Framework for the Modelling of the Decision View

of the Supply Chains Collaborative Planning Process

D. Pérez, Fco-Cruz Lario, M.M.E. Alemany

Centro de Investigación en Gestión e Ingeniería de Producción (CIGIP),

Universitat Politècnica de València,

Jorge E. Hernández

Management School, University of Liverpool

Abstract

In the context of supply chains operations planning and from a research point of view, it has been mainly assumed that different supply chain members make decisions in a centralised manner (one decision centre). However, reality shows that this is not the most usual situation, but the distributed supply chain decision making. This paper proposes a framework for supporting the modelling of the decisional view of the collaborative planning under a decision-making process perspective for both, the centralised and the distributed situation. Along these lines, the framework assumes that the supply chain may be composed by one or several decision centres oriented to support every supply chain planning operations. Thereafter, the main framework contributions are: the consideration of the decision jointly within the physical, organisation and information views; the spatial and temporal integration among the different supply chain decision centres and the definition of the macro level for the "conceptual" modelling of the collaborative planning process and the micro level for the development of analytical models in each of the decisional activities identified in the supply chains operations planning process. Finally, a brief overview of a real case application is also described.

Keywords

Framework, collaborative planning, supply chains, decision-making process, decisional view

Framework for the Modelling of the Decision View of the Supply Chains Collaborative Planning Process

In the last years, many papers are emphasizing the importance of the Supply Chain (SC) Management (Cooper, Lambert, & Pagh, 1997; Croom, Romano, & Giannakis, 2000; Lambert & Cooper, 2000; Lejeune & Yakova, 2005; Min & Zhou, 2002; Stadtler, 2005). In this context, processes, traditionally developed in an intra-Enterprise level, should be adapted to be designed and executed by different enterprises, separated and with distinct characteristics, but at the same time belonging to the same SC. In that sense, processes are becoming more collaborative. Moreover, as defined by Hernández, Poler, Mula and Lario (2011), the collaboration in the supply chain can be defined as the way by which all the companies in a SC are actively working together toward common objectives, and are characterized by sharing information with multiple participants and processes. Among those processes, in the present work, it is approached one of the most relevant, as it is the Operations Planning Process, which in collaborative contexts is commonly known in the literature as Collaborative Planning (CP) Process.

A lot of literature definitions exist about the CP Process concept. The CP is defined in Dudek and Stadtler (2007) as the coordination of planning and control operations across the SC, i.e., production, storage and distribution processes. Another definition, which has been useful is that of Stadtler (2009), in which are identified several Decision Levels, from the most strategic until a programming level, and in which are placed the Operations to be planned, carried out by different “entities” of the SC collaborating among them.

Based on Stadtler (2009) we define CP as a distributed decision-making process pertaining to a SC in which different decisional units (or Decision Centres) have to be coordinated to achieve a certain level of SC performance. However, this coordination is narrowed to a tactical level (aggregate planning) and further to a tactical-operational one (master plan). Therefore, it is not included in our definition, neither the strategical (design) nor the operational programming levels.

By the other hand, the design, analysis, adaptation, monitoring, control and improvement needs of the CP Process are becoming higher, which has led, mainly since the beginning of this century, to the publication of many papers addressing the importance of its modelling, from multiple points of view: functional, analytic, etc. Nevertheless, for an efficient and effective modelling is essential to take into consideration all the aspects influencing it as well as the relationships among them.

Such a contention justifies the development of a framework (Fleischmann & Meyr, 2002; Pontrandolfo & Okogbaa, 1999; Stadtler, 2009; Stadtler & Kilger, 2002) to facilitate the modelling of the SC CP process in an integrated manner. In Alarcón, Lario, Bozá and Pérez (2007) some of this paper authors propose an appropriate framework whose principal contributions concern as follows.

Firstly, it integrates four different Modelling Views, as they are Physical, Organisation, Decision and Information ones and their relationships. That facilitates the development of integrated models of the CP Process, leading to more realistic and versatile models, being able to be applied to complex SCs. Particularly, the proposed Framework uses the Decision View as the main one, but complemented and enriched with another Views, since the CP Process implies to take decisions about Resources/Items (Physical View) taking part of an Organisation in which the different "entities" are more or less integrated (Organisation View) and the SC activities consume and generate information (Information View), in order to be able to make appropriate decisions and SC operations plans.

Secondly, it is stressed the importance of Distributed Decision-Making contexts (Schneeweiss, 2003) in which are embedded the CP Process, by explicitly taking into account at the same time the two interdependence relationships types, Temporal (among Decision Centres belonging to different Decision Levels) and Spatial (among Decision Centres belonging to the same Decision Level).

Finally, the Framework is not only conceptual but also analytical, that is, it includes all the necessary aspects to conceptually model the CP Process (Macro-Level) and also the aspects to facilitate the formulation of Analytical Models as an aid to the Decision-Making of the CP Process (Micro-Level).

In this paper it is only explicitly analyzed the Decision View at a Macro Level, or what is the same, the Macro-Decision View. The Decisional View is closely related to Decision-Making and therefore to activities of a decisional nature, which mostly define the CP Process. The Macro-Decisional View presents all the aspects to the CP Process Modelling since a "conceptual" point of view, that is, defines all the Decisional activities and their interdependence relationships, which mainly determines their execution order within the whole CP Process.

The rest of the paper is arranged as follows. In the next section it is described the Framework where it is embedded the proposed Decision View. Then it is analyzed the Decision View, briefly showing which aspects in the Macro and the Micro Level are included. Afterwards, it is explicitly considered the Macro-Decision View and some snapshots about its application in a real case. Finally, some conclusions and further research are offered, some of them being currently carried out.

Brief Framework Description

The CP process is primarily regarded as a decision-making process since most of the activities within this process are of a decisional nature. Nevertheless, CP decisions are made in a predetermined sequence (Decision View) with regard to elements such as physical and human resources, and items (Physical View), and their specific arrangement (Organisation View), and specific information (Information View) which are required to appropriately model the CP process. Therefore, there is a need to relate all these Views in order to provide more realistic and integrated models of the CP process (Figure 1).

The Framework identifies the structure and the relevant features of any SC based on the previous views and provides all the necessary aspects either to model the SC CP process itself or develop analytical models in each of its decisional activities.

A brief outline of each view is provided for clarification purposes:

- Physical view: identifies how a specific SC is configured, that is, the resources and the items about which the decision-making process is being undertaken.
- Organisation view: identifies the relationships among the resources represented in the physical view, an important aspect which strongly influences the decisional view.
- Decision View: is divided into two sub-views: macro-decisional and micro-decisional. The first identifies the “decision centres”, their interdependence relationships and the decisional activities making up the CP process along with the shared information. The second, strongly influenced by the macro-decision view, identifies all the aspects that internally characterise the decision-making process of each decision centre facilitating their analytical modelling.

- Information View: may be considered as the "integrated view" as it collects and represents the necessary information from the other three views to support the SC CP process, which implies the information sharing among them.

The Framework made up of the four Views: Physical, Organisation, Decision and Information is represented in Figure 1. The Framework feeds on one hand the Methodology (I), to "conceptually" model the SC CP process itself and on the other hand the Methodology (II) to develop Analytical Models in each of its Decisional Activities (Figure 2). These Methodologies, are strongly linked but named differently and are not approached in the present paper.

In this paper, that part of the Framework which relates to the Macro-Decision View is only detailed since it is aimed the SC CP process modelling from a "conceptual" point of view (Figure 1). Nevertheless, some aspects of the another interacting Views are also briefly addressed.

Decision View Description

The Framework Decision View is divided into two sub-Views: Macro-Decision and Micro-Decision Views (Figure 2). Although it is only the Macro-Decision View that is considered, it is important to briefly indicate some relevant aspects of the second, the Micro-Decision View, which is linked with the Macro-Decision one.

The Macro-Decision View analyzes which Decision Centres are implied in the Decision-Making Process and, taking into account the Decisional Level where they are and their Interdependence Relationships which are the Decisional Activities of the CP Process, their execution order and information shared among them. This analysis allows to respond to the following key questions in order to model the SC CP Process: who performs the Decision

Activity?, when it is performed the Decision Activity? and what it is performed (at a Macro level) in the Decisional Activity? (Figure 3).

