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Cooperation models for Supply Chain Management

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Abstract. Supply Chains or Supply Networks (SN) are usually managed according to two main methods: centralised planning of the SN using an APS (Advanced Planning System), or point-to-point relationship, each partner being possibly managed by an ERP (Enterprise Resource Planning) system. The autonomy of each partner often makes the centralised planning solution questionable, whereas point-to-point relationship seems to implicitly consider that a high level plan (the Sales and Operation Planning-SOP) is generated by the final assembler, like in the automotive or aircraft industry, and is used for building a Procurement Planning which is sent as forecasts to the partners/suppliers. Iteratively, this procurement planning should allow the suppliers building their own SOP, and then generating forecasts for their suppliers. After having performed a number of case studies in various SN, we suggest that the characteristics of the companies involved in the SN have a deep influence on information processing, and especially on the way the procurement planning is processed. We suggest a taxonomy of collaboration situations which influence information processing all along the SN. Reference models for coordination based on this taxonomy are then presented. Typical coordination situations are discussed in order to show the practical use of these models.

Keywords. Coordination, collaboration, taxonomy, enterprise modelling, procurement planning.

1. Introduction

Companies are nowadays facing an unstable environment with a short visibility on their market, but have to be more and more efficient in order to answer to tighter and tighter consumer constraints. Moreover, job complexity is growing with the complexity of products and technology, combined with new legal constraints, such as energy market strain, or environmental and health care issues. In order to keep their strategic market advantages, companies are therefore focussing on their core business. As a consequence, manufacturing complex products requires more and more accurate competences only available from different companies, leading to the necessity of knowledge and information integration. Consequently, an economy of interfaces has grown where interface management tends to become as important as the added value process itself.
In this context, a new challenge is to create Supply Networks (SN), in which different autonomous companies are able to provide high added value but also coordination capabilities, including the ability to build realistic Procurement Plans from the final consumers to the initial supplier, in order to reach an overall efficiency of the Supply Network.

According to commonly admitted statements, information and means are shared in SN and decisions are aligned to reach the global SN objectives (Sahin, 2005). The interest of the partners in being part of the SN is considered as the mean for reaching global performance of the SN. Then, the main problem remains to manage a large amount of complex data flows and decision processes from the final customer to the upstream partners of the SN, in order to coordinate the supply process. Two coordination mechanisms are usually considered in that purpose: centralised coordination or point to point coordination.

In centralised coordination, decisions are made in an external decision centre controlling the whole supply network through processing, in one single step, the procurement plan for each partner of the network. Such a coordination process can be supported by an APS (Advanced Planning System) (Stadtler et al., 2005), and is mainly implemented for managing a set of workshops or distributors belonging to the same company. The reason is that it requires the partners to accept a poor level of autonomy and to share confidential information (e.g. related to costs or capacity). This can hardly be acceptable for independent companies, moreover belonging to several SN.

For autonomous companies, having their own financial and technical strategy, a point to point process is usually considered as the ad-hoc coordination mechanism. In that case, it seems of common sense that the procurement plans are generated successively by each individual company using the MRP logic (Orlicky et al., 1994), usually through ERP (Enterprise Resource Planning) systems, starting from the end of the SN. These middle/long term procurement plans become forecasts for their suppliers, and so on (see Figure 1). In that context, many research works focus on tools and methods able to optimise these plans and the inventories which are their consequence, in order to provide agility and reliability at low cost.

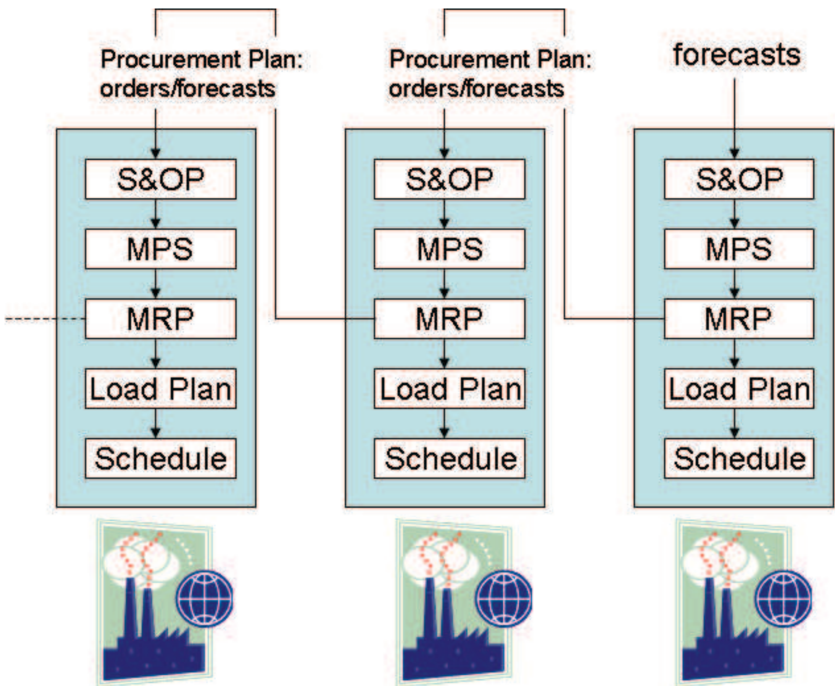

Figure 1. Point-to-point coordination in a SC using MRPII

However, reality is much more complex. A company belonging to several SN receives several procurement plans, on which an arbitrage should be made, according to local constraints and strategies. Then, depending on this local coordination process, the procurement plans may be accepted, questioned, adjusted or negotiated with the customer, who will accept or not such a situation.

So, it appears that the coordination process along the SN may be very different from a simple step by step process, but may depend on the context, on the company features, on the coordination rules and on the properties of the SN itself. On that base, we suggest in this article to analyse different types of relationships that may exist between companies, depending on their main characteristics. Our objective is, as a second step, to choose methods and tools of information processing which would be better adapted with these relationships.

This article is structured as follows: a short state of the art of Supply Chain management will first be described, showing that an almost unidirectional information flow is usually considered. This will be compared to case studies showing that reality may be sometimes different. In the third section is suggested a modelling framework for multi-site coordination based on the GRAI tools (Doumeingts et al., 1994). A taxonomy of coordination situations will be proposed and described using this framework in section 4, providing a base for suggesting coordination models in section 5. In section 6, the proposed model is applied for analysing the coordination in a complete SN. Then, directions are provided for choosing the most relevant information processing approaches on the base of the various coordination process requirements described in section 2.

2. State of the art and industrial examples

2.1 Literature survey

A centralized control of the Supply Chain potentially allows to better meet the global SC objectives (Sahin, 2005). In that purpose can be used tools such as APS, allowing to optimize the material flow between several distant manufacturing entities (Stadler et al., 2005). Other tools may also be considered, like ERP systems (Kelle et al., 2005), portals (Carlsson et al., 2004) or more generally Internet (Garcia-Dastugue et al., 2003), commonly used to coordinate companies in a centralised way. Centralized control has motivated many studies in the research literature, which often consider that coordination by integration characterise Supply Chain Management (see for instance (Christopher, 1992, Lee et al., 1997, Stock et al., 1998)). Beamon (1998) presents a survey on supply chain modeling techniques considering the supply chain as a whole: through deterministic, stochastic, economic or simulation models, the supply chain management and planning problem is solved by the optimization of decision variables all along the Chain. A more comprehensive and recent review on Supply Chain control by global optimization is given by Geunes et al. (2003). The beneficial effects of information sharing through centralised analytical models is also analysed in studies like (Cachon et al., 2000) or (Thonemann, 2002). Collaborative Planning, Forecasting and Replenishment (CPFR), initially suggested by the VICS (Voluntary Interindustry Commerce Standards) in 1996, has a quite similar view, aiming at integrating companies for developing business plans and forecast between partners. This approach has been the base of many research papers like (Chung et al., 2005).

