

A GOAL-ORIENTED FRAMEWORK FOR BUSINESS MODELING

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Abstract. This paper proposes a modeling framework that provides rigorous concepts for conducting early organizational requirements analysis. The aim is to allow business analysts to produce an organizational model that precisely captures the knowledge of an organization and of its business processes. To this end, the framework offers a conceptual meta-model that identifies constructs that enable capturing the intrinsic characteristics of an organization setting for a corporate information system-to-be. The approach allows the analyst to have a holistic perspective integrating human and organizational aspects to gain better understanding of business system inner and outer modelling issues. The framework takes roots in both management theory and requirements analysis. It helps bridging the gap between enterprise and requirements models proposing an integrated vision, comprehensive and expressive to both managers and software (requirements) analysts.

1. INTRODUCTION

A critical success factor of information systems deployment in terms of their functionality and acceptance by their users depends on a large extent on the ability of systems developers to engineer high-quality requirements (see e.g., [Mey85, Zav97, Myl98]). Requirements analysis is concerned with the elicitation of the objectives to be achieved by the system envisioned (WHY dimension), the operationalization of such objectives into specification of services

and constraints (HOW dimension), the information required to perform those services (WHAT dimension), the assignment of responsibilities for the resulting requirements to agents, such as humans, devices and software available or to be developed (WHO dimension), timing issues (WHEN dimension), and localization of people and services (WHERE dimension).

Because the deployment of information systems depends intrinsically on the wider human or organization environment in which they will exist, requirements analysis usually makes the distinction between the *organizational world* and the *system world*. The former describes the organizational setting about which the proposed system has to provide some services, while the second is concerned with putting these services into place. Both worlds can be modeled according to the aforementioned six dimensions: WHY, HOW, WHAT, WHO, WHEN, WHERE.

Many requirements modeling languages including UML [Uml04] only take the system view into account, and even without completely addressing the six dimensions. It has however been recognized that the organisational and system worlds cannot be treated separately (see, e.g., [Yu95, Yu97]). Unfortunately, the focus on the description, analysis and specification of system requirements in their organizational context has been done so far without taking into account the inherent ambiguity and uncertainty of this context. This has been due to the bounded rationality [Sim79] of organization's stakeholders that implies their information-processing capabilities to be limited and their choice not perfectly rational. Stakeholders rarely have precise requirements due to specialisation, limited responsibility, or simply the complexity of operational processes in which they are involved [Coh92]. They may not be aware of the business opportunities offered by the available technology. Moreover, their requirements can evolve over time according to the organizational or environmental changes.

For too long has the state of the art in requirements analysis adopted a positivistic and deterministic view of human organizations in which the information system operates. We consider that requirements analysis should not ignore the realities of emergent complexity within the open human environment and should acknowledge the evolving nature of requirements. Not addressing these issues leads to a 'gap' between the needs of the organization and the implemented systems [Fee98, Pep01].

Our proposal attempts to revisit the requirements analysis rigorous approach in light of the issues of organizational complexity, uncertainty, and ongoing organizational change. We situate our work in the field of *early organizational requirements analysis*, which aims at modeling and analyzing

stakeholder interests within the organization environment and specifying how they might be addressed by various systems alternatives. We propose a framework for early requirements acquisition based on an organizational meta-model and on a structured method which provides guidelines to discover, interpret and record stakeholders experiences. Such process is adequate, not least because building complex information systems according to users' needs is a difficult and risky undertaking, but mainly because it is through a structured approach that potential risks will be addressed early, opportunities will be exploited, and better communication will be ensured between the stakeholders. The framework assists the creative and rigorous business analyst in structuring her approach to the problem at hand; facilitates the acquisition, the representation and analysis of the knowledge about the organizational context; helps in communicating between stakeholders; and enhances the analyst's understanding of the organizational complexity.

Due to lack of space, we only focus here on the overall presentation of the concepts of the framework rather than giving a detailed account of one or more aspects. We are currently using the framework to deploy a production information system for a large steel industry [Car04] that is overviewed in the paper.

The article is structured as follows. Section 2 introduces the motivation of the framework with respect to the literature. Section 3 overviews the organizational meta-model while Section 4 illustrates it with an industrial case study. Section 5 concludes the paper and points to further work.