The Micro-Decision View analyses the aspects that internally characterise the decision-making process, in each of the Decision Centres, aiming to provide the basis to respond to the following questions: what type of specific Decisions are taken in each Decisional Activity (Decision Variables)? and how is the Decision Activity performed (Decisional Model and Input Information)?. Therefore, this Micro-Decision View, must collect, among others, the Decisions to be made, and the Decisional Model (made up of some Objectives/Criteria and Constraints/Decisional Field) to take them. They are relevant for formulating their associated Analytical Models as an aid for the decision-making process in each Decisional Activity of the CP Process, taking into consideration the Interdependence Relationships, in the form of shared information, previously analysed in the Macro-Decision View.

Macro-Decision View

The Macro-Decision View is made up of three main blocks: definition of the DCs implied in the CP Process, characterization of the Interdependence Relationships (Temporal and Spatial) among the defined DCs (Pontrandolfo & Okogbaa, 1999; Schneeweiss, 2003; Schneeweiss & Zimmer, 2004) and the identification of the Decision Activities of the CP Process and their execution order along with the exchanged information among them.

Decision Centres Definition

It is relevant to stress that the Macro-Decision View is based on the fact that the initial Decisional problem of the CP Process may be divided into several sub-problems, belonging to the various DC. At the same time, a collaborative context implies that those sub-problems are not fully independent but the are overlapped, and therefore, leading to Interdependence Relationships, either from a Temporal or Spatial points of view (Alemany, 2003).

At this point, it is necessary, to a better understanding of the DCs definition, to show some concepts of the Physical and Organisation Views which are closely related to them. In the Physical View are defined “Stages” (Suppliers,Procurement, Manufacturing/Assembly and Distribution), “Nodes”, and “Arcs”, which connect dyadic Nodes and represent the flow of items from an origin to a destination node. Besides, each of these Nodes and Arcs perform the “Processing Activities” (Production/Operations, Storage and Transport).

In the Organisation View are defined the “Organisation Centres (OCs)”, which are responsible of the execution and control, and in some cases of the decision-making, of one or more Processing Activities previously identified in the Physical View. These OCs are placed in two “Organisation Levels”, that is the Tactical and the Operational ones.

From the Physical and the Organisation Views, in the Macro-Decision View are identified the different DCs. A DC corresponds to a “decision-maker” (human or computer resource), which in an automated manner or not, are responsible of the Decision-Making of one or more OCs. The taken decisions (tactical and operational plans) affect to the Processing Activities of which were responsible the OCs.

As in the Organisation View, in the Macro-Decision View are also defined two “Decision Levels”, each of them, Tactical and Operational made up of one or more DCs. This allows to have a first approximation of how centralised or decentralised/distributed is the Decision-Making Process in each of the Decision Levels. This “decisional map” is the input to the second block, in which are characterized the DCs Interdependence Relationships.

Interdependence Relationships Characterization

Once defined the DCs in each of the Decision Levels, it is established in a second block which type of Interdependence Relationships exist among them, either temporally (among Decisional Centres belonging to different Decisional Levels) or spatially (among Decisional Centres belonging to the same Decisional Level), which allows to have a first approximation

The fact that exist more than one DC in certain Decisional Level imply that decisions are not centralised (in this case from a spatial point of view), but doesn´t imply that these are fully decentralised, but distributed (in case of collaborative contexts). This distributed Decision-Making (more or less hierarchical) is of special relevance when characterizing the DC Interdependence Relationships.

At this point, it is important to know how the Macro-Decision View and the Information View are related since these interdependence relationships require transmitting a certain type of information among DCs. Since a Macro point of view, this information may be of two different origins. In one hand, that information which comes from decisions already taken by others DCs and in the other hand, that which concerns certain attributes characterising different aspects of other DCs. These two types of information are known as Joint-Decision Making and Information-Sharing, respectively.

In Figure 4, there are shown the Information View concepts needed to characterize the Interdependence Relationships between a “Top” DC (DC^T) and a “Base” DC (DC^B). First, DC^T sends and Instruction (IN_k) to DC^B, which is composed by one hand of the part of its previously taken decision which affects DC^B (known as Global Variables-GV) and by the other hand information which may help in their joint coordination/collaboration

Decision-Making Process (known as Global Information – GI). Before sending that IN, CD^T could have anticipated (ANT_k) some relevant aspects of DC^B in order to enhance the Process. Secondly, in non-hierarchical schemes, the DC^B could send back a counterproposal to DC^T within a Reaction (R_k). There may be several cycles k IN_k-R_k during the joint Decision-Making Process. Finally, both DCs "agree" and "implement" their decisions (Tactical or Operational Plans).

Based on the concepts explained about Figure 4, the Macro-Decisional View characterizes the interdependence relationships among DCs within the description of five parameters, being each one of them, in turn, made up of several attributes (Table 1).

Finally, it is also defined the concept of Decision Environment of a DC (Schneeweiss, Zimmer, & Zimmermann, 2004) formed by those DCs which have some kind of interdependence relationship with.

However, the Macro-Decision View highlights the fact that the DC Decision Environment of a generic DC^M is made up of either by those which interacts temporally (DC^{Tt}, DC^{Bt}) or spatially (DC^{Tt}, DC^{Bt}) (Figure 5).

Decisional Activities Identification

In this third block are defined the necessary concepts to identify each of the Decisional Activities of the SC CP Process, as well as their execution order, since in a Collaborative context, they are all interconnected. Finally, the input and output information of each of the decisional activities due to the former interdependence relationships are also addressed.

As previously pointed out, the decision view has two decision levels, the tactical and operational ones, each one with their own temporal characteristics, namely horizon and planning periods. Here, a new temporal characteristic is defined in each of the decision levels, called replanning (or revision) period in order to stablish the sequence in which the decisional activities are executed/activated by the DCs.

It is necessary to stress that the DCs definition is not the same as the decisional activities identification. For instance, in the case of a non-hierarchical context negotiation process carried out by two DCs, depending on the number of cycles in the decision-making process, a DC may lead to more than one decisional activity, as a result of its successive activations generating proposed decisions or plans.

It is assumed, that two DCs placed in the same decisional level present the same replanning period and horizon. If this is not the case, an initial effort should be made to synchronise them in a CP context.

Within the replanning period it is possible to know when a DC placed in any of the decision levels should make its decisions, that is, when it has to be executed or activated, leading, as it was commented before, to one or more decisional activities.

The former implies that all the decisional activities of the CP process are activated periodically (as it usually happens with the decision-making at a tactical/operational level). Nevertheless, as there may be several of them being executed at the same time, their sequence is based on which DCs are “top” ones (DC^T). The rules to consider a DC as a DC^T regarding another one are as follows:

- DCs placed at the tactical decisional level are always activated before DCs placed in the operational decisional level, and therefore the last ones are always regarded as a “base” from a temporal point of view. In this case the replanning periods and the horizon of the DCs placed in the tactical decisional level are multiples of the DCs placed in the operational one. Furthermore, these DCs placed in the operational level review their operational plans with a higher frequency (shorter replanning periods) so that the decision-making only matches in specific instances of time.

- Given one of the two decisional levels (tactical or operational), a DC is activated before all of the "base" from a spatial point of view. The DC "top" is therefore activated just an instant before despite sharing the same replanning period. This is often due to power-related issues.

Finally, the input and output information due to temporal and spatial integration issues of each SC CP decisional activities are also addressed. As previously depicted in figure 4, there are two types of exchanged information in a collaborative context, known as joint-decision making and information-sharing, which determines the previous interdependence relationships' characterisation. It is important to note that at this macro-level are just represented if there are instructions (IN) coming from decisional activities executed by "top" DCs (joint-decision making) and if certain type of anticipation (ANT) exists (information sharing). None of them are explicitly addressed in the Macro-Decision View of the framework but in the Micro-Decision View, for the analytical modelling of the CP process.