On the other hand, authors like Kok et al. (2003) have emphasized the hierarchical nature of supply chain management but have also insisted on the interest of decentralized decision models, for both decreasing the amount of data to be processed and keeping a local autonomy, hardly questioned by the centralized model. Such a mix between centralization/integration and cooperation has been promoted in various types of works. Coordination can for instance be obtained through pricing (Bernstein et al., 2006) or revenue sharing strategies (Cachon et al. 2005). More practically, Malone (1987) defines coordination as a pattern of decision making and communication among a set of actors who perform tasks to achieve goals. Some authors (Thomas et al., 2000, Génin, 2000) consider that the Sales and Operations Planning (S&OP) is a relevant process for providing coordination and integration intra- and inter- companies, while keeping their decision autonomy among the SC. In that case, the S&OP is often considered as generated by the final assembler, like in the automotive or aircraft industry, and is used for building a Procurement Planning which is sent as forecasts to the partners/suppliers. Iteratively, this procurement planning should allow the suppliers themselves to build their own S&OP, then to generate forecasts/procurement plans for their suppliers. Such approaches can be considered as providing a framework for cooperation, usually understood as including a dialogue between partners. In all the cases, the final goal is to define a framework for a win-win policy, also based on the development of mutual trust (Durango-Cohen et al. 2006)

This idea of an upstream main information flow providing a global framework for decision making, completed with point to point cooperation allowing local adjustment, is very consistent with industrial habits. Nevertheless, it leads to the implicit idea of a uniform way to process information all along the chain (see Figure 1). In that context, any occurring problem is interpreted as a difficulty to process information adequately. As a result, the use of supplier assessment tools is generalised, together with programs aiming at improving their competence, seen as their ability to process information in the expected way (see for instance (Prahinski et al., 2005)). Within this global framework, a classification of the levels of cooperation has for instance been suggested by Lauras et al. (2004), according to the type of data and data processing facilities exchanged between companies. Different types of cooperation are also detailed through a literature review in (Albino et al., 2007), showing that cooperation is mainly considered at a mid-term level, e.g. through agreements or contracts aiming at risk sharing or definition of common design tools. Operational cooperation is addressed by (Parrod et al., 2007) in the case of project-supply chains, consisting mainly in negotiation dealing with capacity booking. The influence of the type of suppliers on the SC is considered in (Haffmans et al., 2003) and (Demeter et al., 2006), but the identified characteristics are considered as influencing mainly SC design, including partnership definition and contracts, but not really the way information is processed along the SC. The dominance between partners is considered in (Hua et al., 2006) as a consequence of demand uncertainty; again, the influence of this type of relationship on information processing through the chain is not fully explored.

Decentralised approaches are also a topic of interest in the research community, especially using negotiation through Multi-agent systems (MAS) (see for instance (Ulieru et al., 2002, Nissen, 2001 or Archimède et al., 2003)). Nevertheless, the global supply chain performance is hardly consistent with local approaches, which sets questions regarding the short term industrial applicability of such studies. Especially, they suppose perfect collaboration willingness from each partner, and an equal-to-equal collaboration position in the SN.

Constraint based approaches are also often promoted for supply chain management (Schragenheim et al., 2001), the coordination process being seen as a complex bi-directional information exchange, where procurement plans are first built with the most constraining supplier in the whole SN. The procurement plans are then built out of these local plans at the upper level of the SN (the final assembler for example) and distributed to the other lower levels.

It can be seen that many approaches and tools can be considered for supporting the collaboration process along the SN. Nevertheless, their exact domain of interest is seldom addressed. As a consequence, we found interesting to compare this short survey to industrial habits: this has been done through interviews of supply chain managers in various companies, as detailed in next section.

2.2 Industrial examples

The following examples on real practices in supply chains do not pretend to any kind of exhaustiveness, but aims at illustrating that reality is often inconsistent with the ideal framework summarized in Figure 1.

2.2.1 Type of considered supply chains

This study has mainly been conducted in the south-west part of France, where an important number of companies work for the aeronautic/aerospace industry. Some specificities compared to other large supply chains (e.g. in the electronic, agro-food or automotive industry), is that the considered products are rather expensive, complex to manufacture and require long cycle times: we are mainly in a make-to-order perspective, on the base of middle term programs. The final demand does not concern very large quantities, and is mainly subject to slow variations through time. Another interesting point is that an important part of the added-value on the product is given at the end of the supply chain (30 to 40%), where large companies are found. Therefore, companies are usually smaller in the middle of the chain, the raw material providers belonging usually to large industrial groups.

A simplified typical structure of such supply chain is illustrated in Figure 2. Tier 0 is usually a large company which designs and assemblies complex products, like aircrafts. Tier 1 suppliers can be other large companies which design and manufacture large sub-systems of the aircraft (engine, landing gear, air circulation system, actuators...). At tier 2, these companies use smaller enterprises (which are often SMEs), manufacturing precision parts or simple sub-systems. These companies usually sub-contract thermal or surface treatments to specialized companies (tier 3). The raw material providers (usually steel plates) are also found at tier 3.

This simple structure is of course made more complex by the fact that a company or a type of company can be present at different levels of the supply chain: for instance, companies of tier 0 or 1 also use sub-contractors performing thermal or surface treatments. Therefore, these SMEs are resources shared by companies of different levels, with the result of possible conflicts.

We have conducted several interviews of supply chain managers in charge of the coordination aspects in companies of various tiers. Some of these interviews are shortly summarized in the two following sections, with the aim to illustrate various situations, which led us to suggest the modeling framework described in sections 4 and 5[1].

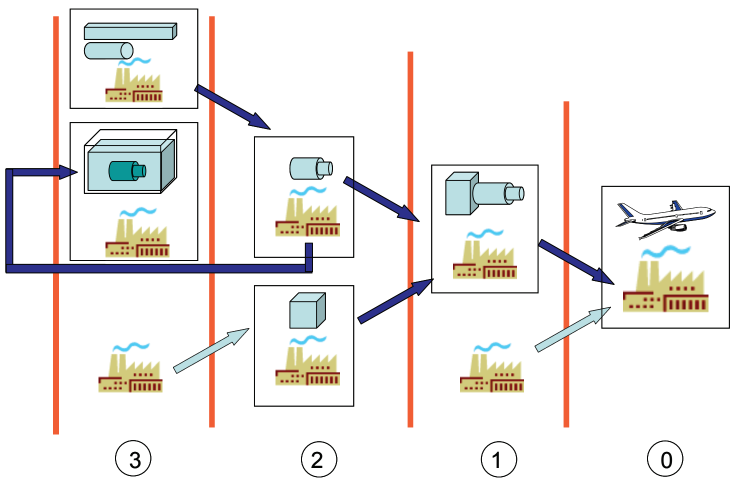

Figure 2. Typical structure of considered supply chains

2.2.2. The customer's side: interviews of some large companies

These companies are all large companies and in all the cases, an important part of the value of their products comes from their suppliers and sub-contractors (from 50% to 70%), which is a clear consequence of their increasing specialization. The following short summaries of the interviews are centered on the coordination mechanisms and on the information exchanged with the customers and suppliers for each company.

[1] the names of the companies and some of their secondary characteristics have been modified

Rose: Rose's typical suppliers are specialised in the machining of precision parts. In addition to technical considerations, they are selected according to their capacity to directly use the supply plans in their information system, and for their reactivity in case of problems (see Figure 3.).
Rose makes partnership efforts with its direct suppliers, for which they are an important customer (40 to 60% of their revenues) since they can have an influence on them, for instance for leading them to decrease their cycle time or simply making efforts to meet delivery requirements.

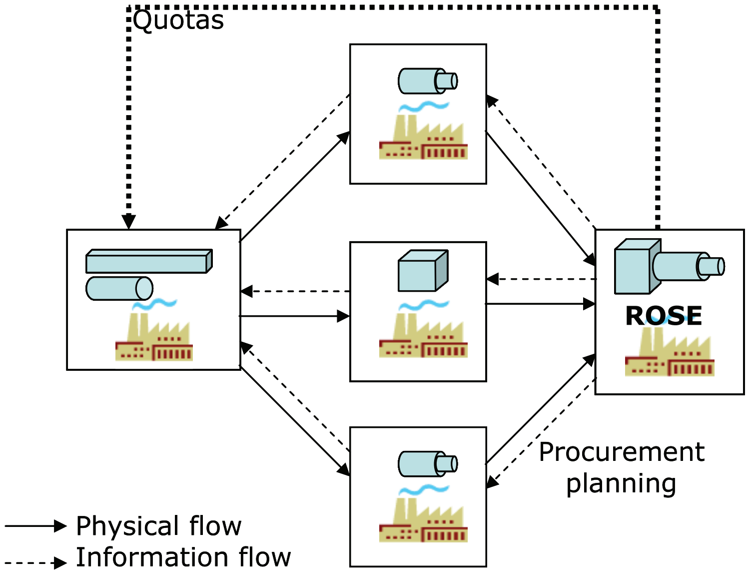

Figure 3. Rose supply network

For long term coordination, Rose establishes a Sales and Operation Planning, defining the global production volume, based on its own capacity but taking in account the capacity of the direct suppliers. On the base of this planning, costs and delivery requirements are negotiated once a year with these direct suppliers.
Since these suppliers can be very small SMEs, Rose manages for them the negotiation with the upstream suppliers (large providers of special steel or founders). Rose negotiates under its name quotas with these suppliers of raw materials, to define costs and volumes per month for the year.