2. RELATED WORK AND MOTIVATION

Many requirements languages (e.g., [Dar93, Cas02]) have been proposed for making requirements precise, and complete. To complement these languages, the literature proposes many frameworks which represent knowledge and support reasoning during requirements analysis [Dar93, Yu97, Myl98, Cas02, Uml04].

Within a requirements effort, one can discern between a requirements elicitation phases and a requirements consolidation phase. Whereas the former concentrates on finding the requirements, the latter focuses on completeness, consistency, and automated verification of requirements. In the context of this paper, we will call this distinction "*early*" versus "*late*" requirements. Note that as gathering organizational requirements is assumed to precede col-

lecting system requirements, these activities are sometimes also termed as *early* versus *late* requirements (see e.g., [Kol03]). In this paper we however consider an early and late phase both for the organisational and system dimension of requirements.

As argued in [Yu97], most existing requirements languages and frameworks are intended more for the late system phase of requirements, which focuses on completeness, consistency, and automated verification of requirements. The late phase assumes the existence of organisational and even early system requirements in some form: often, this is the requirements statement, expressing customer's wishes about what the system should do. In contrast, the early organisational phase aims to model and analyze stakeholder interests and how they might be addressed by various composite system alternatives, i.e., it helps stakeholders to actually come up with the requirements.

It has been suggested in [Let01] that goal-oriented requirements engineering framework such as KAOS [Dar93] spans both organisational and system requirements analysis phases. Even though both phases use similar concepts (i.e., goals, actors, objects, etc.), their meaning at each phase is different. The concept of goal is illustrative in this respect. At the system phase, functional and non-functional system goals are analysed in detail. They express *why* the operations and data composing the system (i.e., internal aspects of the system) should be developed in a specific way [Yu97]. Inversely, goals in the early-phase specify *why* the *composite system* should be structured in a specific way. Indeed, early goals are most often broadly defined and more fundamentally informal. Hence, formal reasoning emphasised in KAOS cannot readily be transposed to the informal and dynamic nature of early requirements.

Existing requirements modeling frameworks such as KAOS [Dar93] i* [Yu95], Tropos [Cas02] or the business use-case model [Uml04] usually lack of advanced organization-centric concepts such as roles, organizational rules, groups, obstacles, divergences and conflicts. This limits the expressivity and restricts the scope of reasoning that should be supported during the organizational requirements analysis process. For example, not to reason about conflicts will ultimately result in a composite system prone to faults and errors, which does not measure up with its user expectations. More important, such frameworks usually do not acknowledge that requirements elicitation for an information system is mainly a collaborative process in which the management of the collaboration itself is essential. Furthermore, the requirements acquisition strategies fail to acknowledge the inherent complexity of the multidimensional information about organizational processes, by most of the time reducing them to sets of decomposable tasks. It is sufficient to refer to busi-

ness process modelling literature (e.g., [Pep01]) to see the difficulty which exists in specifying processes using concepts with such a limited expressivity.

Our aim is to propose a framework which provides conceptual support for early organizational requirements analysis, bringing the following contributions:

- A clearer focus on the early phase of the organizational requirements analysis, coherent with main ideas from existing frameworks.
- A conceptual meta-model that guides the early organizational requirements acquisition, using comprehensive concepts such as goals, organizational roles, actors, conflicts, obstacles, etc. The meta-model is constructed so that the acquired knowledge can be used with existing frameworks when requirements analysis is realized.

3. AN ORGANIZATIONAL META-MODEL FOR EARLY REQUIREMENTS ANALYSIS

To drive the requirements acquisition, we propose a meta-model which provides modeling elements relevant for specifying both strategic and operational aspects of the organizational context in which the future information system will be deployed. This meta-model is made of *meta-concepts* (e.g., “Actor”, “Organizational Roles”, “Goals”, etc.), *meta-relationships* relating meta-concepts (e.g., “Pursue”, “Occupy”, “Require”, etc.), *meta-attributes* of meta-concepts or meta-relationships (e.g., “Status”, “Precedent”, “Contain”, etc.), and *meta-constraints* on meta-concepts and meta-relationships (e.g., “An actor occupies a position if and only if that actor possesses all the capabilities required to occupy it”). By lack of space we only present here the meta-concepts and meta-relationships of our meta-model. A detailed description of the meta-model can be found in [Fau04].

