UNIVERSITY
OF TRENTO

DEPARTMENT OF INFORMATION AND COMMUNICATION TECHNOLOGY

38050 Povo – Trento (Italy), Via Sommarive 14
http://www.dit.unitn.it

Requirements Engineering for the Business Process re-engineering: an example in the Agro-Food Supply Chain

Paolo Bresciani, Floriana Marin, Lucia Martinelli, and Fabrizio Sannicolò

Nov 2003

Technical Report # DIT-03-080

REQUIREMENTS ENGINEERING FOR THE BUSINESS PROCESS RE-ENGINEERING: AN EXAMPLE IN THE AGRO-FOOD SUPPLY CHAIN

Key words: Requirements Analysis, Modelling Notations, Business Processes Re-engineering, Systems Engineering Methodologies

Abstract: Being able to reduce the gap between Requirements Engineering and Software Engineering is crucial to foster the developments of better Informations Systems that more precisely adresses the organizational needs of the stakeholders. One of the key factor toward this objective is adopting methodologies in which the the conceptual level of Requirements Engineering techniques is raised, so that formal representations can be used since the very early stages of requirements elicitation and analysis. The Tropos methodology targets this objective by means of the so called *Early Requirements Analysis*, that is aimed at understanding and analyzing the organizational goals by means of a precise and very expressive diagrammatic notation.
The paper exemplifies the use of Tropos Early Requirements while applied to a simplified case of business analysis in the context of the terminal part of the agro-food products delivery chain. The case is extracted from a more comprehensive analysis performed in the context of an ongoing project in the field of the dissemination of knowledge concerning the topic of the "Genetically Modified Organisms" (GMO).

1 Introduction

In industrial practice, as well as in academia, two Information Systems development activities are seen as quite different and stand-alone phases: Software Engineering and Requirements Engineering. Of course, their complementarity is clearly recognized and accepted, but, at the practical level, still very little is proposed in order to really consider them as part of an integrated process. In Software Engineering, requirement issues are typically dealt with at a very system-oriented level, as this were the most preliminary phase that can be conceived on which concretely base the Software Engineering activities. From the other side, Requirements Engineering practitioners and researchers focus on requirements deriving from the stakeholders needs and the organization analysis and business models, regarding this as a stand alone process mainly aimed at evaluating and managing the project definition or, at most, at proposing a project development process; but, in any case, little concern is given on how the requirements should really influence the architectural and design characteristics of the system-to-be and the adopted technological solutions.

In this scenario —to cope with this gap between Requirements Engineering and Software Engineering— in the last years, one methodology, among other, is has been being proposed as a possible solution: *Tropos*. The Tropos project (Castro et al., 2002; Bresciani et al., 2003) aims at dealing with such a gap between Requirements Engineering and Software Engineering by proposing a methodology aimed, among others, at two important objectives: i) raising the conceptual level of Requirements Engineering techniques, so that formal and semiformal languages and representations can be used since the very early stages of requirements elicitation and analysis (this means that empirical measures, tables, and transcripts or cards provided in free text form (Robertson and Robertson, 1999)) have to be transformed into more precise and more easily analyzable formats, so that transforming them into functional and non-functional requirements —to feed the Software Engineering process— results to be a more straightforward step; ii) providing and supporting the system architecture and functions definition with a set of "social-oriented" notions —to be used aside the traditional system oriented concepts— that allows for a easier mapping of the requirements provided in terms of social and organizational needs —as provided by Requirements Engineering— into the characteristics (functional, architectural, and design oriented) of the system-to-be.

Tropos aims at this objective by adopting two specific strategies: i) it pays attention to the activities that precede the specification of the prescriptive requirements, like understanding how and why the intended system can meet the organizational goals. Even preliminary to this step (called in Tropos *Late Requirements Analysis*) it is important to understand and analyze the organizational goals themselves (this phase is called *Early Requirements Analysis*). In this, Tropos is largely inspired by Eric Yu's framework for requirements engineering, called i^*, which offers actors, goals, and actor dependencies as primitive concepts (Yu, 1993; Yu, 1995; Yu and Mylopoulos, 1994). ii) Tropos deals with all the phases of system requirement analysis and all the phases of system design and implementation in a uniform and homogeneous way, based on common mentalistic notions as those of actors, goals, soft-goals, plans, resources, and intentional dependencies.

One of the main advantages of the Tropos methodology is that it allows to capture not only the *what* or the *how*, but also the *why* a piece of software is developed. This, in turn, allows for a more refined analysis of the system dependencies and, in particular, for a much better and uniform treatment not only of the system functional requirements, but also of its non-functional requirements.

The Tropos methodology is mainly based on four phases (Bresciani et al., 2001b; Bresciani et al., 2003):

- *Early Requirements Analysis*, aimed at defining and understanding a problem by studying its existing organizational setting;
- *Late Requirements Analysis*, conceived to define and describe the system-to-be, in the context of its operational environment;
- *Architectural Design*, that deals with the definition of the system global architecture in terms of subsystems;

  and the
- *Detailed Design* phase, aimed at specifying each architectural component in further detail, in terms of inputs, outputs, control and other relevant information.

In particular, during the Early Requirements Analysis the existing organizational setting is analyzed, in terms of *actors*, who plays some role in the organization, and of their *intentional dependencies* in the context of the organization. The output of this phase is an organizational model which includes relevant actors and their respective intentional dependencies. Actors, in the organizational setting, are characterized by having *goals* that each single actor, in isolation, would be unable —or not as well or as easily— to achieve. Intentional dependencies are used to describe this kind of relationships among actors. Goals are the elements around which the intentional dependencies are established.