The information exchanged weekly with the direct suppliers is a typical procurement planning, giving quantities required per week for the next 8 weeks (firm orders for the next 3-4 weeks), so that the quantities per month for the 11 following months.
In contractual documents, the consequence of a change in the orders depends on the time horizon: for the first month, Rose covers the costs induced by any change. For months 2 to 4, Rose asks his suppliers to be able to accept a variation of 50% of the quantities, and accepts to take the excess in the year in case of decrease of the quantities. In reality, Rose tries to make its supplier respect the procurement planning, whatever the changes are.

Buttercup: The complexity of Buttercup's supply chain is linked to the number of companies involved, but also of the fact that some suppliers (surface treatment) are involved at various levels of the same supply chain (1st tier, 2nd tier…). Buttercup itself sub-contracts surface treatment, which is one of the last operations in Buttercup routings (see Figure 4.). Considering direct and indirect (via its suppliers) sub-contracting, Buttercup represents almost 40% of surface treatment supplier business.

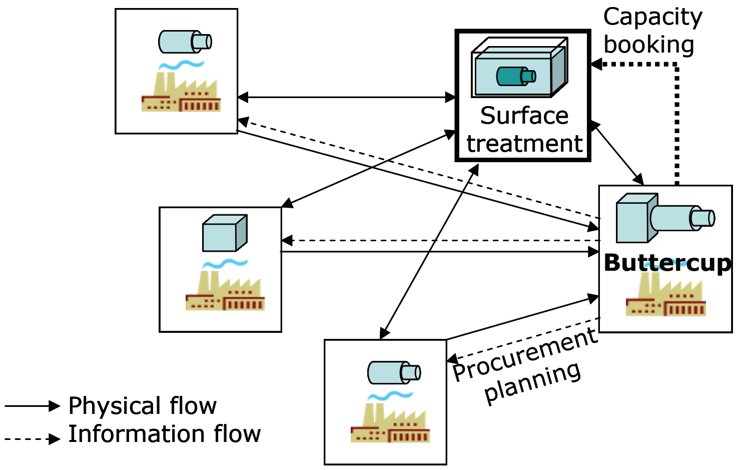

Figure 4. Buttercup supply network

Based on customer forecasts, Buttercup makes a Sales and Operation Plan. Thanks to the MPS (Master Production Schedule) and MRP (Material Requirement Planning) processes (Orlicky et al. 1994), a negotiation is performed with the surface treatment supplier to contractually book capacity per period. Buttercup Procurement Plan and Purchased orders are then established on a 18 months horizon on average. This Procurement Plan is sent to the 1rst tier suppliers on a monthly basis.
In addition to Procurement Plans, firm orders are sent weekly through a contractual document.
The operational coordination process of the supply network consists mainly in checking at least every week the job queue in the surface treatment supplier planning, from which priorities are sent to other suppliers. This operational coordination is very important for all the SN partners, especially regarding costs. Actually, surface treatment is usually the last operation for each partner, so the work in progress costs are very high for the product owner.

Orchid: Orchid designs and assembles large sub-systems for aircrafts.
The typical customer (aircraft assembler) sends forecasts giving quantities to deliver each day on a period between four and five years. This sales planning is updated each month, with a firm part of only few days (typically, two weeks).
The overall cycle time for Orchid product is around one year, including the supply of raw materials (6 months), suppliers tier 2 (2 months) and direct suppliers (2 months). The Orchid SN is illustrated in Figure 5.

On the base of its sales plans, Orchid builds a procurement planning every month for each of its direct but also indirect suppliers at tiers 1, 2 and 3 (raw materials). In that purpose, since Orchid has no contractual relations with the suppliers at tiers 2 and 3, and since he does not control the production planning at tier 1, these procurement plans are sent via the direct suppliers, with slack times added to the average cycle times. The average cycle times are negotiated once a year and checked twice a year. These cycles are integrated in a complex MRP system (based on simplified bills of materials), which allows performing requirements planning for the suppliers of the suppliers.
This process (procurement planning to tiers 1, 2 and 3) aims also at compensating their lack of internal production and procurement planning process capabilities, in order to secure upstream flows.
The delivery planning sent to the suppliers takes into account that suppliers are often smaller companies, which need more security than larger ones. Therefore, the firm period of the delivery planning is around 40 days. This firm involvement allows Orchid to prioritize its own product among all the customers of its suppliers.

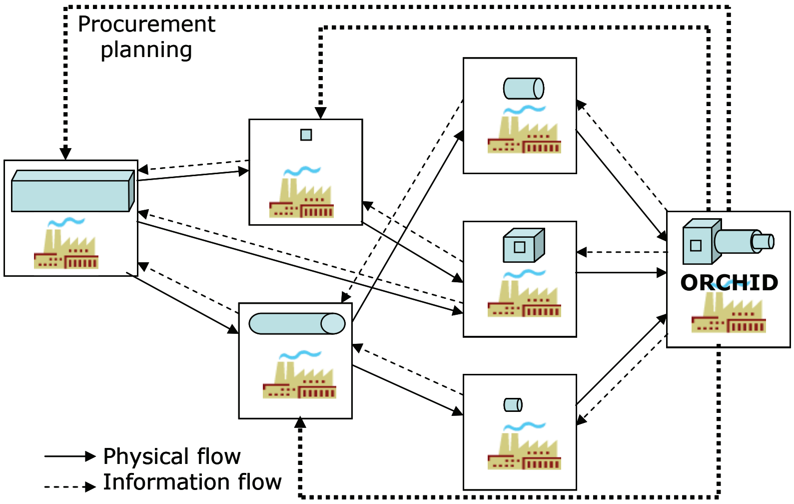

Figure 5. Orchid supply network

Two types of coordination are here performed:
- several months before the expected delivery, Orchid checks with the steel and forged parts providers that the orders are in progress, for its own orders but also for those of its suppliers, because of its influence on these providers, much larger than the sub-contractors.
- 1 month before the due date, the suppliers are asked to check whether the deliveries are expected on time or not. It is interesting to notice that only problems related to the raw materials supply are usually reported by the sub-contractors. Procurement plans are adjusted according to the situation.

Finally, Orchid internal assembly is scheduled according to the suppliers' expected deliveries. The important use of temporary employees allows Orchid to adjust its capacity according to the supplier deliveries.

Orchid has an important level of work in progress because of the lack of synchronisation of the supply, due to a complex coordination based on slack time utilization.

Violet: Violet designs and assembles onboard equipment and systems.

Like Orchid, Violet main customers are aircraft assemblers. It has basically organised its supply network in three main groups, related to a basic ABC class analysis: strategic and critical parts (A class), non strategic components (B class), and C class.

For the strategic parts, a strong collaboration and cooperation process is established, with highly connected information systems for development, technical design and production control processes. Procurement plans are exchanged after discussions on inventory locations. This continuous negotiation and follow up process is managed in the supply department of Violet by persons individually in charge of each product.

For the non strategic components, Violet has chosen a service provider, in charge of managing this supply. The negotiated costs include a very strict delivery performance, with possible demand variations defined by given limits, secured by a minimum inventory under the responsibility of the service provider. This partner provides directly the assembly lines with kits according to the Violet MRP requirements, electronically sent every day.

For the C class components, a safety inventory of 3 months in Violet warehouse has been decided, with a supply triggered on order point.

After this short analysis of some characteristics of large companies involved in the end of the Supply Chains, it is interesting to also consider the case of much smaller companies, which are usually sub-contractors.

2.2.3 The sub-contractor's side: interviews in SMEs

Lily: Lily mainly performs turning and milling operations. Two of the companies analysed in previous sections are their major customers (with contractual relations).
Forecasts are usually provided by the customers on 3 years horizon.
When the orders are received, they are transferred in the production management tool. On that base, the buyer checks raw materials inventory (mainly steel) and decides to order or not. Depending on the estimated reliability of the customer requirements and on the accounts engagement, supply orders are created on the base of customer forecasts or only on firm orders. Only firm orders are sent to suppliers (no forecasts).

