

- Indicators on the dimension tables only: "Time" represents a dimension table of dates, "Destination" and "Locality".

- Indicators on the dimension tables and/or on the dimensions' attributes: "Source" of the indicator "Direction" can take both roles (dimension table or its attribute) "beneficiary", "Means", and "Reference" which can be either a measurement or a fact table (in another context) that is considered a dimension table for our fact table.

For the formalization of the indicators on the dimensions of an informational goal, the following model is defined:

Table 3 Formalization model of the indicators on the dimensions

ID IG	Direction		Beneficiary	Way		Locality	Time	Reference
	Source	Destination		Means	Manner			
IG i	From what?	Aimed at whom?	For whose benefit?	Using what?	How to do it?	To what place?	For how long or on what date?	Compared to who / what

4. CONCLUSIONS

Throughout this paper, a state of the art on DN analysis approaches was presented; and by studying the origins of an intention in the theories of psychology, these works have been extended in order to see how to realize these intentions by representing them in the form of a new structure, which will help us to deal with the different DNs, according to their three levels of abstraction: strategic, tactical and informational in the process of the analysis of the DN.

In order to facilitate the extraction of facts' indicators and dimensions' indicators, the focus has been on the informational goals as they represent the source of the decisional data that make it possible to establish the multidimensional schema. In order to systematically extract these decisional data, the informational goals must be formalized.

A new version of the meta-model for the formalization of the informational goals has been proposed, in which two sections are available: indicators on facts and indicators on dimensions, each of these sections contain a set of mandatory and optional parameters; this meta-model has been instantiated using several models.

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