In this paper we will concentrate on the Early Requirements Analysis phase of Tropos. In particular, we will base our discussion on the assumption that a deep organizational analysis is needed as a preliminary phase of any project that aims at introducing or modifying the use of Information Technologies inside an organization (Bresciani et al., 2003; Donzelli, 2003; Bresciani et al., 2001b; Donzelli and Bresciani, 2003; Bresciani and Donzelli, 2003).

Accordingly to this view, the social setting is the motivating factor that justify any technological choice. In this paper, we will shown with an example how balancing social and business issues can be properly addressed and analyzed by means of Tropos Early Requirements. In particular, we refer to an ongoing project that aims at proposing and adopting web based technologies to divulgate information and data and disseminate knowledge on the so called "Genetically Modified Organisms" (GMO). The very preliminary step we faced in this project has been to asset the scenario of the problem. Only after an intentional analysis of the objectives of the different actors involved in such a scenario it will be possible to better understand the problem and propose solutions. This is greatly helped by using the Early Requirements phase of Tropos.

In Section 2 we will introduce the general setting of the current debate on GMO and the problem of scientific and economic knowledge dissemination. In Section 3, due to the available space, we will concentrate only on few aspects involving few of the stakeholders considered by our analysis. This simplified case will be formally illustrated by means of Tropos Early Requirements in Section 4. This allow us also to introduce some methods to elicit the knowledge on the scenario not yet explored in the Tropos literature. The contribution of this paper on the extension of the Tropos methodology will be discussed in the Conclusion.

2 The Debate on GMOs

Biotechnologies are valuable applications of "genetic engineering", one of the key tools available today for studying and understanding the biology of the living organisms. The possibility to isolate and introduce foreign genes into an organism opens important perspectives for plant breeding programs, where genetic improvement based on parental cross is hindered behind biological constraints (long life cycles, breeding depression) or strategic purposes (preservation of a cultivar constitution) (J. Shell, 1982). An organism expressing a foreign gene after cell fusion or gene transfer without sexual cross is called "genetically modified" (GM) or "transgenic" (E.U. Directive, 2001). In agriculture, the goals of genetic improvement based on GM plants are the same aims of traditional breeding, i.e. production of plants with qualitative and quantitative improved traits. In this framework, intrinsically resistant plants to pathogens and herbicides, crops with improved nutritional value, and plants capable of soil decontamination from heavy metals are the most ambitious objectives (Vasil, 2002). The application of genetic engineering in agriculture could be explained also in economic terms, related both to an increased production and the reduction of costs for pesticides or fertilizers. Among the GM plants produced in these perspectives, we remember the Bt corn expressing the *Bacillus thuringensis* Cry genes for a self protection against *lepidoptera*, in the view of reducing the chemical product for pest control (Pioneer, 2003); besides, the "Golden Rice", a rice variety modified to increase provitamin A content with the perspective of fighting childhood blindness and malnutrition in the Developing Countries, is a promising product (Potrykus, 2003); finally, the RR ready soybean is the most spread GM crop produced for herbicide resistance (Monsanto, 2003). Recently, GM plants are also exploited for producing nutriceutical and antibodies for human health care (Vasil, 2002).

Today, USA and Argentina are the greatest global producers of GM crops for commercial purposes, yielding respectively 70 and 95 % of the total harvest of corn, wheat and soybean (Piazza, 2003). This great success is also explained by the improved economical convenience offered by some GM varieties.

In Europe, GMOs are present in many products sold in the supermarkets, and officially imported from abroad. At the moment, GM—planted fields are allowed only for experimental trials since European Union opted for the application "Precaution Principle" (Comm., 0001), which states that whenever (Appell, 2001):

> "an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically."

This is a cautious political choice, aimed at avoiding the GM plant use before science, time and use will definitively prove the safety of these organisms. Each country applies the own regulation concerning GM plant and product use. As for Europe, besides the safety assessment required before any authorization is given to human consumption, a severe control, based on labeling the food and the feed containing GM product, is regulated by law (Regulation, 1997). Today, however, the debate on agrobiotechnology products is quite passionate all over the world.

In Europe, the core of the social debate about agrobiotechnologies stands in the general diffidence of Society towards the GM products, in spite of the possible benefits of an increased production and best opportunities to defeat global starvation promised by the scientific progress. Several surveys have been already held to monitor public opinion on this theme, being Eurobarometer (Gaskell et al., 2003) and PABE (Public Acceptance of Biotechnologies in Europe) (A.A.V.V., 2002) the most well known and highly regarded. The results of these researches prove a general dislike for agrobiotechnologies, while biotechnology applications for human health are more tolerated. In general, people resulted controversial concerning biotechnology applications while proved to be more tolerant when the techniques are applied for research purpose only. Furthermore, in the case of GM food, acceptance and knowledge are not positively correlated. Finally, a mixture of rational and emotional attitudes (i.e. trust in Insitutions, results of environmental campaigns, ethical values) lead the public acceptance of agrobiotechnology products. In other words, what people think about biotechnologies is strongly related to their interests and expectation (in terms of quality of life and preservation of the environment for future generations).

The debate on modern agrobiotechnologies is surely one of the most controversial questions of the last years, involving many levels of interests and actors, each viewing the facts from specific perspectives. Economic, politic and scientific significance involves the discussion since the application of this technology has a great impact on "life quality", a field where many actors are implicated. Besides, the difficult communication attitude often achieved by the scientific community to the Science does not help a confident debate on the question, and allows an uncontrolled spread of incorrect information.

Consumers have at their disposals great amount of available information, but in many cases this could generate misunderstanding of the real data and drastic reactions.

Communicating science has the advantage both to offer people suitable tools to build a personal opinion on the facts and to increase social condivision (and new funds). This is not an easy task. In fact, scientists are often unable to have a direct dialogue with people: difficulties stand in used language, often too specialistic, and in the priorities a researcher gives to his/her activity and career.