The operational management of products is done on an Excel sheet on which are mentioned the forecasts (updated when firm orders are received), the present level of inventory and the forecasted one. It is so possible to detect shortage, allowing generating orders for the suppliers. In order to try to cope with the supply problems, the production of sub-systems ("kits") is anticipated of two months in comparison with the theoretical cycle times mentioned in the Excel sheet. Therefore, the inventory level is high, also because of a poor visibility at middle term and to the increasing pressure of the customers, who often modify their forecasts.

The Sales and Operation Planning level of the production management tool is not used, neither the module of load management. Moreover, there is no link between the Excel sheet and the production management tool, which makes difficult to anticipate supply or load problems. Each Monday, the production manager calls the 2 main customers. Day by day scheduling is made once a week, depending on the priorities provided by the customers.
As they do not manage load, the capacity is often the critical constraints at short term to deliver on time. A quite important level of work in progress allows Lily to improve his delivery performances at short term, to the detriment of the working capital.

Primula: The Company is specialized in surface treatment, painting and chemical machining. It employs around 150 persons on two sites, and works exclusively for the aeronautical/aerospace industry. Almost all the companies previously listed are its customers.

Primula considers its work as "service": agreements have been made with the customers (more than 300) on prices and macro-cycle times of surface treatment operations. Three typical cycle times are considered: one week for simple operations, two weeks for more complex ones, and three weeks for the most complex. However, when started, the treatment should not be interrupted to avoid unexpected chemical process like oxidation before painting. The forecasts eventually sent by the customers are not used. The orders are only known "when the truck is in the yard".
When the parts arrive, their exact routings are checked, and they are processed to the first step, then to the second with only a basic management of priorities based on the type of treatment and on their due date. The major challenge of the person in charge of production management is to respect the agreed cycle times while balancing the load between the various baths and the type of treatment. This is possible since, for Primula, the work in progress is not costly, the parts belonging to its customers.
The company communicates with its customers through a web site showing the operations already done on each order, so that the remaining ones. This transparency, presented as a service, is much appreciated by the customers.

2.3 Some lessons drawn from these examples

The mains lessons drawn from these examples are the following:
- information processing in the supply chain has not a unique direction: loops may be created, for instance by the interference of the customer on the suppliers (Rose, Orchid),
- new management strategies, like capacity booking (Buttercup), definition of quotas (Rose), contractual agreements (Violet), are more and more widely used. They are very different from sending orders in a MRP logic (Buttercup), and should be processed as such,
- slack times are often required for coping with late deliveries which are sometimes predictable and could be controlled by accepting to process constraints expressed by the suppliers (Orchid),
- Negotiation is useful but its complex use should obey to strict criteria, and is definitely not a global management strategy (Violet),
- there can be conflicts between the due dates required by the customers and the lead times of the suppliers; these conflicts may result in predictable delays (Lily),
- cycle times may be sometimes negotiated, and should be in that case integrated as flexible constraints in information processing (Primula),
- the way some companies process information is very different from the ideal case of Figure 1 (Lily) ; either right or wrong, this way to process information has to be taken into account for being able to foresee the possible problems resulting from it,
- the company size does not strictly condition the company power in the network (Primula),
- different levels of coordination exist with different expectations and constraints (Rose, Buttercup, Orchid).

According to this survey, coordination along the SN is not a simple point to point process, where information moves from the downstream company to upstream suppliers, but a rather more complex bi-directional flow, where company characteristics and supply chain properties influence the coordination mechanisms, and therefore should influence too the information processing.

The objectives of our study being to be able to specify which kind of information processing approach is relevant for which SN and for which company, it is important to understand these coordination mechanisms and the context in which this coordination is made.
In the following parts, we present first a model aiming at understanding the coordination process as a set of interrelated decision makings, based on specific types of information. As a second step, we will propose a taxonomy to analyse collaboration situations.

3. A decision frame to describe the coordination process

Many methods and modelling tools have been defined for enterprise modelling, including CIMOSA (CIMOSA Association, 1996), PERA (Williams, 1994) or PETRA (Berrah et al., 2001) which have a general purpose, others like ARIS (Scheer, 1999) being dedicated to process modelling. We have chosen here the GRAI model (Doumeingts et al., 1994) because of its well known ability to represent the decision making environment, including the elements required to coordinate an added value process, according to the performances to be reached.

3.1 Basic model

In the GRAI framework, a decision is defined by a "decision frame" which identifies the main elements required to make a decision (including a coordination decision) (cf. Figure 6): the objectives, the decision variables and the constraints.

Objectives: results or performances to be reached by the added value process. Once the objectives are defined, they will be structured in a hierarchy.
Let us underline that the way this hierarchy is defined may influence the choice of a decision support method for this decision activity. A possible solution is for instance to consider that the main objective will be the priority (objective to be absolutely satisfied), the others becoming criteria which optimisation will allow ranking possible solutions. For example, if the first objective is "customer service" and the second "cost minimisation", the manager will look for solutions which allow the added value process to respect customer requirements, and will then select the less costly solution (lexicographical approach). In that case, several optimisation criteria are successively applied. If it is considered that the objectives have to be taken into account at the same level, but can have different importance, many studies suggest to build a complex objective function using weighted criteria. Another method is to build the Pareto front on the solution space, i.e. the set of solutions for which increasing the satisfaction of an objective requires to decrease at least the satisfaction of another.

It is so clear that the way a set of objectives is considered may influence the methods chosen for building a solution. Similarly, one of the aims of this study is to analyse the link between the coordination process and the methods used for building procurement plans.

In all the cases, the performance objectives are related to performance indicators allowing monitoring their satisfaction.

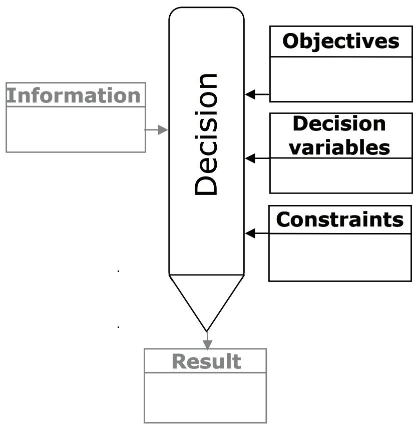

Figure 6. Decision frame according to the GRAI model (Doumeingts et al., 1994)

Decision Variables: parameters that modify the added value process properties in order to reach the expected objectives (performances). These decision variables may be local or they can be provided by external partners. For example, in order to meet manufacturing objectives, the company can use overtime, temporary workers, but could also adjust the procurement planning, in accordance with its customer, or use a network of sub-contractors.

Constraints: limits of use of a decision variable. These constraints may have two origins:
- type 1: they may express technological, contractual or legal limitations in the use of the decision variables, like "sub-contracting has to be planned two weeks in advance", "the overtimes are limited to 120h/month", "inventory cover is limited to 5 days ", etc.
- type 2: they can also come from external partners, like customers or suppliers. An example can be the inventory level limited by the customer, the delivery date (with penalty for delay or advance), the maximum amount of raw material the supplier can provide, or the capacity available from the sub-contractor.

All additional information allowing to make decision, like follow up information, backlog, inventory level, supplier capabilities, etc., is included in the "Information" box of Figure 6.

An example of decision frame is presented in Figure 7. It defines precisely the frame (represented by the large arrow in Figure 7.) of the coordination process which is performed.

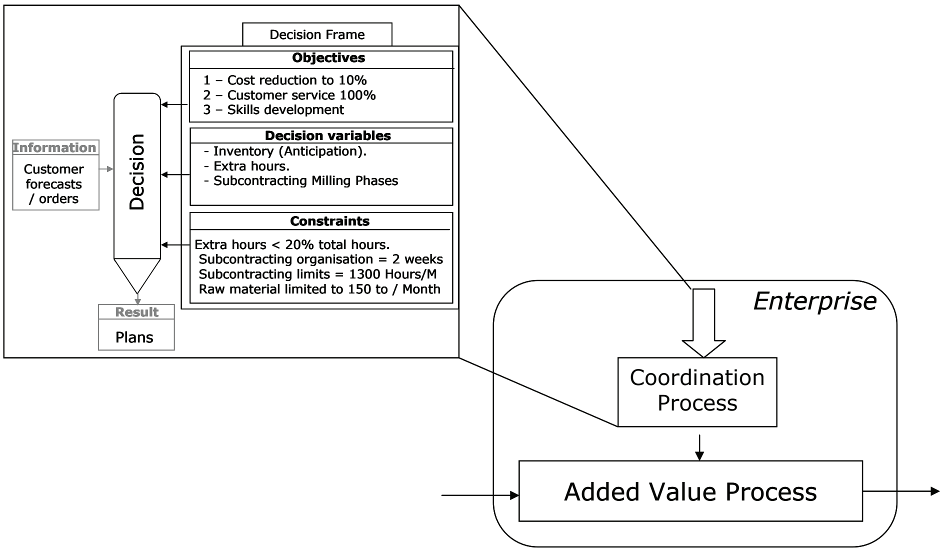

Figure 7. Example of decision frame

3.2 Application to the SN context

The concept and definition of decision frame is also relevant in the context of the coordination of the whole added value of the SN, with the objectives of the SN, the available decision variables at the level of the SN, and the related constraints. Such a SN decision frame is illustrated in Figure 8.