Macro-Decision View Application: A Brief Overview

The main purpose of the present paper is describing a Framework for the modelling of the decision view of the supply chains collaborative planning process, that is, its Macro-Decision View. Nevertheless, for a better understanding of it, a real case application is also included, but only showing its main snapshots. Such a real case regards to a Spanish SC dedicated to the design, manufacture, marketing and distribution of white clay-based and red clay-based (glazed), ceramic flooring (technical porcelain and glazed porcelain stoneware), and white clay-based (glazed) and red clay-based (glazed) ceramic coverings. The SC is briefly described in the following paragraphs.

With regard to suppliers, those considered are N3, N4 and N1, which supply white clay, red clay and frits/glazes respectively. Each of them supplies to each of the manufacturing firms N7.1, N7.2 and N8, except N4, which does not supply to N7.1.

With regard to manufacturing firms, those considered are N.7.1, N.7.2 and N8, which belong to the same Industrial Group (IG), that manufacture a broad catalogue of finished goods. There are finished goods with high added-value that are manufactured only in production plants; others may be partly subcontracted, while some may be totally subcontracted to external suppliers (normally products with low added-value). In this sense, supplier N6, which supplies manufacturing capacity, could be regarded as another manufacturing firm.

All of them supply to each of the two existing central warehouses. The SC suppliers and manufacturers considered are shown in Figure 6.

Finally, with regards to the distribution phase, different customers (from the two central warehouses) are considered:

- Independent distributors: only one of them is explicitly considered, with which there exists a weak collaborative link. It is only supplied from the central warehouse 2 due to the specific brand distributed, and supplies two independent retailers. The remainder of the independent distributors are viewed as having independent demand assigned to both central warehouses.
- Construction firms: similarly to most of the independent distributors, they are also viewed as having independent demand assigned to both central warehouses.

- Logistics centres: this distribution channel is the most downstream-integrated, mainly because the logistics centres and retailers belong to the same IG as the manufacturing firms N7.1, N7.2 and N8. Two logistics centres are considered, which are indistinctly supplied by each of the two central warehouses, with the exception of the logistic centre 2 which is only supplied by the central warehouse 1. Finally, both logistics centres supply two retailers previously assigned to them.

The SC distributors and customers considered are depicted in Figure 7.

Once described the Spanish ceramic SC, the decisional challenge to be addressed consists of the mid-term and short-term operations planning process for the replenishment, production and distribution of the SC.

In the following sub-sections, some snapshots of the macro-decision view application, that is, the SC "collaborative" process modelling from a conceptual point of view, are shown. However, the way in which the methodology (I) (Figure 2) has been applied to the SC process is not explicitly reported.

Decision Centres Definition

This is the first step of the Macro-Decision view application. At this point, it is important to remark that the methodology (I) has already addressed the Physical and Organisation Views, closely related and interconnected with the definition of the Decision View, and particularly the Macro-Decision one. From the Physical and the Organisation Views, in the Macro-Decision View are identified the different DCs in the tactical and operational decisional levels. The DCs identified in the tactical decisional level are represented in Figure 8.

As observed, DC4 is making decisions about several PAs (P: production, S: storage and transport) which, although in this decision view are not depicted, were executed and controlled by different OCs.

These PAs are carried out by different arcs-nodes which belong to different SC stages (SUP: Suppliers, PRO: Procurement, MAN: Manufacturing and DIS: Distribution). In this case transport from suppliers to manufacturers, production and storage in manufacturers (as it may be seen there are several node sub-stages), transport from manufacturers to central warehouses, storage in warehouses, transport from warehouses to logistic centers and storage in logistic centers. The DCs identified in the operational decisional level are also represented (Figure 9).

Interdependence Relationships Characterization

This is the second step. As an example, the interdependent relationships of the DC4 placed at the tactical decision level, that is, TDL-DC4 are characterised (Table 2) according to the parameters/attributes previously defined in Table 1.

It is shown, for example, that TDL-DC4 has an interdependent relationship with the TDL-DC2, which is characterised by five attributes: spatial (E), hierarchical (H), organisational (O), non-reactive (NR) and non-opportunistic (NO). To fully complete this step it would be necessary to construct as many tables as DCs defined in the previous step.

Decisional Activities Identification

This is the last step of the Macro-Decision view application. The identification of the decisional activities of the CP process is represented (Figure 10 and Figure 11), based on the concepts previously explained about the identification of decisional activities and their execution order rules.

The tactical and operational decisional levels are defined on the left-hand side, in addition to the identification of the DCs in each case (Figure 10).

Each DC periodically executes its own decisional activity according to the re-planning period (RP). It may be observed that the RP of tactical DCs are all monthly while the RP of the operational ones are weekly. Since the former DCs' decisional activities are not isolated, but are part of an interrelated CP process, it is needed to keep a certain execution order which depends on which DCs are "top" ones (DC^T).

From a temporal point of view, it seems reasonable to assume that the decisional activities of DCs at higher decisional levels are executed before the lower ones. For example, the TDL-DC4 decisional activity is executed before ODL-DC6. Nevertheless, from a spatial point of view, that is, among the DCs' decisional activities placed at the same decision level, it does not appear so evident. For example, the TDL-DC4 decisional activity is executed before TDL-DC5, due to the previous characterisation of relationships (step 2).

The execution order of the decisional activities in T_0 is considered. The sequence of execution is numbered from (1) to (13) (Figure 11).

The CP process of this case study starts at the tactical level with the decisional activity (DA) numbered as (2), that is DA (2), when TDL-DC4 draws a tactical plan (aggregate plan) for the product families produced in the three manufacturing plants (N7.1, N.7.2 and N8) that are distributed between the manufacturing plants and the central warehouses, and between the central warehouses and the logistics centres. The planning horizon consists of one year divided into months. The main inputs are the final product families' forecasts in each of the logistics centres, from the joint demand generated by the retailers belonging to the IG, along with that in each of the central warehouses, mainly from the demand generated by independent distributors and construction firms.

In addition, and due to spatial integration issues, a tactical demand plan coming from

TDL-DC6 also exists. Once executed, this aggregate plan, TDL-DC4, transmits its requirements of annual amounts of raw material to TDL-DC1, TDL-DC2 and TDL-DC3 which correspond to frits/glazes, and white and red-clay suppliers belonging to the IG (N1,N3 and N4 respectively). Additionally, annual subcontracted requirements of each product family are also transmitted to TDL-DC5, which corresponds to the supplementary capacity plant (N6).

The DA (1) on the CP process is precisely the one executed by TDC-DC6 which draws a tactical distribution plan for all the product families to be sold by the independent distributor from the joint demand generated by the independent retailers. It transmits the previous tactical demand plan.

Also at this tactical level, TDL-DC1, TDL-DC2, TDL-DC3 and TDL-DC5 make decisions relating to their annual production capacity, which leads to DA (4), DA (5), DA (6) and DA (7) respectively, in accordance with the annual demand required by the TDL-DC4 and the demand of their other customers. All these DCs incorporate this information as client demands into their respective decision models due to spatial integration issues.

At the operational level, the DA (3) is executed by ODL-DC7 leading to an operational distribution plan derived from the capacity decisions previously made in the DA (1) by TDL-DC6 (temporal integration) and the final products´ forecast in each of the independent retailers. The DA (8) is executed by ODL-DC6 leading to an operational distribution plan from the central warehouses to logistic centres and from the logistic centres to each of the retailers belonging to the IG. This plan derives from the distribution capacity decisions previously made in the DA (2) by TDL-DC4 (temporal integration) and the final products´ forecast in each of the retailers.

These two decisional activities, DA (3) and DA (8), jointly with the DA (2) provide the main inputs to the ODL-DC4, which executes the DA (9). At this operational level, ODL-DC4 prepares an operational plan (master plan) for each of the final products produced in the three manufacturing plants, N7.1, N.7.2 and N8. The planning horizon consists of two months divided into weeks. The main inputs concern, as previously identified, the capacity restrictions as a result of the execution of DA (2) by TDL-DC4 (temporal integration) and the final products' demand decisions in each of the central warehouses transmitted from the execution of DA (3) and DA (8) by ODL-DC7 and ODL-DC8 respectively (spatial integration).