The great number of available data and information should be allocated in an efficient way, to allow all the actors concerned to choose for themselves, without being influenced in any way. Society wants and needs to play an active part in the debate. Differences in interests and roles should be regarded as driving force in the debate to answer to the number of unsolved questions still existing on the matter. In what we could call a deliberative democracy, each part should be provided with the same amount of information, but at the same time should be allowed to express a personal and aware opinion, free from any interference or others' influence. Such a purpose explains the need to rationalize the way information and data are made available to the different actors of the scientific debate on GMOs.

In order to contribute to this ambitious goal, we are currently working at a project (Osserva3), the aims of which include also to provide an Information Technology and/or mediatic infrastructure to support knowledge and information sharing and broadcasting for a better informed deliberative democracy.

In this context, we chose to adopt the Tropos methodology, for the engineering phases of such a system, that shall be capable to offer the proper information about agrobiotech to the various actors involved in the debate (Marin et al., 2003b). In the Tropos framework, a preliminary and necessary step, required before the design and even the very definition of a new system, is to provide a clear analysis of the current socio-economical and scientific scenario on biotechnologies, in which many actors —each with his/her own interests—, are involved. In fact different actors (Institutions, Scientists, Industries, Farmers and Breeders, Consumers, Mass Media, Food Retailers, Associations, etc.) are related to and have an influence on the question thanks to their proper priorities and interests.

3 A simplified scenario

In the previous section we tried to give a short overview on the debate on the GMOs and, specifically, on the delicate aspects that are concerned when communicating scientific knowledge on GMO to support a better deliberative democracy process. As mentioned, several and very diverse actors are involved in the context. Here, in order to prepare the background to show how the Tropos Early Requirements analysis can be applied, we refer to a partial and very simplified scenario that includes only few actors. That is, we concentrate only on (some of) the dependencies relationships among two actors who play a central role in the debate: the consumer and the food retailer. That is, we start analyzing the terminal part of the agro-food products delivery chain. The final objective will be to analyze which aspect may have the consumer attitudes toward the GMOs products to foresee possible consequences for the marketing strategies. Of course, this is only a small and simplified fragment of the analysis already developed inside the Osserva3 project (that includes more then 27 actors). In the next section, we will analyze this scenario by using Tropos Early Requirements Analysis, and show how we can derive some consequences that are relevant for the whole business analysis. Before starting, let us note that, when we refer to an actor (e.g., the consumer) we always refer to the generic kind of that actor, and not to any specific instance.

In our scenario we want to evidence the fact that the two main actors (the consumer and the food retailer) are characterized by having a set of goals, and depend each other for achieving some of these goals. Thus, we may want to consider that the consumers aim at environment protection, technical development and social equality, for themselves, the future generations, and the society in general. This “social” attitude is reasonable, as well as it is reasonable the fact that the food retailer aims at obtaining high economical profits from its activity, as its normal for every enterprise. It is important to notice, now —to better understand their motivations— that the two actors cannot be considered and analyzed in isolation; in fact, they depends each others to reach some other direct objectives that, with little effort, can be seen as representing relevant driving factors that enable the achievement of the already goals mentioned above. First of all, the food retailer depends on the consumer to have her as a costumer (each costumer can choose a different food retailer whenever she wants), or better, to have her keeping on shopping with it. On her side, the consumer clearly depends on the food retailer first of all to buy food, bust also to to have it at a good level of quality and at reasonably low prices. Starting with these elements we can go on with further considerations, including the trade-off between quality and prices, a more detailed analysis on what kind of quality can be considered, the strategies that the food retailer can adopt to better match consumers expectations and how they impact on its primary goal, i.e., to maximize its profit, and so on. The analysis can easily became quite intricate now. Tropos provides a diagrammatic notation to deal with this kind of complexity: by using diagrams we have a visual tool that allow us to focus different aspects on turn, and to breach the global cognitive effort into smaller chunks of knowledge, that can be more easily understood and analyzed. In the next section we show in practice this feature by providing the Tropos Early Requirements Analysis of the scenario just sketched above, also extending it.

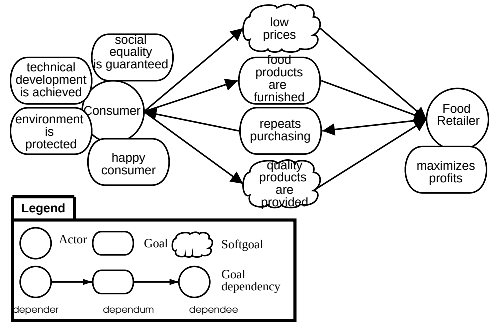

Figure 1: Actor Diagram figuring goals and intentional dependencies between two relevant actors, Consumer and Food Retailer.

4 Applying Tropos

At the current stage of the project Osserva3 we have already provided a quite comprehensive Early Requirements Analysis Document (Marin et al., 2003a), that deals with 27 actors and 35 dependencies. Here, we have room to present only a small portion of this analysis (derived form the simplifies scenario introduced in the previous section), to introduce the Early Requirements Analysis technique of Tropos and highlight some of its relevant features. Rephrasing the scenario by means Tropos diagrams allow for a more precise description, so that a deeper business analysis can be carried on.

4.1 Building the Tropos Actor Diagrams

The first step of Tropos Early Requirements Analysis is to identify the most relevant actors in the social environment. It is here worth to recall that each Tropos phase is not a linear process, but may require a cyclic and incremental approach, during which details introduced in previous steps may be revised, refined and modified[1]. Thus, identifying and describing, initially, only few actors, together with their goals and reciprocal intentional dependencies, is really in the spirit of the Tropos methodology. Tropos diagram development is a very dynamic process, and more and more details can be added whenever needed.