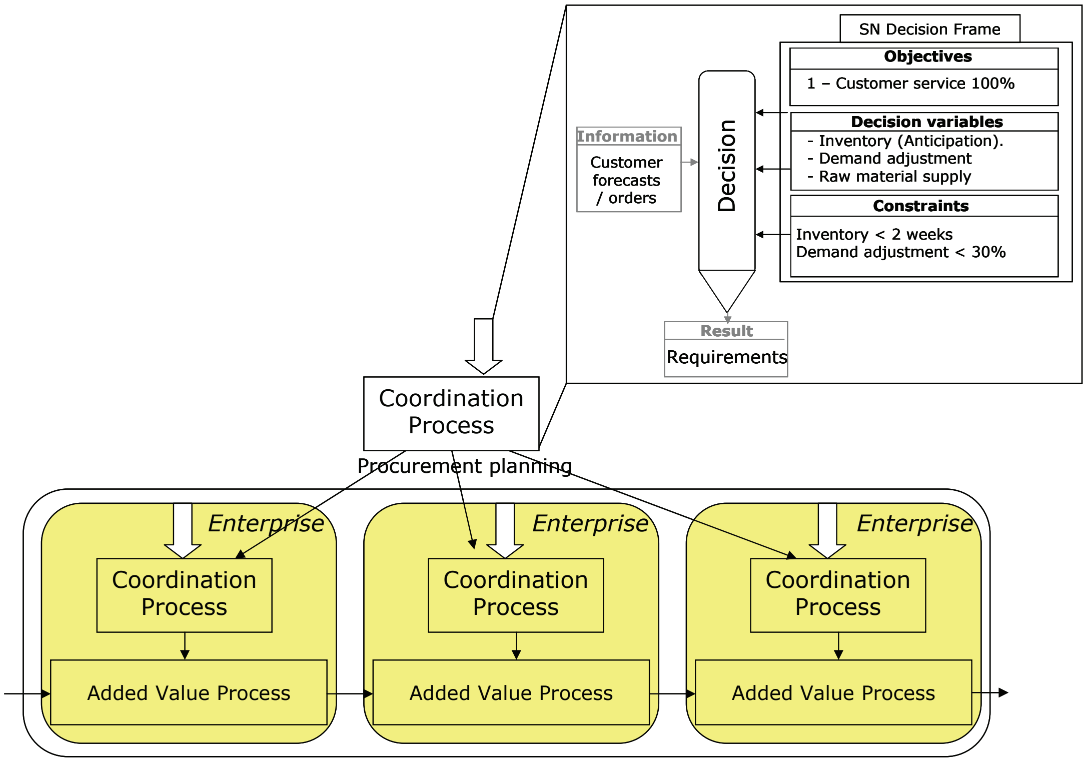

Figure 8. Example of SN decision frame

In a SN, the purpose of the coordination process is to specify the requirements for each partner (through procurements planning for example) so that the global performance of the SN will meet its objectives. It should also take in account the partner's constraints, or distribute the adjustment variables, like time slot, inventory, quantity to be delivered, etc., so that the partners can adjust the requirements regarding their local constraints.
The allocation of decision variables from the SN to its various partners is a key point for defining a consistent coordination process: it is for instance clear that two different partners should not act on the same decision variable separately.
On the other hand, the distribution of decision variables among distributed decision centres, together with their constraints of use (type 1) is a key point for defining a compromise between optimised and flexible decision making. Moreover, more decision variables allocated to each partner means more flexibility, but more difficulty to meet the global objectives in every situation.

Therefore, a company in a SN has to take into account the SN requirements (see Figure 9), in addition to its local frame. These local SN requirements are usually expressed through the procurement planning received from its direct customer, or from the SN pilot if it exists (see Orchid, which provides procurement planning to tiers 1, 2 and 3). Then, the arbitrage between the local decision frame and the SN requirements has to be addressed.

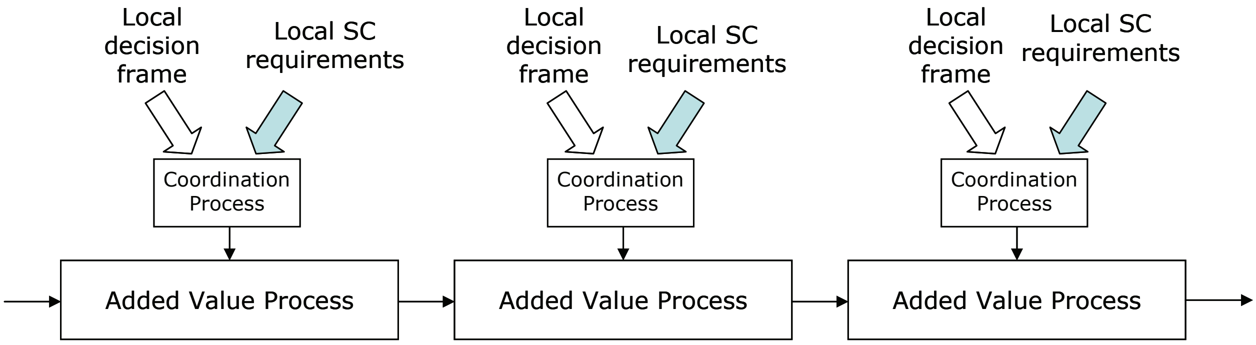

Figure 9. SN requirements and local decision frames

Depending on the context, the arbitrage between the Local decision frames and the SN requirements will be different.
Actually, we have seen in our case study that the local interpretation of the procurement planning is not unique, but depends on the situation defined by the respective characteristics of the company, of its customers in the SN, and of its suppliers in the SN. In an ideal situation, the objective of the SN, like "100% service level", should become an objective for each company in the SN, or even a local constraint (which must absolutely be respected).
In applying this model to real situations, we have seen that the coordination process between the local decision frame and the SN requirements was dependent on the collaboration context. Actually, according to this context, the information received by a decision centre could be interpreted in different manners. For example, a company which receives a procurement plan from the SN can interpret it as an *objective* to be reached or as a *constraint* to be respected, or simply as *information* to be processed among other requirements.
For example, when Primula's manager tries to balance work load as its first objective, the SN service level becomes locally a criterion to be optimized after the work load is balanced. If the company would consider the procurement planning as a priority, the SN service level would also be locally the first objective. The Primula planning rules should in that case aim firstly at trying to respect the delivery dates.

So, to better understand these coordination mechanisms, we have tried to identify the factors to be considered in order to specify this interpretation process which conditions the coordination mechanisms.

4. From company and SN characteristics to a taxonomy of collaboration situations

The collaboration context influences the way companies arbitrate between local requirements (local decision frame) and SN requirements, expressed through procurement plans.
The purpose of the collaboration seen from the SN perspective is to promote negotiation between the companies in order to increase the SN global performances, instead of local optimization by each company on its own objectives.
Based on our case studies and interviews, we have identified many factors, which influence the relationships between a company and the SN in which it is supposed to contribute. Some of these factors are:

- the weight of the SN in the local business (see Rose),
- the contribution of the company in the added value process of the SN (surface treatment for Buttercup),

- the capacity for the company to provide an answer to SN requirements, i.e. the capability and capacity of processing the procurement plan, using ERP / MRP system (see Orchid),
- the quality of the procurement plans, in terms of reliability (Buttercup),
- the reliability of the company in terms of customer service (Orchid or Violet),
- the market environment, in terms of concurrency,
- the service level (product development, after sale service, helping out,…),
- the financial, logistic, technical and SN downstream risks (related to the company contribution),
- the strategic plans of the company and the strategic perspectives from the SN point of view (the willingness of the company in belonging to the SN or the willingness of the SN in having the company in the SN).

Another important factor is the time horizon on which the coordination takes place. Especially, at short term, the technical and logistic constraints lead to different coordination mechanisms. For example, Buttercup negotiates on long term with the surface treatment supplier to contractually book capacity per period, and controls its own workshop on short term, according to the surface treatment supplier decisions.