In addition, a final products´ forecast generated by independent distributors and construction firms also exists. Once this master plan is executed, ODL-DC4 transmits its requirements of weekly amounts of raw material to ODL-DC1, ODL-DC2 and ODL-DC3 which correspond to frits/glazes, and white and red-clay suppliers belonging to the IG (N1,N3 and N4 respectively). Additionally, weekly subcontract requirements of each final product is also transmitted to ODL-DC5, which corresponds to the supplementary capacity plant (N6). Finally, also at this operational level, ODL-DC1, ODL-DC2, ODL-DC3 and ODL-DC5 make decisions relating to their own two-month master plans, which leads to DA (10), DA (11), DA (12) and DA (13) respectively, according to the constraints in terms of capacity provided by their corresponding DCs at the tactical level (temporal integration) and the raw material and final product requirement plans required by ODL-DC4 (spatial integration).

Once the decisional activities and their sequence are identified, it is also important to note, in this last step of the macro-decisional view, the input and output information flows due to integration issues (temporal and spatial) of each of the ceramic SC CP decisional activities. As depicted in Figure 3, this information may have two different origins: information which comes from decisions previously made by other DCs (joint-decision making), and, that which concerns certain attributes characterising different aspects of other DCs (information sharing).

As an illustrative example, a graphical representation (at a macro level) of the input and output information, respectively, of the DA (2), executed by TDL-DC4 is displayed in Figure 12 and Figure 13.

Conclusions and Future Research

This paper proposes a framework for supporting the modelling of the decisional view of the collaborative planning under a decision-making process perspective for centralised and distributed scenarios.

The main goal of the proposed Framework is to help, facilitate and guide users to model such process in particular situations. For this, the Framework provides, in an organized manner, all the necessary information in order to considerate all the important aspects which are needed to model the CP Process, either from conceptual or analytical points of view.

The main contributions of this Framework are:

- It integrates four different modelling views: physical, organisation, decision and information ones and their relationships. This facilitates the development of integrated models of the supply chain CP process, leading to more realistic and versatile models, and being able to be applied to any complex SC. Particularly, the proposed framework uses the decision view as the main one, but complemented and enriched with other perspectives, since the CP process implies to take decisions about resources/items (physical view) which are specifically arranged (Organisation View), and specific information (Information View) is required to properly model the CP process. Therefore, there is an imperative need to connect the Decision View embedded in the CP process with the rest of the views.

- It enables the simultaneous spatial and temporal integrations for any type of SC physical configuration. The SC decision-making context considered by the Framework allows the definition of different temporal decision levels. At each level, the decision-making can be centralised (one DC) or distributed (several DCs). These DCs are subject to two Interdependence Relationship types, temporal (among DCs belonging to different decision levels) and spatial (among DCs belonging to the same decision level), characterised by a set of parameters/attributes. This is seen as a contribution since studies that address temporal and spatial integration are lacking (Schneeweiss et al., 2004). In fact, most of them are only valid for specific situations, and do not cover the necessary and simultaneous integration that may emerge in a CP process.
- It considers a Macro-level and a Micro-level. The Macro-level addresses the aspects to conceptually model the CP process. The Micro-level addresses the aspects to facilitate the formulation of analytical models in each of the decisional activities identified in the CP process. This is also seen as a contribution since the Framework facilitates not only the modelling of the CP Process itself but also its analytical modelling (for example Mathematical Programming), in an interconnected manner. This link allows the formulation of analytical models in a structured way for any complex SC, taking into account all the aspects addressed in the conceptual model of the Process, and particularly, the information shared due to the Interdependence Relationships.

In addition, it is remarkable to highlight the lines of future research that are being or will be carried out from the Framework.

Among the first ones, two Methodologies are being developed aiming to indicate all the steps to model the CP Process, based on the proposed Framework.

On one hand, the development of a Methodology (I) which indicates the steps and representation formalisms to “conceptually” model the SC CP Process itself (Pérez, Lyons, Lario, & Alemany, in press) . At this point and for clarification purposes of the theoretical framework, this paper also presents some snapshots of the application of such Methodology (I) to a real case based on a spanish ceramic supply chain, focusing on the macro-decision view of the CP Process.

By the other hand, the development of a Methodology (II) (Pérez, Lario, & Alemany, 2008, 2010) which indicates the steps for the “analytical” modelling (based on Mathematical Programming) of each of the Decisional Activities and therefore of the CP Process as a whole. This Methodology (II) not only will take into account the Framework developed concepts (mainly in the Micro-Decision View) but also the “conceptual” Model of the CP Process previously obtained within the application of the Methodology (I).

In parallel with those methodologies, it is being developed a computer science-based tool (Alemany, Alarcón, Lario, & Boj, 2011) which based on the Methodology (II) allows the execution/validation of the whole SC CP Process.

From a practical point of view, both methodologies and the computer science-based tool are being applied and validated in a particular SC which belongs to the Spanish Ceramic Sector, as it was briefly outlined.

Finally, among the research lines which will be carried out in the near future, it is planned to apply the framework and associated methodologies, by means of the computer tool, to another scenarios with different collaboration schemes.

References

Alarcón, F., Lario, F.C., Bozá, A., & Pérez, D. (2007, September). *Propuesta de Marco Conceptual para el modelado del proceso de Planificación Colaborativa de Operaciones en contextos de Redes de Suministro/Distribución (RdS/D).* Paper presented at the I International Conference on Industrial Engineering and Industrial Management, Madrid, Spain.

Alemany, M.M.E. (2003). *Metodología y Modelos para el Diseño y Operación de los Sistemas de Planificación Jerárquica de la Producción (PJP). Aplicación a una Empresa del Sector Cerámico*, Doctoral dissertation, Universidad Politécnica de Valencia, Spain.

Alemany, M.M.E., Alarcón, F., Lario, F.C., & Boj, J.J. (2011). An application to support the temporal and spatial distributed decision-making process in supply chain collaborative planning. *Computers in Industry*, 62, 519-540.

Cooper, M.C., Lambert, D.M., & Pagh, J.D. (1997). Supply Chain management: more than a new name for logistics, International Journal of Logistics Management, 8, 1-13.

Croom, S., Romano, P., & Giannakis, M. (2000). Supply chain management: an analytical framework for critical literature review, *European Journal of Purchasing & Supply Management*, 6, 67-83.

Dudek, G., & Stadtler, H. (2007). Negotiation-based collaborative planning in divergent two-tier supply chains. *International Journal of Production Economics*, 45 , 465–484

Fleischmann, B., & Meyr, H. (2002). *Planning Hierarchy, Modeling and Advanced Planning*, Amsterdam, North-Holland: Ed. A. G. de Kok, S.C. Graves.

Hernández, J.E., Poler, R., Mula, J., & Lario, F.C. (2011). The Reverse Logistic Process of an

Automobile Supply Chain Network Supported by a Collaborative Decision-Making Model. *Group Decision and Negotiation Journal*, 20, 79–114

Lambert, D. M., & Cooper M.C. (2000). Issues in Supply Chain Management*. Industrial Marketing Management*, 29, 65-83.

Lejeune, M.A., & Yakova, N. (2005). On characterizing the 4 C's in supply chain management. *Journal of Operations Management*, 23 (1), 81-100

Min, H., & Zhou, G. (2002). Supply chain modeling: past, present and future. *Computers & Industrial Engineering*, 43(1-2), 231-249

Pérez, D., Lario, F.C., & Alemany, M.M.E. (2008, September). *Metodología para el Desarrollo de Modelos basados en Programación Matemática en un contexto Jerárquico de Planificación Colaborativa de una Red de Suministro / Distribución (RdS/D).* Paper presented at the II International Conference on Industrial Engineering and Industrial Management, Burgos, Spain.