Thus, following Section 3, let us consider here only two actors: the Consumer and the Food Retailer, as shown in Figure 1. The figure presents a Tropos *Actor Diagram*. These diagrams are used to represent goal dependencies among actors. *Actors* are represented in the diagram by means of circles, labeled by the actors’ names. In Figure 1, some of the possible *goals* of the two actors Consumer and Food Retailer are represented. As already reported in the previous section, the main Food Retailer’s goal is maximizes profits. In Tropos diagrams, goals are represented by means of labeled ovals. In the case of maximizes profits the goal appears in the diagram attached to the actor that aims at fulfilling it (Food Retailer). Similarly, the actor Consumer wants to attain the goals social equality is guaranteed, technical development is achieved, and environment is protected, as well as the goal happy consumer. Some other goals appear in Figure 1 not directly attached to any actor, but in the middle of a path of the kind actor1→goal→actor2 (e.g., as in Food Retailer→repeats purchasing→Consumer). The meaning of such a pattern is that actor1 (referred as the *depender*) *depends* on actor2 (referred as the *dependee*) to achieve the goal (referred as the *dependum*), either because she is not able to satisfy it by herself, or not as easily or not as efficiently (Yu, 1995). The notion of goal-dependency is central in Tropos (Bresciani et al., 2001b; Bresciani et al., 2003). Having a goal dependency means that it is recognized (and accepted by the parties) that the goal can be better *delegated* to the second actor, who accepts this responsibility and either deals with it as with one of her own goals or further delegate it to a third actor (who may further delegate it and so on). In Figure 1, we can see that Consumer depends on Food Retailer for fulfilling the soft-goals[2] low prices, quality products are

[1]This cyclic and incremental approach is a characteristic feature of the Tropos methodology. In this paper we have not enough space (and even it is not the main goal) to explore in a deeper way the whole details about the process; more details can be found in (Bresciani et al., 2001a; Bresciani and Sannicolò, 2002; Bresciani et al., 2003).

[2]A distinction is made in Tropos between goals —also called hard-goals— and soft-goals. While hard-goals define objectives the satisfaction of which can be easily defined with clear-cut cri-

Actors, goals, and goal dependencies		
Depender	**Kind: Dependum**	**Dependee**
A1: Consumer	D1(G): social equality is guaranteed	
A1: Consumer	D2(G): technical development is achieved	
A1: Consumer	D3(G): environment is protected	
A1: Consumer	D4(G): happy consumer	
A1: Consumer	D5(G): food products are furnished	Food Retailer
A1: Consumer	D6(SG): quality products are provided	Food Retailer
A1: Consumer	D7(SG): low prices	Food Retailer
A2: Food Retailer	D8(G): maximizes profits	
A2: Food Retailer	D9(SG): repeats purchasing	Consumer

Table 1: Tabular format to list all the graphical dependencies depicted in Figure 1.

provided, and the goal food products are furnished. Finally, as mentioned above, Food Retailer delegates the goal repeats purchasing to the Consumer.

Several methods and techniques can be used in order to support this initial phase of drawing Actor Diagrams, including drawing them in contemporary with the activity of knowledge elicitation. This can be feasible for small, or even medium sized cases, if the analyst is an expert in the requirements engineering techniques. In more realistic cases, it is advisable to keep track of this activity. It may be the case, for example, when the number of actors and dependencies considerably grows together with the complexity and criticality of the domain (and, of course, with the number of the interviews made), or in the cases in which the analyst needs some guidelines (because of her limited experience with the notation or her little knowledge of the domain). In this project, due to the complexity of the domain, for the first time we adopted a methodical approach to collect knowledge on the domain before starting to draw any diagram. In fact, in other real case studies (Garzetti et al., 2002b; Garzetti et al., 2002a), we experience some difficulties in directly trying to capture the domain knowledge into diagrams, and the stakeholders manifested some troubles in reading and deeply understanding the organizational setting as a whole by only using the Tropos diagrams. Thus, we chose to introduce a tabular format to helps ourselves to list all the dependencies before starting drawing any diagram, and to better support understandability of the model by the stakeholders. A small portion of table is shown in Table 1. In (Marin et al., 2003a) 27 actors and 35 dependencies were listed as a very preliminary step before starting to draw any diagram. This approach allows us to exploit several advantages, among others:

Stakeholders' acceptability. Many stakeholders prefer to deal with tables that for some aspects can be easier to be browsed than the corresponding (and sometimes complex) set of diagrams. Tables show all the elements, like actors, their goals and dependencies, in a linear, ordered, and more comprehensive way.

Better understanding of the terms. There are multiple stakeholders involved in the requirements engineering process, each with different background, skills, knowledge, concerns, perceptions, and expression means. Very often, these stakeholders have conflicting viewpoints on the same simple terms. The table allows them and the analysts to extract which actors, goals or dependencies really have the same meaning. For large domains like this or (Garzetti et al., 2002a; Garzetti et al., 2002b), the same conceptual term is likely to be referred in different documents (or uttered by different stakeholders) by means of different, bur almost equivalent, nouns or expression. For example, in our context, *Costumer*, *Consumer* and *Citizen* can be considered as synonyms.

To facilitate this process, we also provided a glossary of the terms, with definitions, alternative expressions/synonyms and, where appropriate, hyponyms and hyperonyms (see Table 2).

Attori individuati durante il processo di acquisizione dei requisiti	
Attore	**Definizione**
Consumatore	Tale categoria di attori sottende la panoramica più ampia della gente comune, nella sua individualità, o in quanto facente parte di associazioni.
Distribuzione alimentare	La grande Distribuzione alimentare è rappresentata da catene di negozi/supermercati affiliati ad uno stesso nome. Costituisce l'attore più prossimo al consumatore finale, trovando ragione nella fornitura di approvvigionamenti e vendita di prodotti alimentari finiti, tra i quali figurano anche beni etichettati con il marchio della catena stessa, che trova un comprensibile interesse nel raggiungimento di alti livelli di soddisfazione dell'acquirente, l'attore Consumatore, implicanti la sua scelta in favore della stessa catena di distribuzione.
Agenzie di pubbliche relazioni	Agenzie che operano allo scopo di promuovere le relazioni con il pubblico da parte di particolari attori interessati (es. Multinazionali).