At the moment, we have not strictly defined the way to combine all these factors and their individual influence, but, based on our case study, we propose, as a first step, to consider two synthetic criteria resulting from the combination of these factors:
- the influence of the SN in the company,
- the influence of the company in the SN.

These two criteria are in our opinion representative of the current balance of power between the company and the SN.

The influence of the SN in the company can be considered as a complex aggregation of various factors such as: amount of SN business in the company, willingness of the company to be in the SN according to its own strategy (new market opportunities, skills development, partnership,…), or fact that the company has a legal connection to other dominant partners in the SN. This first criterion will be denoted as the ***SN power***.
More important is the SN power, less negotiation space is available for the company, and so, more the SN requirements will have priority in the local coordination decision. On the other hand, a partner who has a low dependency regarding the SN will have a real negotiation power to promote local requirements in its coordination process.

The company's size, know-how, market position, capacity, etc., can turn out to be critical for the SN. In that case, the company has a real strategic advantage regarding the SN business, and the company has a negotiation power which may significantly influence the collaboration situation. The company managers will be in position to favour local objectives, as long as the strategic advantage is not questioned. A basic illustration is the SN leader who tries to drive the SN according to his own requirements thanks to its power, or a sub-contractor with a specific competence which is in a strong position due to constraints on the market for this specific competence. This second criterion, denoted as ***Company power***, represents to what extent the company is critical for the SN.

In Figure 10 have been summarized the four collaboration contexts (regarding coordination) according to the combination of these criteria.

1rst situation: this is an ideal collaboration situation. The company is important for the SN and the SN is important for the company. There is a mutual interest in collaborating. In that case, the company is **a strategic partner** in the SN.
In our industrial examples, Rose and its providers of special steel or founders, or Violet with its strategic component supplier, are in this situation. A special negotiation takes place on long term with these partners, on the base of the procurement planning.

2nd situation: this is a constraining situation for the SN since the company is important for the SN, but the SN cannot really influence the local decisions towards the SN requirements. The company is a **constraining partner** for the SN. E.g. for Buttercup, the short term coordination process is basically constrained by the surface treatment supplier.

3rd situation: this is a situation of dependency of the company regarding the SN. The SN requirements will then have priority in the local coordination process. The company is a **dependent partner**. A non specialized sub-contractor in a competitive market will be in this situation: it is the case for The Rose suppliers; Rose tries to keep a set of suppliers on which it has enough influence to promote its own requirements in the local coordination processes.

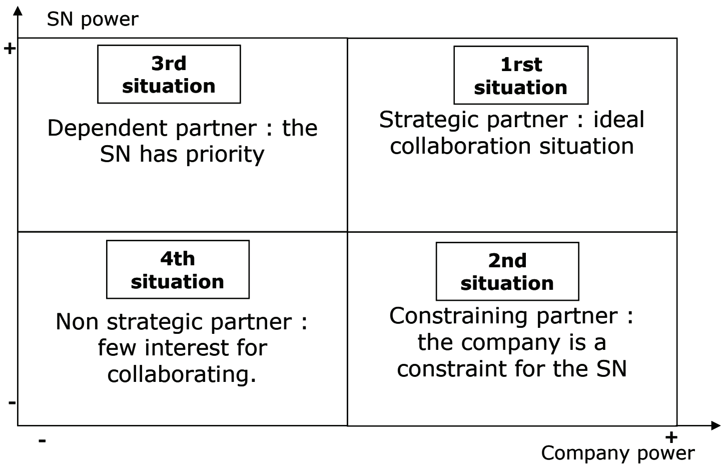

Figure 10. The collaboration situations

4th situation: it is a situation of mutual indifference regarding coordination between the SN and the company. Without constraints, strategic issues, or mutual interest, there are very few reasons to collaborate or to put energy in coordination. The company is a **non strategic partner** regarding the SN. An example can be a large company which provides some spare parts to another large company in another industrial sector. In our industrial examples, the Violet management of class C requirements is a good illustration, where the security stocks allow to cope with the coordination problems.

Obviously, a strategic issue for a company is to keep a competitive advantage regarding its market, and, from the SN point of view, it is important to keep partners with competitive advantage. So, globally, the success factor remains the win-win relation, such as in the first situation where company power and SN power are high.

These four situations constitute a rather trivial taxonomy, but we shall show in the following that it already provides support in order to understand the way the coordination elements described with the GRAI decision model correspond one with another in the SN coordination process. Therefore, this simplification allows us to easily link the collaboration context to the coordination mechanisms. This is the purpose of the next section.

5. Taxonomy of coordination mechanism

We have seen in the state-of-the-art of section 2.1 that many approaches and methods have been suggested for coping with the problem of Supply Chain management. In each case, a given method is tested all along the chain, whereas the main idea which has

governed our study is that understanding the coordination mechanisms between the companies and the SN should allow to provide some specifications for the requirements regarding local information processing.
For each situation, we study first the way the procurement plan is interpreted by the company in its local coordination process. Afterwards, from the SN perspective, we will analyse the way the SN should consider each partner in its global coordination process.

5.1 Taxonomy of local coordination mechanism for a company in a SN

In Figure 11 are presented different coordination processes, depending on the collaboration situation. This framework allows to describe the way the SN requirements (procurement planning) are taken into account in the coordination process of the company.

In order to illustrate the local coordination process, the procurement plan received by the company is considered as representing the requirements from the SN: quantity to be provided with date or time fences, specific constraints (lot size, minimum quantity, traceability,…), but also possible adjustment variables on quantity, dates or delivery conditions.

In the **1rst situation**, there is a real collaboration to arbitrate between local and global requirements. Then, the received procurement plan is processed as a *decision frame*. In this case, the collaboration process will take place through bi-directional information exchange between the enterprise and the SN. The result of this collaboration process will be a compromise respecting local and global requirements.

In the **2nd situation**, the company is a constraint for the SN. It receives a procurement plan from the SN, but in its local coordination process, the company will first take into account its local requirements. As a consequence, this procurement plan is not considered as an objective, but as a potential *adjustment variable*, allowing for example to smooth or adjust the work load if necessary.

In the **3rd situation**, the SN will impose its requirements. In that case, the company has no alternative but to respect the SN requirements. The procurement plan is so interpreted as a *constraint* which has to be respected.

Finally, in the **4th situation** (mutual indifference), the procurement plan will only be considered as an *information* among other requirements, to be integrated in the coordination process.

Thanks to the collaboration situation in the SN, it is possible to specify what kind of coordination mechanism is used for the partner.

In the next section, the same analysis is performed from the SN perspective, leading to identify how each partner influences the global coordination process of the SN.