The meta-model is composed of two sub-models: the *Strategic Goal-Role Model* (SGRM) and the *Operational Process Model* (OPM). Each model, presented separately, relate to the other through concepts that are common in both models. The meta-model plays the following roles: (i) it determines the structure and completeness of the models when applying the methodology; (ii) it focuses the attention of the stakeholders on relevant aspects of the organizational context, limiting the scope of the requirements elicitation activities; (iii) since it uses common system requirements analysis concepts (e.g., goals, actors, event, process, domain property, etc.), it links the two requirements analysis phases.

3.1 The Strategic Goal-Role Model

The SGRM support the acquisition, representation and reasoning about the strategic knowledge of the organization.

Figure 1 depicts the SGRM. **Actors** are intentional entities used to model peoples, physical devices or software systems that are processor for some actions. They have some **Goals** that guide their actions. They occupy **Organizational Roles** which are abstract characterizations of expected behaviour of an **Actor** within some specified context of the organization. Each **Organizational Role** requires a set of **Capabilities** to fulfil or to contribute to **Organizational Goals** for which it is responsible.

To fulfil **Goals**, **Organisational Roles** will be involved in **Dependencies**. They symbolize the need for interaction and the importance of social relationships between members of the organization. Indeed, as **Actors** (who occupy **Organisational Roles**) have limited capabilities and access to resources, they will depend on each other to realize their responsibilities.

Actors have also individual interests shown as **Personal Goals** that they pursue. **Goals** can also be classified as **Operational Goals** or **Softgoals**. An **Operational Goal** describes a desired state of the environment that can be achieved by applying actions, a **Softgoal** describes a desired state that cannot be achieved by means of a pre-defined action, or does not specify the criteria for verifying it has been achieved.

Actors organize themselves in emergent **Actor Groups**, or formally structured **Role Groups**. **Groups** constitute **Organizations**. Both **Groups** and **Organizations** enforce specific **Organizational Rules**, which contribute positively or negatively (i.e. help or hinder) to fulfilling **Goals**. Since organizations operate in an unpredictable environment and may have conflicting objectives, **Obstacles** that may harm **Goals** and the various types of **Goal Inconsistencies** may exist. Additional concepts such as a **Goal Refinement Alternative** are used to represent and reason about alternative structures of the organizational context.

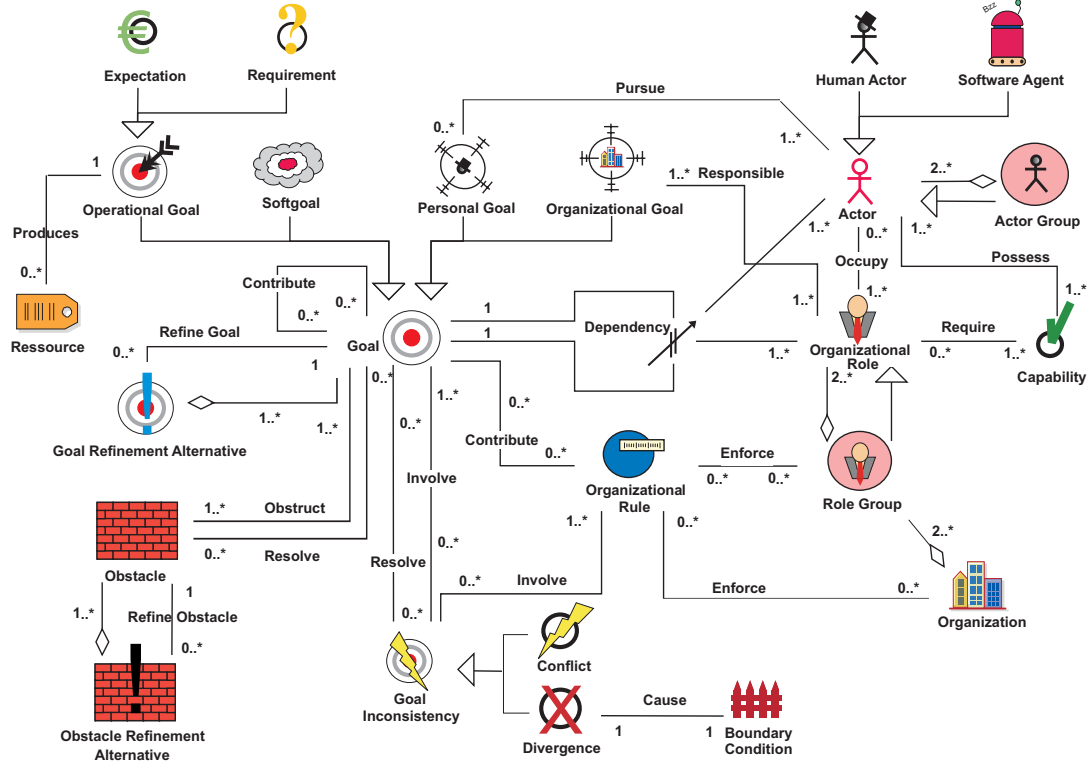


Figure 1. Concepts and relationships of the Strategic Goal-Role Model (SGRM)