Table 2: A short glossary where the term Consumer ("Consumatore" in Italian), Food Retailer ("Distribuzione alimentare"), and Public Relationship Agency ("Agenzie di pubbliche relazioni") are defined.

4.2 Building the Tropos Goal Diagrams

After identifying the relevant stakeholders, their goals, and intentional dependencies, the Tropos Early Analysis phase proceeds by decomposing each goal in subgoals by means of techniques of *AND-OR decomposition* and *contributions analysis* (Bresciani et al., 2001a; Chung et al., 2000; Mylopoulos et al., 2001; Dardenne et al., 1993; Garzetti et al., 2002a). The resulting diagrams are called *Goal Dia-*

teria, the soft-goal achievement cannot be sharply defined, and we talk instead of *soft-goal satisficement* (Yu, 1995).

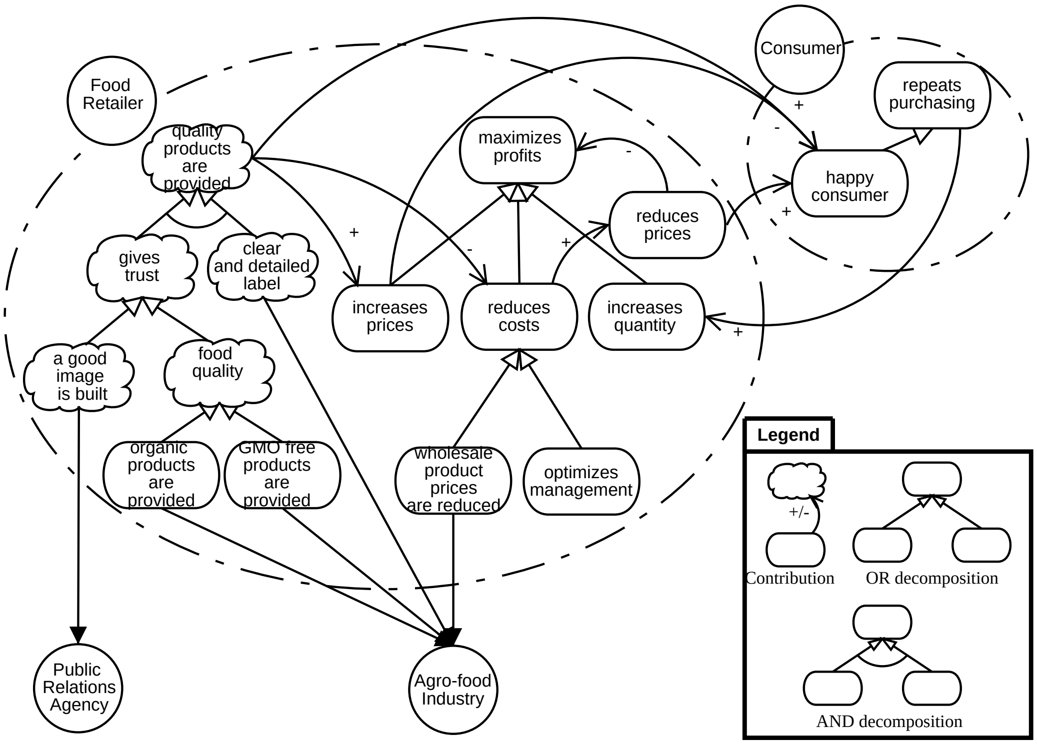

Figure 2: Goal Diagram depicting the goal analysis carried out from the Consumer's and Food Retailer's point of views.

grams (Bresciani et al., 2001b; Giorgini et al., 2001; Bresciani et al., 2003). AND-OR decomposition allows for a combination of AND and OR decompositions of a root goal into subgoals, thereby refining a goal structure. In particular, AND-decomposition implies that all subgoals have to be fulfilled for achieving the root goal, while for OR-decomposition the fulfillment of one of them is enough. Contribution analysis allows the designer to point out goals and soft-goals that can contribute positively or negatively at reaching the goal under analysis.

By using these kind of techniques, we can build some diagrams in which we analyze each goal and goal dependency from the actor's point of view in order to acquire a deeper understanding on *how* and *why* to achieve that goal. The idea is that a goal may be decomposed in one or more subgoals, that could be delegated to other actors or fulfilled in isolation.

Figure 2 shows a Goal Diagram where the goals of the actor Food Retailer are decomposed by means of AND-OR decomposition. In particular, we OR-decompose the goal maximizes profits into the subgoals reduces costs, increases quantity, or increases prices: the satisfaction of (at least) one of the sub-goals guarantees also the satisfaction of maximizes profits. In order to represent the OR-decomposition inside the Goal Diagram, we adopt arrows with hollow triangle (see Figure 2).

Again, the goal reduces costs is further refined into the two subgoals wholesale product prices are reduced and optimizes management. The former is delegated to the actor Agro-food Industry, establishing a new goal dependency between the actor Food Retailer and Agro-food Industry. The dependency is denoted by means of the same filled arrows already adopted in the actor diagrams (see Figure 1), but, here, the arrow is pointing directly from inside the context of the depender.

Thanks to this kind of analysis, we can complete the Actor Diagram depicted in Figure 1 with new details like hard-/soft-goal dependencies, new actors, and so on. The Tropos methodology foresees to incrementally increase the detail level of each diagram, gradually coming up to the real structure of the organizational setting, by performing a cyclic process in which more and more precise details are added at each iteration.