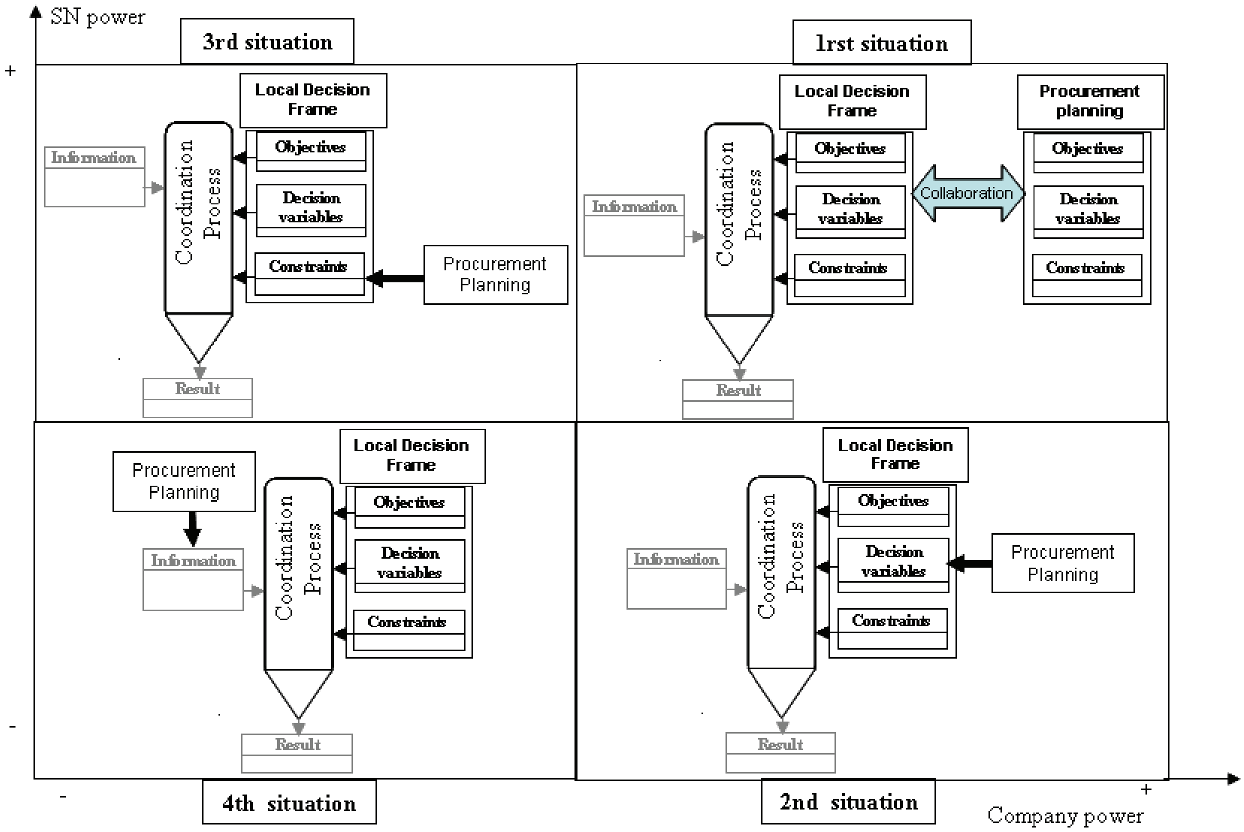

Figure 11. Taxonomy of coordination mechanisms according to collaboration situation

5.2 Global coordination mechanism in a SN

Each partner receives from the SN a set of requirements expressed through procurement planning. Each partner processes this procurement plan and eventually negotiates or proposes an answer to the SN, according to the local collaboration situation and to the local requirements.
This section is now devoted to the description of the way each partner should be considered in the coordination process at the level of the SN. In that purpose, and in order to illustrate this proposal, a theoretical SN is suggested with four partners, representing each collaborative situation. This global coordination process is summarized in Figure 12.

For a strategic partner (1rst situation), there will be a negotiation. Company and SN will build together a solution, respecting the local decision frame and the SN requirements. It is then important to find the method and the tools allowing to perform this negotiation, like collaborative web portal, or any ad-hoc interactive system.

A constraining partner (2nd situation) will promote his own objectives. Then, the local coordination results will be considered as a constraint to be respected by the SN. As an example, if the constraining partner decides to adjust the SN requirements in order to optimise its capacity usage, the SN will have to adjust its own coordination process according to this adjustment. In such a context, we believe that it is important to adopt a pragmatic approach, in trying to integrate such a constraint earlier in the global coordination process.

For the dependent partner (3rd situation), one can consider that all the local decision variables are potentially available for the SN (limited by the local constraints related to these decision variables). Actually, the SN has the power to dictate its procurement plan on the company, which will use its own decision variables in order to meet the SN requirements. Then, in the global coordination process, such a partner will rather be taken into account after the constraining partners and after negotiation with the strategic partners.

Finally, the non strategic partner (4th situation) will have a very low influence on the global coordination process. His answer to the procurement plan will be integrated as an information to be taken into account. For example, the use of security lead-times or inventory allows decoupling the supplier from the SN. The inventory supports in that case the coordination constraints.

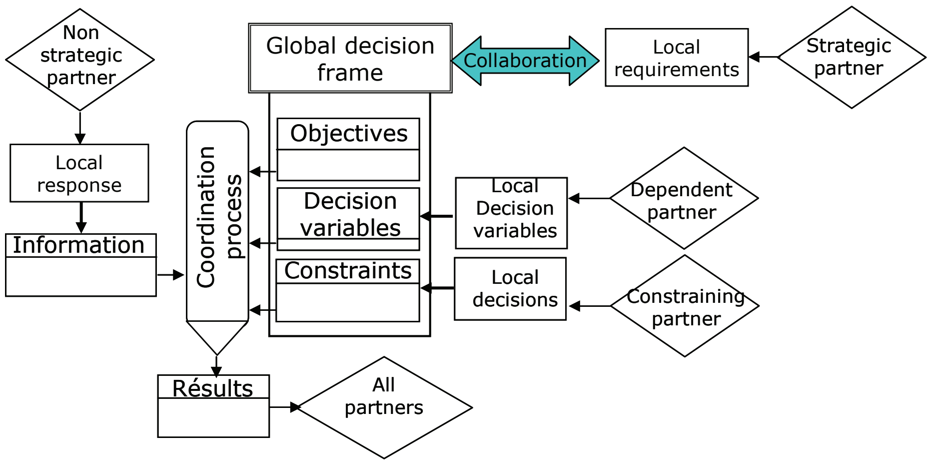

Figure 12. Global coordination mechanisms according to types of partners

Figure 12 illustrates the way the global coordination will have to take into account the various partners, in a way depending on their collaboration situation. This analysis provides a model to describe and understand of the whole SN coordination mechanism, then to specify the adequate way to process information accordingly.

6. Application of the modelling frame

6.1 Application to the case studies

For each case described in section 2, the coordination process related to the identified collaboration situation will be described, using the suggested modelling framework. In the following section are suggested some findings on the specification of the relevant information processing methods or technologies related to these coordination mechanisms: constraints based management, optimisation (through APS), multi-agent systems (MAS), ERP, Collaborative Planning Forecasting and Replenishment (CPFR), simulation, etc.
For each company presented in section 2 are presented the collaboration situation and the related coordination process. The coordination process for the long term coordination (Sales & Operation Planning level) and for the short term coordination (rather Master Production Scheduling and detailed planning) are described separately when they exist.

Rose:
The Rose strategy is to keep power on its supplier network. In that purpose, Rose maintains an important business level in each of its supplier (more than 40%), and it also controls the supply of raw material related to this business. In this way, Rose has created a network of *dependent partners*. Even if it is a real advantage for operational coordination, this situation sets questions on the long term risks: risks of suppliers failure

if Rose has to face business problem, low development capabilities for the suppliers, low level of partnership.

Two different coordination processes exist for Rose. At long term, Rose negotiates a significant dedicated capacity from each direct supplier, looks for other suppliers if required, then buys quotas to raw material suppliers (see left part of Figure 13). Through this process, Rose controls raw material costs, secures supply and increases its power on the suppliers. At short term, the operational coordination process aims at maintaining Rose delivery performances, by using supplier's decision variables (limited by the suppliers constraints related to these decision variables). Since they are dependent, Rose can adjust and send them new procurement plans (see right part of Figure 13).

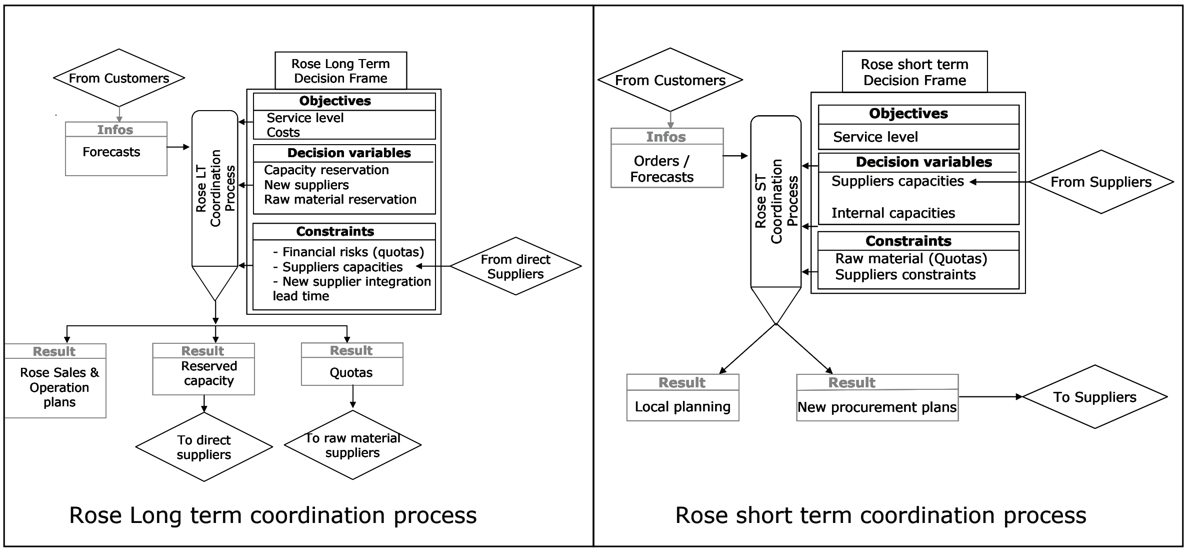

Figure 13. Rose SN coordination mechanisms

Buttercup:
The collaboration situation for Buttercup is to deal with a constraining partner: the surface treatment supplier.
On long term, Buttercup aims at negotiating capacity reservation and process cycles, in order to minimise the level of constraint. It uses volume and guaranteed price to get this capacity reservation per period (see left part of Figure 14).