Pérez, D., Lario, F.C., & Alemany, M.M.E. (2010). Descripción detallada de las variables de decisión en modelos basados en programación matemática en un contexto de planificación colaborativa de una Red de Suministro Distribución (RdS/D. *Revista de Dirección, Organización y Administración de Empresas*, 42, 7-15

Pérez, D., Lyons, A., Lario, F.C., & Alemany, M.M.E. (in press). The application of a methodology for modelling collaborative planning decisions in the supply chain. *International Journal of Computer Integrated Manufacturing.*

Pontrandolfo, P., & Okogbaa, O.G. (1999). Global manufacturing: a review and a framework for planning in a Global Corporation. *International Journal of Production Research.* 37, (1), 1-19

Schneeweiss, C. (2003). Distributed-Decision Making: a unified approach. *European Journal* *of Operational Research,* 150, 237-252

Schneeweiss, C., & Zimmer, K. (2004). Hierarchical coordination mechanisms within the supply chain. *European Journal of Operations Research*, 153, 687–703

Schneeweiss, C., Zimmer, K., & Zimmermann, M. (2004). The design of contracts to coordinate operational interdependencies within the supply chain. *International Journal of Production Economics,* 92, 43–59

Stadtler, H., & Kilger, C. (2002). *Supply Chain Management and Advanced Planning*" Hamburg, Germany: Ed. Springer

Stadtler, H. (2005). Supply chain management and advanced planning - basics, overview and challenges. *European Journal of Operational Research*, 163 (3), 575-588

Stadtler, H. (2009). A Framework to Collaborative Planning and state-of-the-art. *OR Spectrum* 31, 5-30

Notes

This work stems from the participation of the authors in two research projects, both funded by the Spanish Ministry of Education and Science. The first with reference DPI2004-06916-C02-01, “Hierarchical Methodology in an uncertainty context in the Collaborative Planning of the Supply and Distribution Chain/Network. Application to the Ceramic Sector” and the second with reference DPI2008-06788-C02-01, “Mass customisation and intelligent Supply Chains, with complex product y proceses”.

Also to remark the aid of the Universitat Politècnica de València for visiting stays of academic and research staff in prestigious European Research Groups/Centres, in this case, in ULMS (University of Liverpool Management School) within its “Research and development support Program (PAID-00-11)”.

Table 1. Characterization of the Interdependence Relationships

MACRO-DECISION VIEW Characterisation of the Interdependence Relationships	
Parameters	**Attributes**
Interaction Nature (IN)	Temporal (T): The interaction is produced among DCs placed in different Decisional Levels, that is, Tactical and Operational.
	Spatial (S): The interaction is produced among DCs placed in the same Decisional Level.
Interaction Type (IT)	Null (N): No interaction exists. This means that DCs are making their decisions myopically, that is, there are neither Joint-Decision Making nor Information Sharing activities. This implies, they are neither IN nor ANT.
	Hierarchical (H): An interaction does exist. DC^T initialises the joint Decision-Making Process by sending an IN to DC^B. In this case there is no R, so that the "joint-decision" flow only goes in one direction.
	Non-Hierarchical (NH): An interaction does exist. DC^T (in this case it could be the DC which initialises the joint Decision-Making Process) sends an IN to CD^B and in this case there is R. There could be several cycles k IN-R . This case is usual in negotiation processes.
Objectives Sharing (OS)	Organisational (O): This is the case where DCs aim to achieve a common goal, previously defined and agreed, but at the same time retaining its own goals. They are interacting and collaborating as if they were a "team". It is usual the utilisation of fictitious incentives and penalties, even other kinds of information (shared by means of GI), in order to warn another DC of the consequences it has for its decisions on the overall common goal. In these contexts "agreements" instead of "formal contracts" are typical.
	Non-Organisational (NO): This is the case where DCs do not aim to achieve a common goal, but at the same time they understand they may benefit from a joint Decision-Making Process. This is an example of co-ordination. It is typically the utilisation of real incentives and penalties (shared by means of GI) and the use of "formal contracts". This "coordination" process is not suitable for medium and long-term relationships.
Anticipation Degree (AD)	Null (N): An ANT does not exist. DC^T does not anticipate any component from the Decisional Model of DC^B (neither from the Criteria nor from Decisional Field/Constraints). The former does not imply that the type of interaction is null, since at least there is an IN (with GD and probably GI).
	Non-Reactive (NR): An ANT does exist. DC^T anticipates some components from the Decisional Model of DC^B, but only from its Decisional Field/Constraints. It is called "Non-Reactive" because it does not depend on the IN.
	Reactive (R): An ANT exists. DC^T anticipates some components from the Decisional Model of DC^B, but in this case either from its Criteria or the Decisional Field/Constraints. It is called "Reactive" because it depends on the IN. In practice it is more complex to calculate.
Behaviour (B)	Opportunistic (O): This behaviour is common in Non-Organisational contexts, in which the DCs do not have a common goal but individual goals. It doesn´t exist fair play. Most of the cases ulilise real incentives or penalties which change the way the DCs behave.
	Non-Opportunistic (NO): This behaviour is common in Organisational contexts, in which the DCs aim to achieve a common goal and obviously fair play exists [needs re-wording, not sure of the importance of 'fair play'[. However, this "Non-Opportunistic" behaviour may also appear in "Non-Organisational" contexts.

Table 2. Macro-Decision view - Interdependent relationships of TDL– DC4

Analyzed DC	Decision Environment		DCs Characterisation Parameters				
			IN	IT	OS	AD	B
TDL-DC4	DC ^{Te}	TDL-DC6	E	H^B	O	-	NO
	DC ^{Bt}	ODL-DC4	T	H^T	O	R	NO
		ODL-DC6	T	H^T	O	R	NO
	DC ^{Be}	TDL-DC1	E	H^T	O	NR	NO
		TDL-DC2	E	H^T	O	NR	NO
		TDL-DC3	E	H^T	O	NR	NO
		TDL-DC5	E	H^T	O	NR	NO