The elements of the SGRM are instantiated to provide a Strategic Goal Role Diagram (SGRD). A SGRD expresses the intentional structure of the organizational context. It supports the identification of alternative organizational configurations. It shows the potential problems that will be encountered when attempting to fulfil goals and, with the guidance of the methodology, helps reasoning about potential solutions. In its essence, it helps to understand the purpose of the organization in terms of its Goals, the problems (i.e. Obstacles and Goal Inconsistencies) to which they respond, and the social structure (i.e. the Dependencies, Groups, Organizational Rules, Domain Properties, ...) which govern Actor interactions.

3.2 The Operational Process Model

The OPM describes how Operational Goals are fulfilled through the execution of Actions which use or transform Process Elements.

The aim in specifying the OPM is to identify a set of concepts, relationships, attributes, and constraints that need to be taken into account when a process is described, specified and analysed.

Figure 2 gives a representation of the OPM. A **Process** is a set of sequentially and/or concurrently executed **Actions**. Its purpose is to fulfil a set of **Operational Goals** which were described in the SGRM. **Actions** are basic executable operations of actor behaviour. They use or transform **Process Elements**. The execution of an **Action** can generate **Events**.

An **Event** marks the act of transforming a **Process Element**. Essentially, an **Event** is a piece of information that describes how a **Process Element** has been modified through the execution of an **Action**. **Events** may trigger or stop the execution of **Actions**.

A **Process Element** is any entity that is used or transformed in a **Process**. A **Product** is a tangible or intangible entity through which a **Process** adds value to the organisation. An **Artefact** is a set of business records that represents the information content of the business. An **Artefact** records information about the treatment of a **Product**. A **Belief** is information that is assumed to be true. It carries meaning for the **Actors** executing **Actions** in that it influences how **Actions** are executed. A **Domain Property** is a **Belief** about the environment of the **Actor** which is always true, in that the **Actor** is not able to modify it during **Action** execution. An example is an industry-specific regulation imposed by the government. An **Organizational Rule** is a **Belief** assumed to be true within the **Organisation**. As opposed to a **Domain Property**, it is organization-specific and can be modified.

The OPM is instantiated in an **Operational Process Diagram (OPD)**. An **OPD** describes the aspects of the process relevant for process analysis and design steps in the methodology. It externalises relevant knowledge of the stakeholders to support discussion about process change and improvement. It is a blueprint of a process, aiding to understand the various process dimensions.

To facilitate early-requirements acquisition through the SGRM and OPM, our framework provides also a “rich” *acquisition language*. This language offers a variety of built-in concepts that provide formal basis for elicitation and acquisition requirements. The primitives of this language are defined from the meta-concepts, relationships, attributes and constraints of the SGRM and OPM. It allows analysts to elaborate and express the SGRD and OPD

related to the future IS. This acquisition language is not presented in this paper, but a description can be found in [Fau04].