Another kind of analysis used in Tropos is the so called *contribution analysis*. It allows us to highlight hard- and soft-goals which contribute positively or negatively at reaching the goal under analysis. For example, the curved arrows, labeled with a "$+$", pointing from the goal reduces costs to the goal reduces prices, means that the first goal contributes positively at satisfying the second one (even though it is not he only possible way). Again, the goal reduces prices contributes partially positively at fulfilling the goal happy consumer and negatively at maximizes profits (notice the label "$-$" next to the subgoal).

In addition, the goal happy consumer receives other two different contributions: one positive, from the soft-goal quality products are provided, and the other one negative, from the goal increases prices. These contributions highlight the fact that the consumers appreciate the effort to increase the food quality, but, at the same time, they also pay great attention to the costs of the products. Of course, some *compromises* can be accepted; thus, for example, the consumers may accept some negative aspects (as higher prices) if they pay for some positive issue (as food quality).

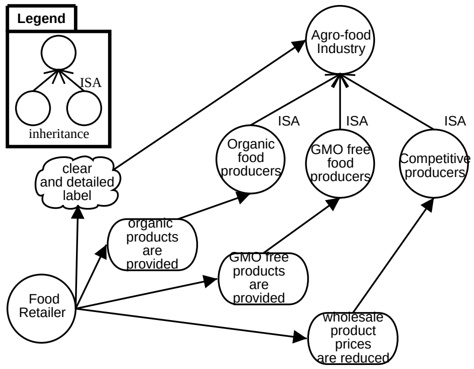

Figure 3: Actor Diagram showing the new actors introduced by effect of the goal analysis.

It is worth noticing that these last contributions span across the two different contexts (the Food Retailer one's and that of the Consumer). The same happens for the positive contribution from the goal repeats purchasing and the goal increase quantity, even though in the opposite direction. Finally, the goal happy consumer is a subgoal of the goal repeats purchasing.

Going back to the Goal Diagram in the context of the Food Retailer, we can see that quality products are provided contributes positively at the fulfillment of increases prices but negatively to reduces costs. As well, the soft-goal quality products are provided is AND-decoposed in two finer soft-goals: gives trust and clear and detailed label. The last soft-goal is delegated to the actor Agro-food Industry, establishing a new soft-goal dependency between the actors Food Retailed and Agro-food Industry. Finally, in order to satisfy the soft-goal gives trust, the actor Food Retailer decomposes it into two further soft-goals: a good image is built (delegated to the actor Public Relationship Agency) and food quality. This last sub-goal is further OR-decomposed into the goals organic products are provided and GMO free products are provided (both are likely to receive negative contributions from the goal wholesale product prices are reduced). In other terms, this part of the diagram proposes a *hard* —i.e., precise— re-definition of the *softness* implicit in the soft-gaol quality products are provided, by means of the two hard-goals. Finally, also these two hard-goals are delegated to the actor Agro-food Industry.

4.3 Revising Actor Diagrams

Accordingly with the Tropos Early Requirements Analysis process, each diagram may evolve incrementally, following an iterative and incremental development. For shake of simplicity, it is sometime the case to revise some dependencies introduced as a consequence of the goal analysis process, in order to define, improve or refine Actor Diagrams. One simple example follows. Let us consider the dependencies among Food Retailer and Agro-food Industry, introduced with the Goal Diagram of Figure 2. A better picture of these dependencies can be given in the Actor Diagram of Figure 3. Here, an extra level of detail is provided, by stating that three of the dependencies posed on the Agro-food Industry are indeed to be delegated to more specific kinds

Qualitative contributions among goals and soft-goals		
Hard-/Soft-Goal	**metric**	**Is Contributed by**
maximizes profits	-	reduces prices
increases prices	+	quality products are provided
reduces costs	-	quality products are provided
increases quantity	+	repeats purchasing
repeats purchasing		
happy consumer	+	quality products are provided
	+	reduces prices
	-	increases prices
happy consumer	+	quality products are provided
		give trust
		clear and detailed label
	+	reduces prices
	-	increases prices
reduces prices	+	reduces costs
		wholesale product p.
		optimizes manag.
increases quantity	+	repeats purchasing
		happy consumer
reduces costs	-	quality products are provided
		give trust
		clear and detailed label
wholesale product p.	-	GMO-free prod.
	-	organic prod.
optimizes manag.		
increases prices	+	food quality
		give trust
		clear and detailed label

Table 3: Tabular format to list all the contributions elicited during the goal analysis of the Figure 2.

of it. Three new actors, Organics food producers, GMO-free food producers, and Competitive producers (see Figure 3) are introduced as specializations (*ISA*) of the actor Agro-food Industry. Thus, they inherit the dependencies and goals of the actor Agro-good Industry, as, e.g., the delegations of the soft-goal clear and detailed label. As well, they are the dependees in the specific dependencies for achieving the goals organic products are provided, GMO free products are provided, and wholesale product prices are reduced, respectivelly, as depicted in Figure 3, thus providing more insight, on this specific aspect, than the diagram in Figure 2.