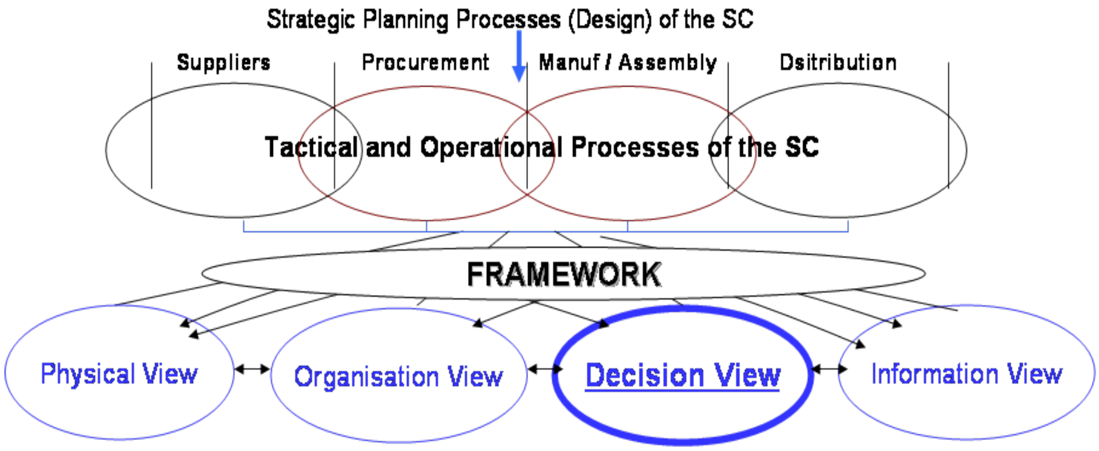

Figure 1. Framework Structure

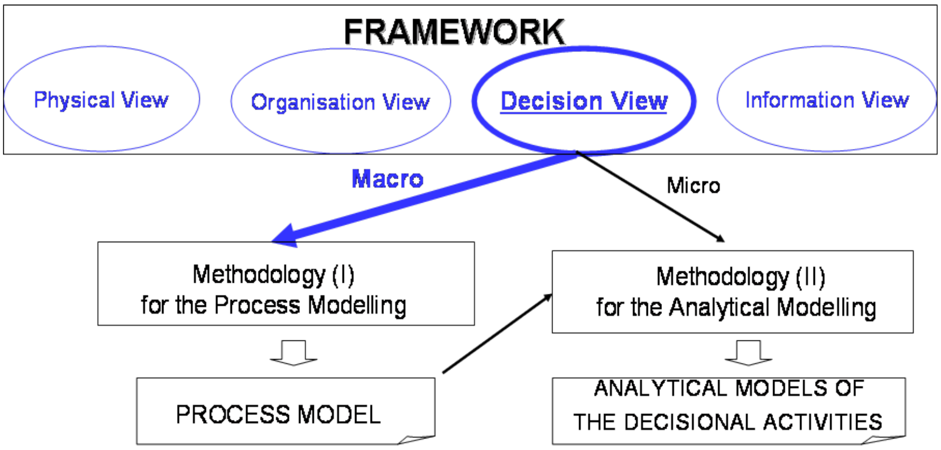

Figure 2. Macro-Decision View for the modelling of the CP Process

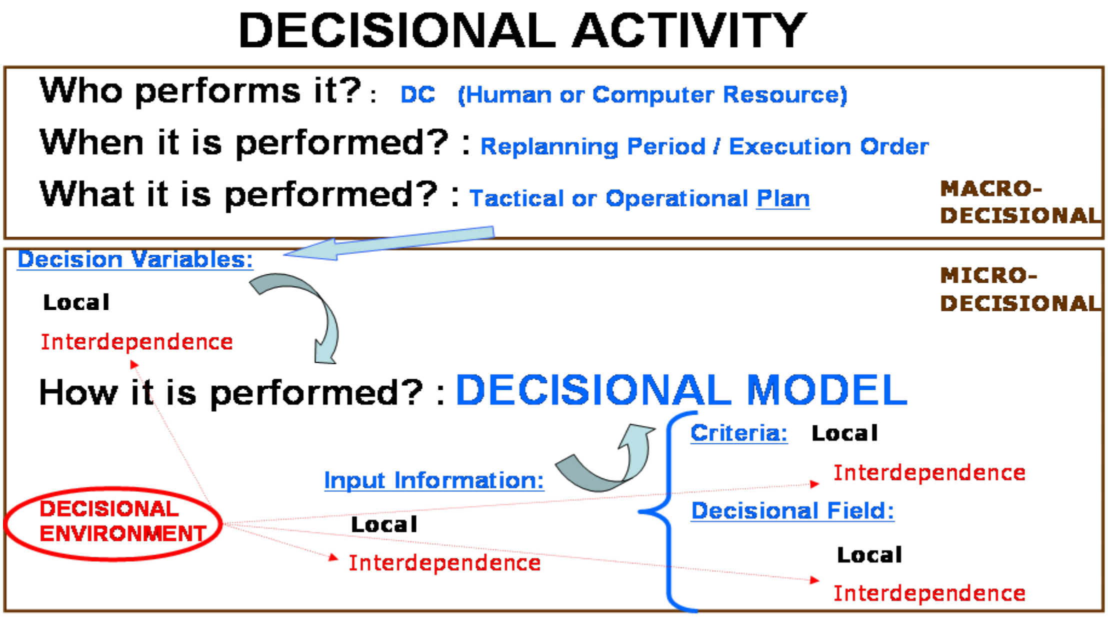

Figure 3. Macro-Decision & Micro-Decision Views of the CP Process

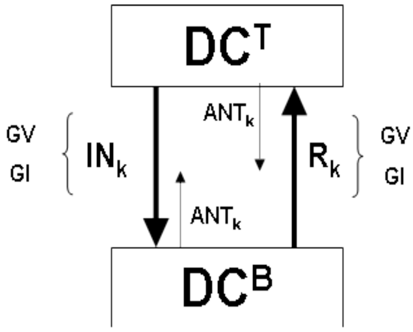

Figure 4. Information View (Macro) for DCs Interdependence Relationships

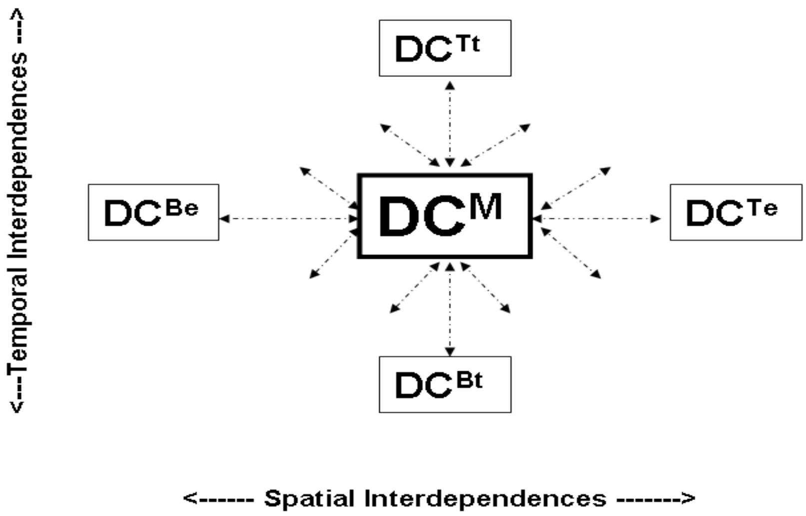

Figure 5. Decision Environment of a generic CD^M