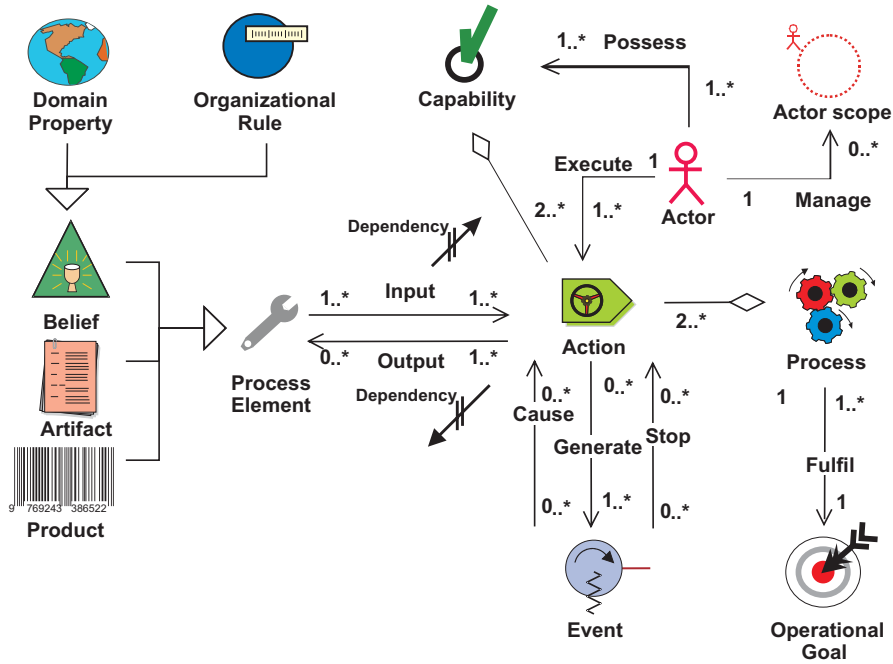


Figure 2. Concepts and relationships of the Operational Process Model (OPM)

4. CASE STUDY

Carsid [Car04] is a joint venture that has recently arisen from the global concentration movement in the steel industry. The alliance, physically located in the steel basin of Charleroi in Belgium, has been formed by the steel companies Duferco (Italy), Usinor (France) - that also partially owns Cockerill-Sambre (Belgium) through the Arcelor group - and Sogepa (Belgium), a public investment company, representing the Walloon Region Government. Usinor has also brought its subsidiary Carlam in the alliance.

Roughly speaking, the aim of a steel industry like Carsid is to extract iron from the ore and to turn it into semi-finished steel products.

Figure 3 models the organization of the Carsid joint venture with our SGRM. Carsid assumes two roles Carsid S.A. ("Société Anonyme" i.e., "Ltd") and Carsid Joint Venture. Carsid S. A. is the legal and contractual interface of the joint venture. It handles the sales of *steel semi-finished products* (bars, plates, rails, sheets, etc. but also slabs, billets) and *co-products* (coke that does not meet blast furnace requirements, rich gases from the different plants, god-roon, naphthalin, etc.) to external *industries* such as vehicle (automobile, train, boat, . . .) manufacturers, foundries, gas companies, building companies, . . . It is also in charge of the *proper environment policy*, a strategic aspect for steelworks that are polluting plants. Most important, Carsid has been set up with the help of the Walloon Region to guarantee *job security* for about two thousands workers in the basin of Charleroi. Indeed, the steel industry in general and the Walloon metallurgical basins in particular are sectors in difficulty with high unemployment rates. As a corrolar, the joint venture is committed to *improve regional economy* and maintain work in the region. Carsid has then been contractually obliged to plan *maintenance investment* (e.g., blast furnace repairing, renovation of coke oven batteries, ...) and develop *production plans* involving regional sub-contractors and suppliers. Since steelmaking is a hard and dangerous work sector, Carsid is legally committed to respect and promote *accident prevention standards*.

The *Carsid joint venture* itself coordinates the steel manufacturing process. The sintering phase to *prepare iron ore* is the responsibility of *Duferco Sintering Plant* while *Usinor Coking Plant* distills coal to turn it into coke. The *sinter charge* and coke are used by Cokerill Blast Furnace to produce *cast iron* by removing oxygen from sinter. *Duferco Steel Making Plant* transforms cast iron into steel to produce slabs and billets for *Carlam Rolling Mill* in charge of the *hot rolling* tasks. Sogepa, the public partner, has the responsibility to develop regional initiative to promote Carsid activities, particularly in Belgium.