These last observations let us to refocus on the original task: to analyze and understand which possible impact may have the introduction of GMO products in a agro-food products delivery chain. In fact, from the diagrams, we can now evidence that price competitiveness is in general a factor contrasting with quality and that —accordingly with our analysis, that reflect the perception of the problem that the average European consumer has (see Section 3)— quality is often related to the absence of *artificial* factors —like chemicals but also GMO— in the products. Thus, organics products and GMO-free products are perceived as having a higher quality standard, and this fits the expectations of the average consumer, despite the fact that she has to pay a higher price. Thus, after balancing all the elements in favour and against (that of course do not have all the same weight), we can propose to adopt our analysis to justify market and business choices.[3]

[3]Of course, this is a very simplistic view of the scenario —we

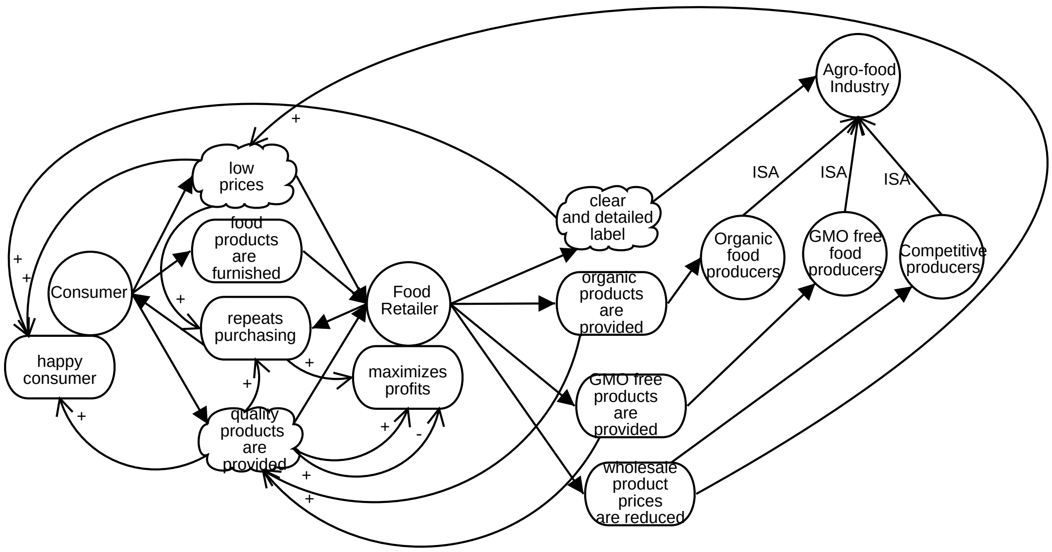

Figure 4: The global Actor Diagram, with goal contributions.

As a final note, let us here consider a possible structured way —still to be validated with future investigation— to supporte the conclusions sketched in the previous paragraph, by means of what we call here a *contribution analysis table* (see Table 3), which aims at summarizing the positive and negative contributions described in the Goal Diagram of Figure 2. The table reports, for each goal (hard or soft) which other goal may contribute (positively or negatively) to its fulfillment. For each goal, also its (direct) subgoals are reported below (evidenced by an indentation), so to discover also non direct contributions[4]. We can easily see that, in our table, quality products are provided is relevant in 5 items out of 7, while reduces prices is relevant in 3 items only. Of course this represents only a first and qualitative approach, but, again, having all the contributions listed and easily browsable represents an interesting alternative presentation of the results of the analysis, that may be more aceptable by some stakeholders and for some tasks.

Finally, we also briefly introduce also another extension fo the Analysis process, where contributions with a relevance for different actors are represented in a more organic and compact way. In Figure 4, all the contributions with a relevance for more than one actor, i.e., spanning outside the local contexts of each single actor, are replicated in a global Actor Diagram. The idea is to highlight the impact that the different goal (hard and soft) may have on the dependencies among the actors. In this way we abstract from contextual details —the single, personal point of views— and can present a more *objective* view of the global contributions network. The aim is to ease the task of capturing the dependums that play a crucial global role, so to facilitate the identification and understanding of the most essential goals on which to focus possible choices and decisions.

are far from proposing, here, any real marketing stategy. Our aim, is just to give an idea of the feasibility of the application of this approach.

[4]This presentation of *inherited* contributions, is in Table 3, expanded only for one level, but it could be propagated to any arbitrary depth.

5 Conclusion

Starting from a simplified business scenario in the context of the current debate on the adoption of GMOs for food products[5], dealing, in particular, with the consequences that possible alternative choices about the option of selling GMO-food may have on the business strategies of the terminal part of the products delivery chain, we introduced in this paper a technique for analyzing business scenarios, also aimed at implementing the Information Systems Requirements Engineering processes. The technique —called Early Requirements Analysis— is part of the Tropos methodology for Requirements and Software Engineering. We presented the Tropos Eraly Requirements Analysis by means of our case-study. As well, we showed how consequences on the businnes process can be directly derived by means of the analysis proposed by using Eraly Requirements.

Going ahead with respect to what is proposed in the Tropos literature we also introduced some possible complementary notational supports, aimed at helping the analysts and the stakeholders in the phases of knowledge elicitation (table of dependecies and glossary), as well as in the phases of contributions understaning and interpretation (table of contributions and Actor Diagram with contributions). The first pair of extension have already been succefully applied in the project Osserva3. Even though the latter two are here proposed for the first time, we believe that they may have a positive impact in practice, and aim at testing them soon in Osserva3 and other projects.

[5]The scenario is a fragment of a concrete complex analysis actually performed in the context of a project —Osserva3, in which we are involved— aimed at improving communication and divulgation of knowledge on the use of GMO in agrobiotechnologies.

REFERENCES

A.A.V.V. (2002). Public perceptions of agricultural biotechnologies in Europe. URL http://www.pabe.net, accessed 15.10.2002.

Appell, D. (2001). The new uncertainty principle. *Scientific American*. URL http://www.biotech-info.net/precautionary.html accessed 28.10.2003.

Bresciani, P. and Donzelli, P. (2003). An agent-based requirements engineering framework for complex socio-technical systems. In *2nd International Workshop on Software Engineering for Large-Scale Multi-Agent Systems. In Conjunction with ICSE 2003*, Portland, Oregon - USA.

Bresciani, P., Giorgini, P., Giunchiglia, F., Mylopoulos, J., and Perini, A. (2003). TROPOS: An Agent-Oriented Software Development Methodology. In press. Journal of Autonomous Agents and Multi-Agent Systems. Kluwer Academic Publishers.