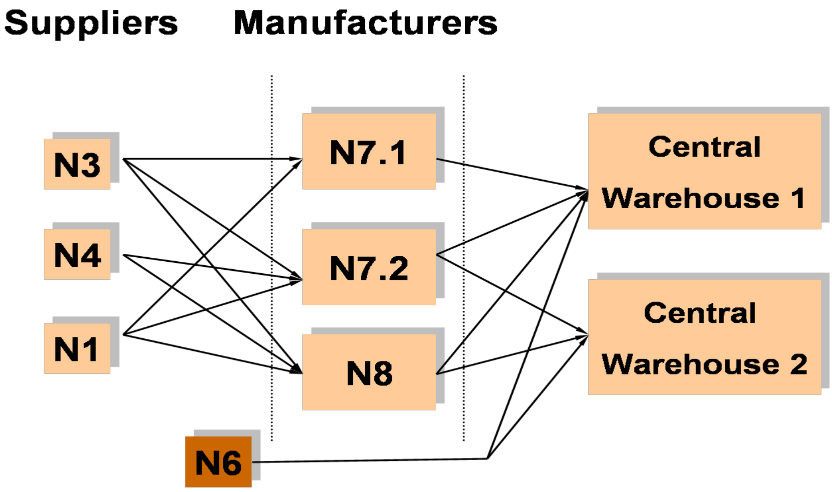

Figure 6. The SC suppliers and manufacturers

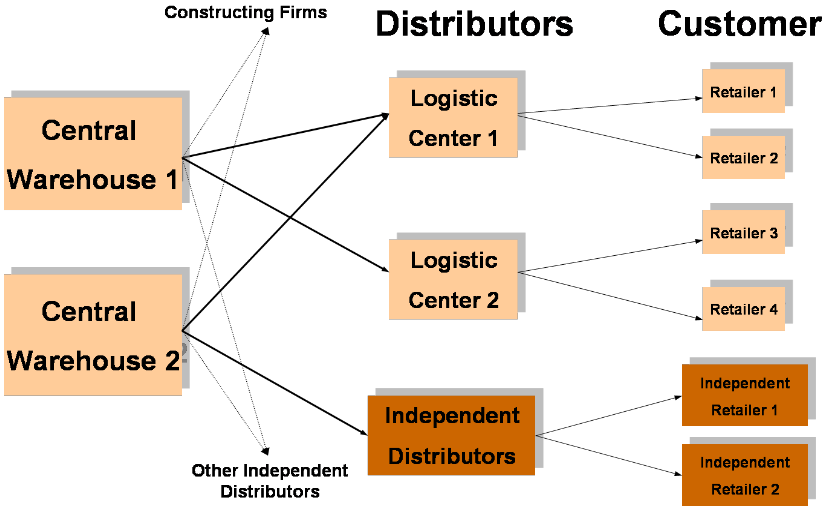

Figure 7. SC distributors and customers

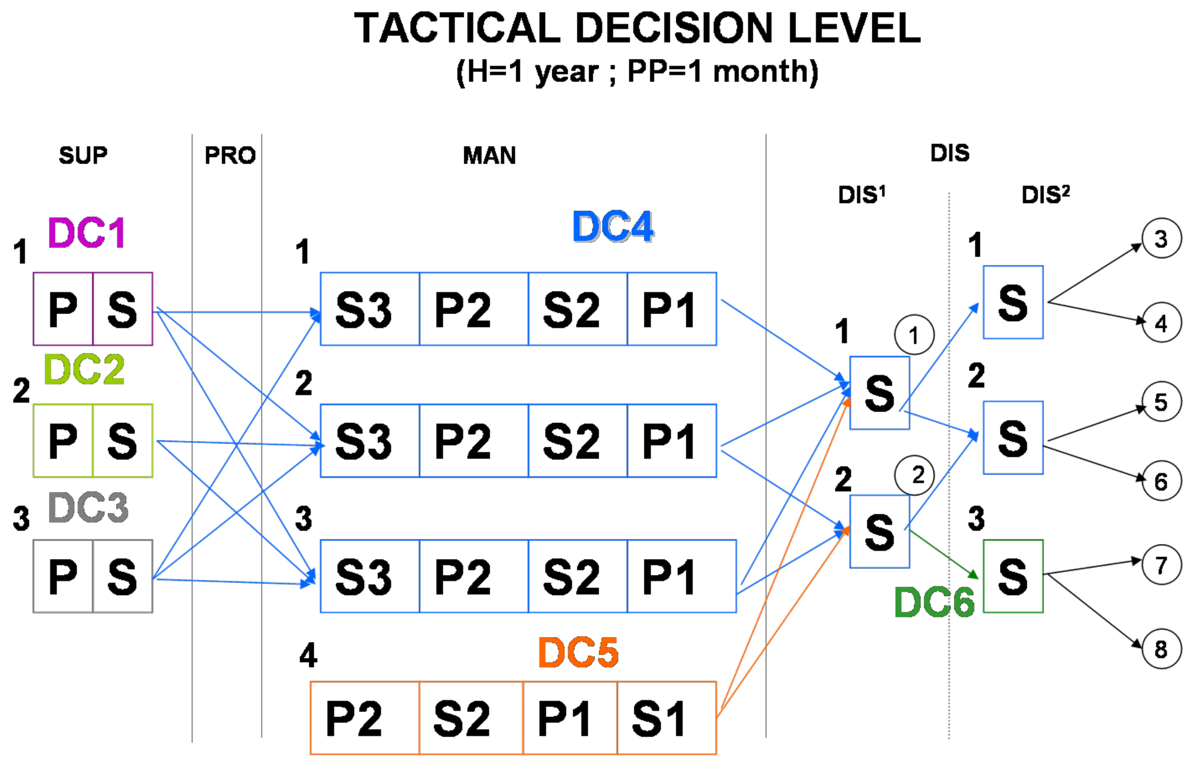

Figure 8. Macro-Decision view – DCs definition (tactical level)

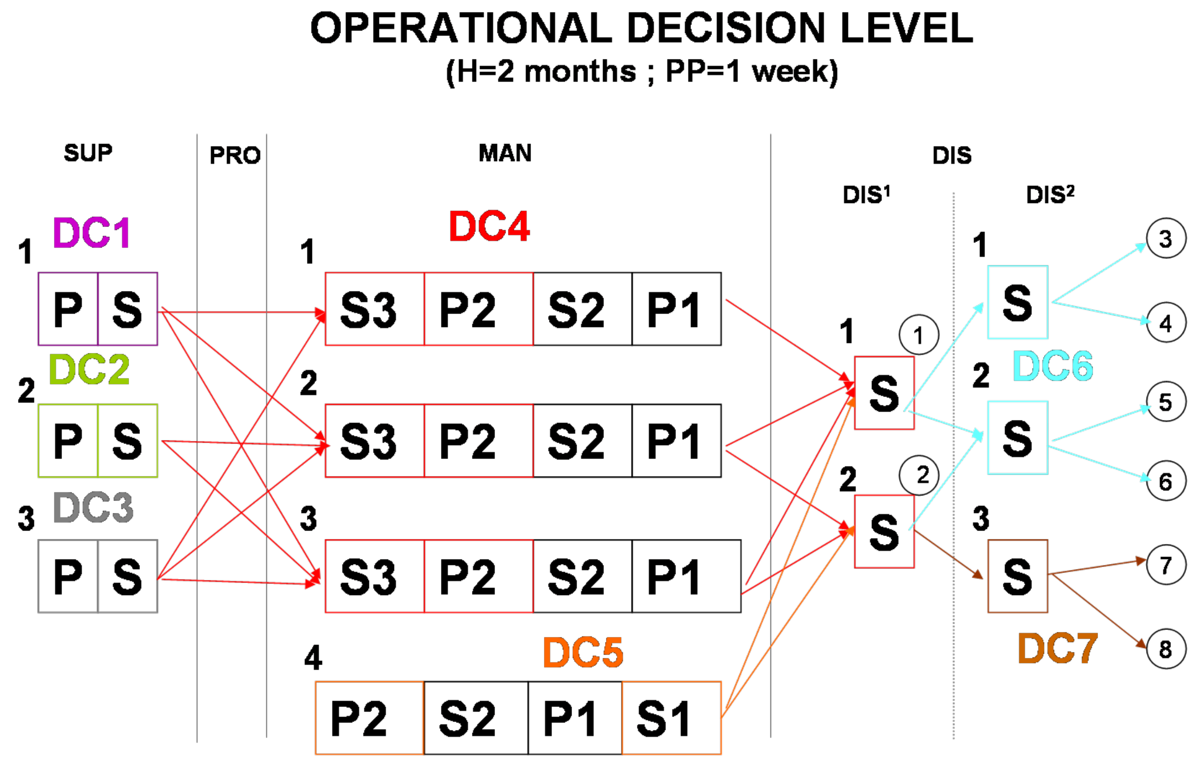

Figure 9. Macro-Decision view - DCs definition (operational level)

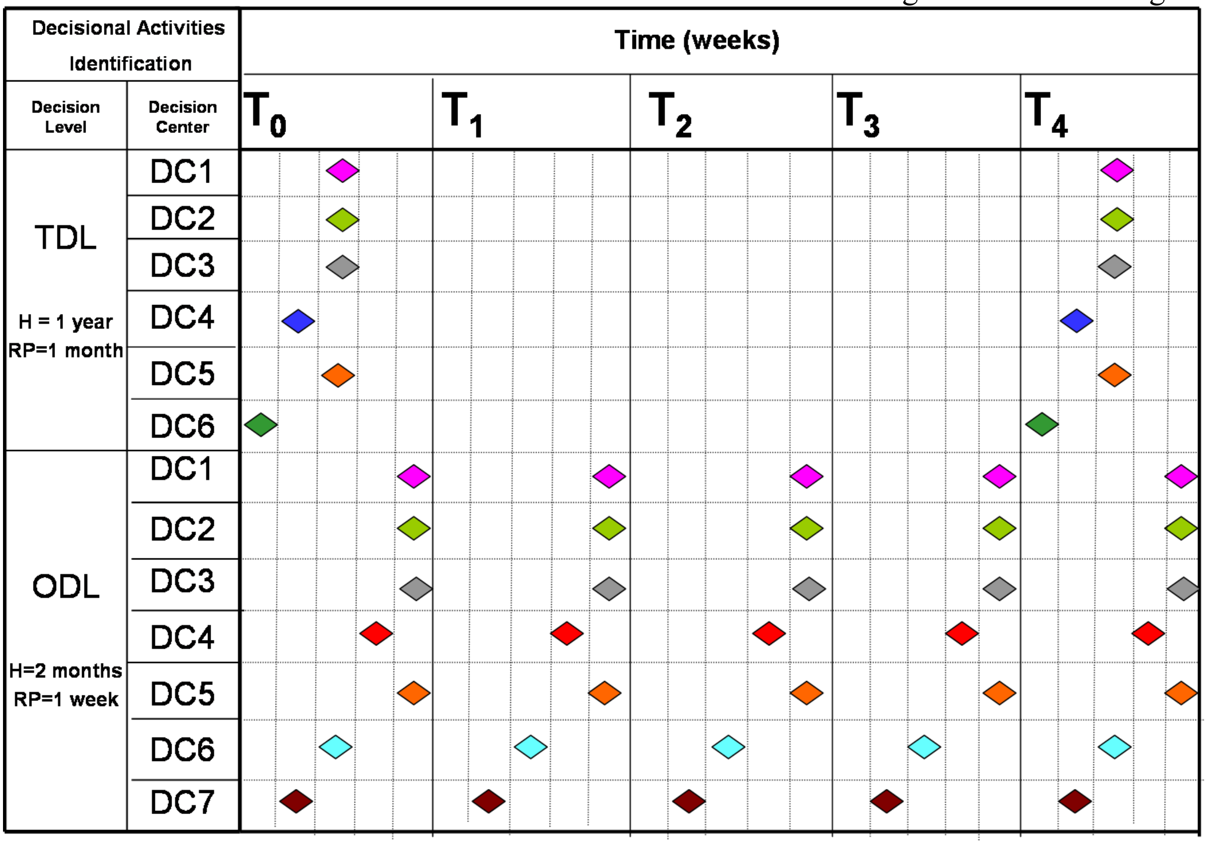

Figure 10. Macro-Decision view – identification of decisional activities (I)