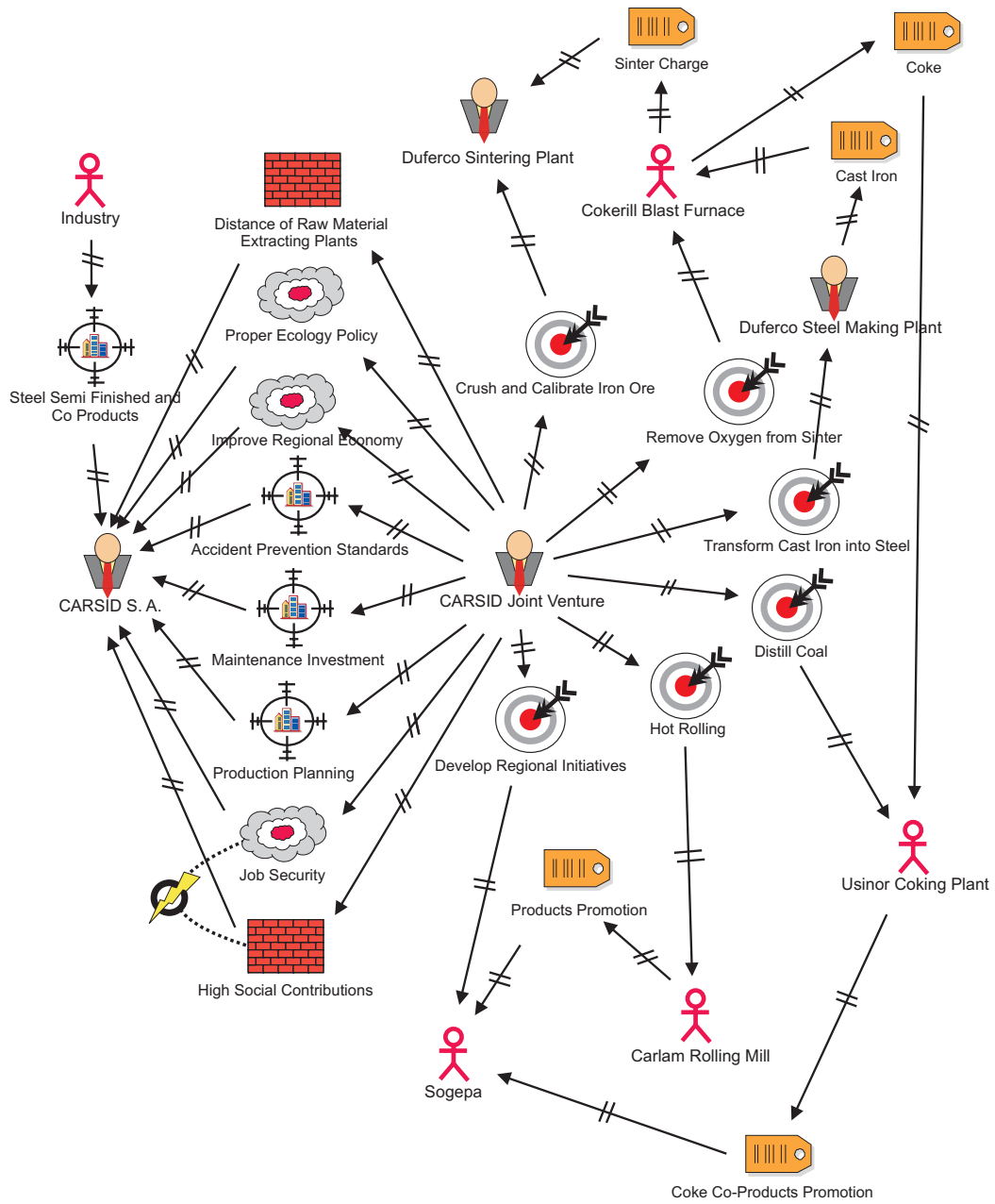


Figure 3. SGRD of Carsid Organization

Figure 4 proposes an operational process representation of Carsid main activities with our OPM. Several steps compose global the transformation process, each step is generally assumed by a specific metallurgic plant:

- *Sintering Plant.* Sintering is the preparation of the iron ore for the blast furnace. The minerals are crushed and calibrated to form a sinter charge.
- *Coking Plant.* Coal is distilled (i.e., heated in an air-impoverished environment in order to prevent combustion) to produce coke.
- *Blast Furnace.* Coke is used as a combustion agent and as a reducing agent to remove the oxygen from the sinter charge. The coke and sinter charge are loaded into the blast furnace to produce cast iron.
- *Steel Making Plant.* Different steps (desulphuration, oxidation, steel adjustment, cooling, . . .) are necessary to turn cast iron into steel slabs and billets. First, elements other than iron are removed to give molten steel. Then supplementary elements (titanium, niobium, vanadium, . . .) are added to make a more robust alloy. Finally, the result - finished steel - is solidified to produce slabs and billets.
- *Rolling Mill.* The manufacture of semi-finished products involves a process known as hot rolling. Hot-rolled products are of two categories: flat (plates, coiled sheets, sheeting, strips, . . .) produced from steel slabs and long (wire, bars, rails, beams, girders, . . .) produced from steel billets.