Bresciani, P., Perini, A., Giorgini, P., Giunchiglia, F., and Mylopoulos, J. (2001a). Modelling early requirements in Tropos: a transformation based approach. In Wooldridge, M., Weiß, G., and Ciancarini, P., editors, *Agent-Oriented Software Engineering II*, LNCS 2222, pages 151–168. Springer-Verlag, Montreal, Canada, Second International Workshop, AOSE2001 edition.

Bresciani, P., Perini, A., Giunchiglia, F., Giorgini, P., and Mylopoulos, J. (2001b). A Knowledge Level Software Engineering Methodology for Agent Oriented Programming. In Müller, J. P., Andre, E., Sen, S., and Frasson, C., editors, *Proceedings of the Fifth International Conference on Autonomous Agents*, pages 648–655, Montreal CA.

Bresciani, P. and Sannicolò, F. (2002). Requirements Analysis in Tropos: A Self-Referencing Example. In Kowalczyk, R., Müller, J. P., Tianfield, H., and Unland, R., editors, *Agent Technologies, Infrastructures, Tools, and Applications for E-Services*, volume 2592 of *Lectute Notes in Artificial Intelligence*, pages 100–114, Erfurt. Spriger - Verlag.

Castro, J., Kolp, M., and Mylopoulos, J. (2002). Towards Requirements-Driven Information Systems Engineering: The Tropos Project.

Chung, L. K., Nixon, B. A., Yu, E., and Mylopoulos, J. (2000). *Non-Functional Requirements in Software Engineering*. Kluwer Publishing.

Comm., E. (2000/1). COM/2000/0001 def.

Dardenne, A., van Lamsweerde, A., and Fickas, S. (1993). Goal-directed requirements acquisition. *Science of Computer Programming*, 20(1–2):3–50.

Donzelli, P. (2003). A goal-driven and agent-based Requirements Engineering Framework. *Requirements Engineering, Springer-Verlag*, (ISSN 0947-3602).

Donzelli, P. and Bresciani, P. (2003). Goal oriented requirements engineering: a case study in e-government. In Eder, J. and Missikoff, M., editors, *Advanced Information Systems Engineering (CAiSE'03)*, number 2681 in LNCS, pages 605–620, Klagenfurt/Velden, Austria. Springer-Verlag.

E.U. Directive, Parlament, C. (18/2001). Deliberate release of genetically modified organisms.

Garzetti, M., Giorgini, P., and Sannicolò, F. (2002a). Applying Tropos Methodology to a real case study: Complexity and Criticality analysis. In Paolo, F. D., Manzoni, S., and Poggi, A., editors, *WOA 2002 – Dagli oggetti agli agenti: dall'informazione alla conoscenza*, Milano, Italy. Pitagora Editrice Bologna.

Garzetti, M., Giorgini, P., and Sannicolò, F. (2002b). The Ice Co case study: Requirements Analysis. Technical report, University of Trento, via Sommarive 18, Povo, I-38050, Trento-Povo.

Gaskell, G., Allum, N., Stares, S., and et al. (2003). Europeans and biotechnology in 2002. URL - http://europa.eu.int/comm/ accessed 15.04.2003.

Giorgini, P., Perini, A., Mylopoulos, J., Giunchiglia, F., and Bresciani, P. (2001). Agent-oriented software development: A case study. In J.P. Müller, E. Andre, S. S. and Frassen, C., editors, *Proceedings of the Thirteenth International Conference on Software Engineering - Knowledge Engineering (SEKE01)*, pages 283–290, Buenos Aires - ARGENTINA.

J. Shell, M. V. M. e. (1982). Plant cell trasformation and genetic engineering. *Plant improvement and somatic cell genetics*, pages 255–276.

Marin, F., Sannicolò, F., Bresciani, P., and Martinelli, L. (2003a). Analisi del grado di diffusione e conoscenza degli ogm mediante tecniche di ingegneria dei requisiti. Technical report, ITC-irst, via Sommarive 14.

Marin, F., Sannicolò, F., Bresciani, P., and Martinelli, L. (2003b). Tropos methodologies applied to an analyasis of actors and goals dependencies in the agro-biotech debate. In *Proceedings of XLVII SIGA Annual Congress, Polo Didattico "G.Zanotto", 24/27*. URL - http://www.siga.unina.it/congresso.html.

Monsanto (2003). URL: http://www.monsanto.com.

Mylopoulos, J., Chung, L., Liao, S., Wang, H., and Yu, E. (2001). Exploring Alternatives during Requirements Analysis. *IEEE Software*, 18(1):92–96.

Piazza, M. (2003). Ogm: il dubbio nel piatto. *Newton*, 2003(9).

Pioneer (2003). URL: http://www.pioneer.com.

Potrykus, I. (2003). Nutritionally enhanced rice to combat malnutrition disorders of the poor. *Nutr. Rev.*, (61(PT2)):101–104.

Regulation, E. (1997). Regulation (1997) Regulation (EC) No. 258/97 of the European Paliament and of the Council of 27 Jan. 1997 concerning novel food and novel food ingredients. Official Eur Communities L 43:1-7.

Robertson, S. and Robertson, J. (1999). *Mastering the requirements process*. Number 0201360462 in ACM press books. Addison-Wesley.

Vasil, I. (2002). Plant biotechnology 2002 and beyond.

Yu, E. (1993). Modeling Organizations for Information Systems Requirements Engineering. In *Proceedings First IEEE International Symposium on Requirements Engineering*, pages 34–41, San Jose.

Yu, E. (1995). *Modelling Strategic Relationships for Process Reengineering*. PhD thesis, University of Toronto, Department of Computer Science, University of Toronto.

Yu, E. and Mylopoulos, J. (1994). Understanding 'why' in software process modeling, analysis and design. In *Proceedings Sixteenth International Conference on Software Engineering*, pages 159–168, Sorrento, Italy.