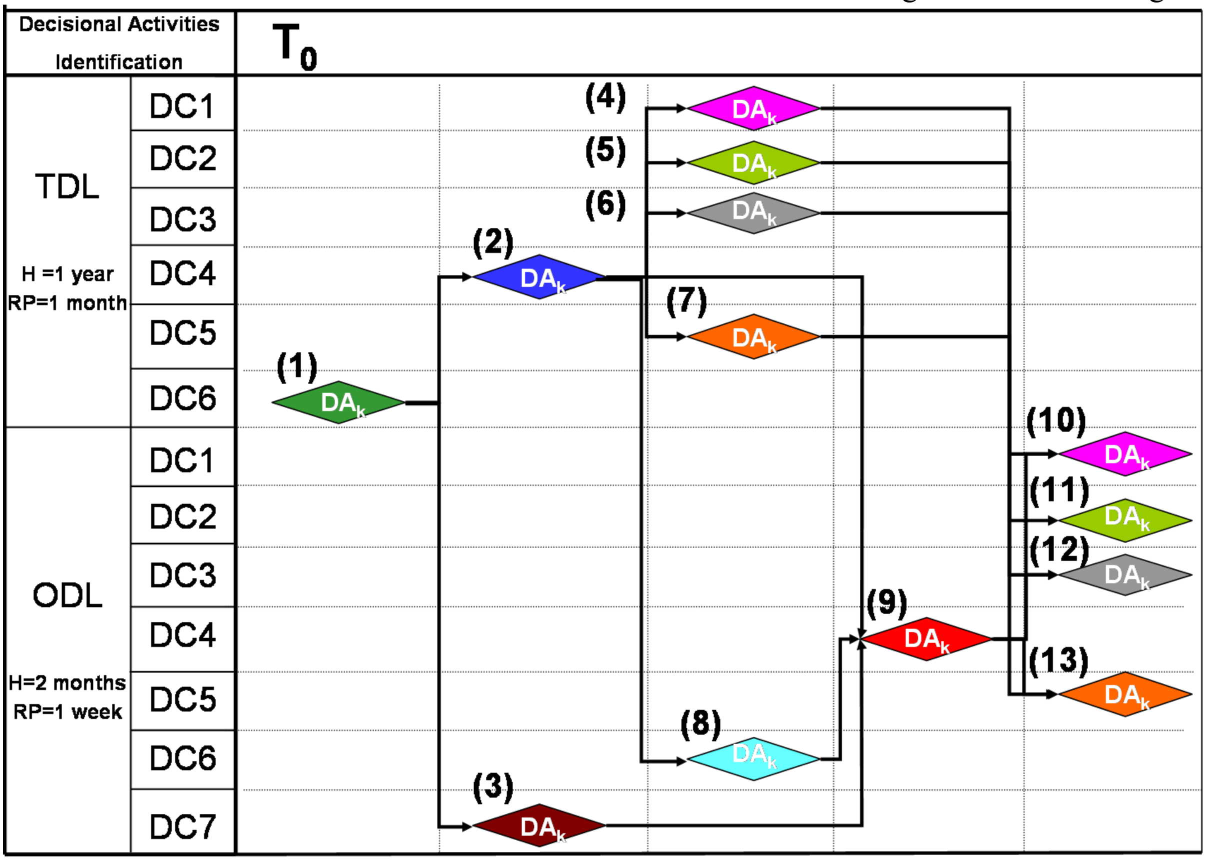

Figure 11. Macro-Decision view - decisional activities identification (II)

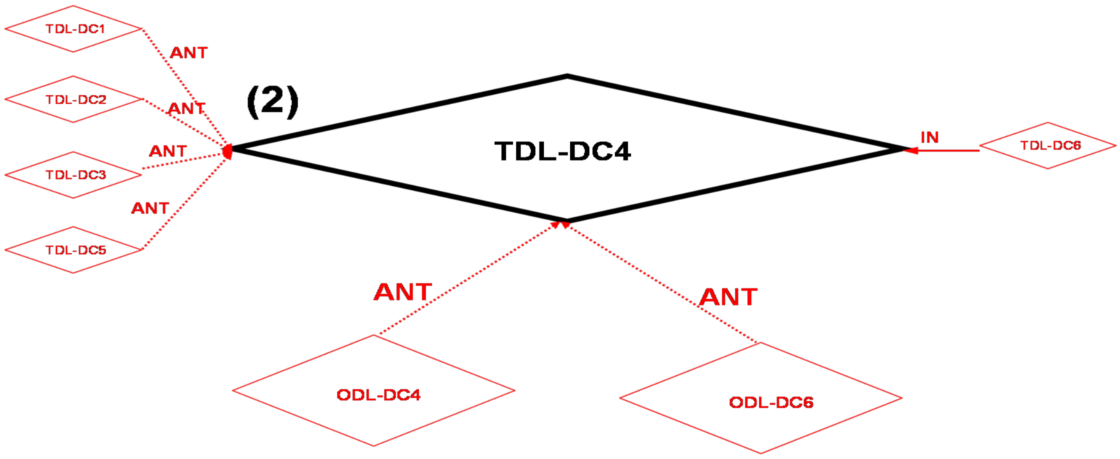

Figure 12. Macro-Decision view – decisional activities´ identification

(input information due to temporal and spatial integration).

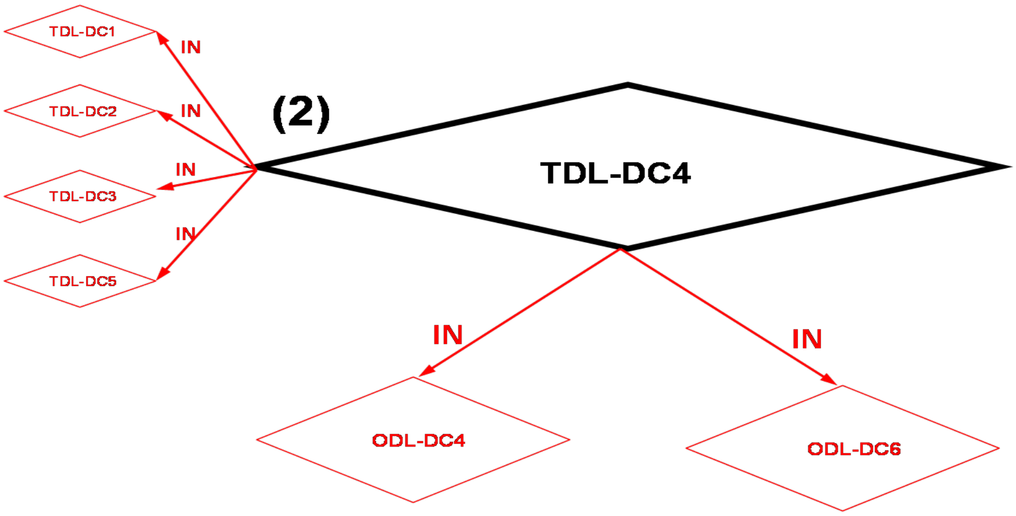

Figure 13. Macro-Decision view – decisional activities´ identification

(output information due to temporal and spatial integration).