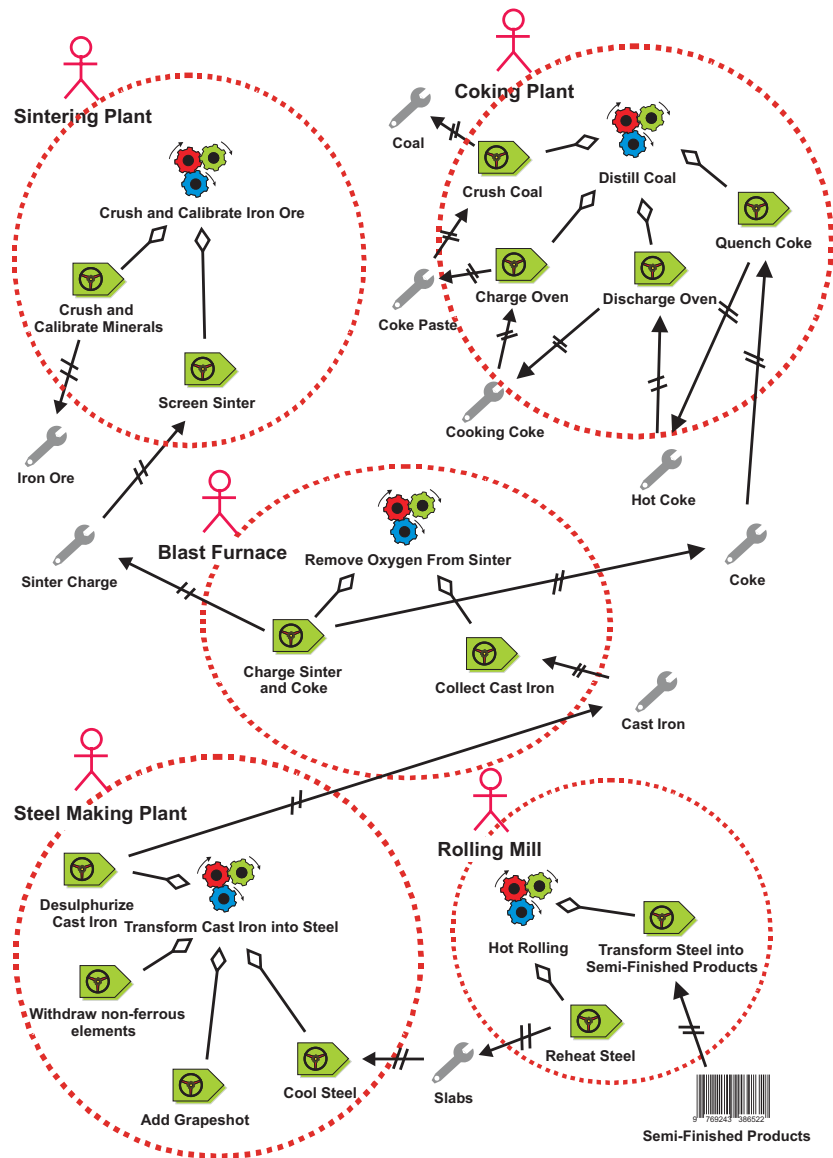


Figure 4. OPD of Carsid Industrial Process

5. CONCLUSION

Modeling the organizational and operational context within which a system will operate is an important element of the requirements analysis process (e.g., [Cas02]). Business requirements analysts need to have a deep understanding of organization's goals, of the processes that fulfil these goals, of the way in which the future system will be involved in the processes, and the way it will contribute to the purpose of the organization.

Unfortunately, no specific organizational framework really exists for engineering requirements of modern corporate information systems. This paper has overviewed an integrated framework to specifically focus on the phase of the organisational requirements analysis process coherent with main ideas from existing frameworks. It has proposed a conceptual meta-model that guides the requirements acquisition to represent the organisational requirements of the system-to-be. Our framework differs primarily in the fact that it is founded not only on ideas from requirements analysis frameworks, but more important on management theory concepts relevant for enterprise ontologies.

We have only overviewed here the fundamental concepts of the meta-model to motivate our epistemological approach. Formal specification of the models can be found in [Fau04]. We are currently using it to produce the complete requirements specification Carsid. A CASE tool is also under development.

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