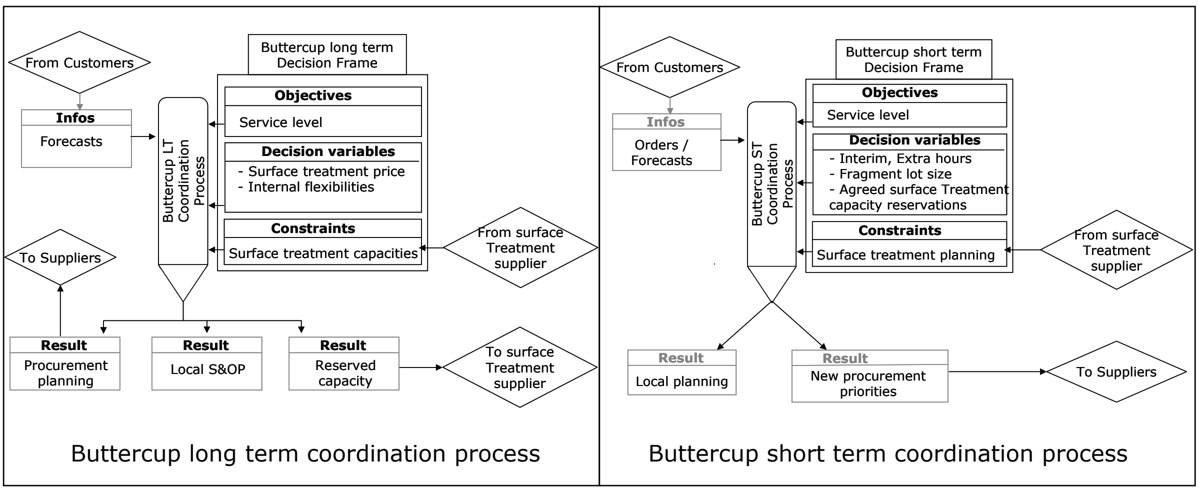

Figure 14. Buttercup SN coordination mechanisms

On short term, all the decision variables available at Buttercup's (capacity adjustment, lot size fragmentation, agreed surface treatment capacity reservation) are dedicated to the management of the surface treatment constraints (see right part of Figure 14). The constraint for Buttercup will so be the planning of the surface treatment supplier (result of the local coordination process).

The main problem for Buttercup is a lack of global constraint management. Each SN partner negotiates individually with the constraining partner, increasing by the demand segmentation the power of the surface treatment partner.
There are various improvement perspectives for Buttercup. On long term, it should support an increase of the surface treatment capacity (through new partnership, investment, external growth) in order to relax the constraints, or buy up the surface treatment supplier to control its capacity.
On short term, and to improve its performances, Buttercup should manage the constraint at the level of its supply network, i.e., it should control the whole capacity of the surface treatment related to its activity. This would allow an arbitrage according to the global performance of the network, and would increase the power of the supply network regarding this constraining partner, since it controls a more important business.

Orchid:
Most of Orchid suppliers are independent suppliers with a low level of maturity on production control. These suppliers are constraining partners for Orchid, since they are not reliable. Moreover, Orchid has not a significant impact on their revenues. So, these suppliers favour their local objectives instead of Orchid requirements.
On long term, Orchid calculates a requirements planning (via a MRP process) based on negotiated manufacturing cycle time and negotiated security (see left part of Figure 15). This allows Orchid to coordinate all the SN, although roughly since each supplier asks for large securities.
On short term, the coordination process is poor, since the management of such a constraining network leads Orchid to absorb most of the SN problems; especially, as the use of the various securities by the suppliers is not coordinated, Orchid suffers from a poor synchronisation of the supplied components. The consequences are important work in progress and inventories (with missing parts), and poor delivery performances. On short term, Orchid manages the constraints of supplier’s deliveries with its local capacity adjustments (see left part of Figure 15).

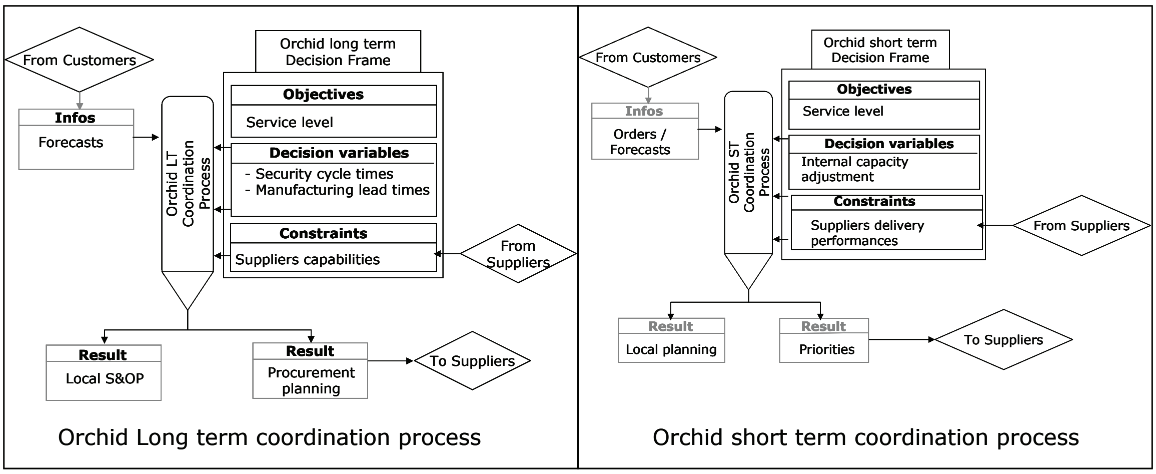

Figure 15. Orchid SN coordination mechanisms

Improving coordination requires to change the collaboration situation, i.e. to increase Orchid power on its supply network, so that coordination could be better controled by Orchid.

Violet:
Violet strategy is to keep a high level of customer service and to develop a strategic supply network. In that purpose, it has built its supply chain according to coordination requirements related to this objective: keep a set of strategic partners with which collaboration is possible, select a service provider able to secure components availability (a dependent partner in order to increase decision variables), and implement a decoupling inventory with C class components to relax synchronisation constraint with these components.

Violet has decided to "buy" the service provider dependence, in accepting extra costs for the services. The same coordination process (see Figure 16) is valid on long term and on short term.

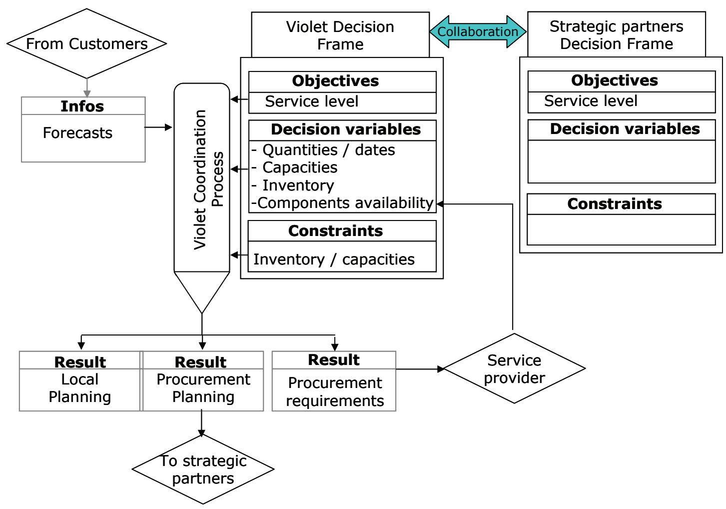

Figure 16. Violet SN coordination mechanisms

Lily:
Lily is a dependent partner. Since long term production planning is not developed, there is no clear decision frame for the long term coordination, except for material supply, for which the manager tries to minimise risks according to financial constraints.
At short term level, Lily maintains high stocks and a high work in progress level in order to support customer changes and delivery requirements, while its objectives are to reduce the working capital needs. This is the consequence of very low degrees of freedom.
The short term coordination process is described in Figure 17.

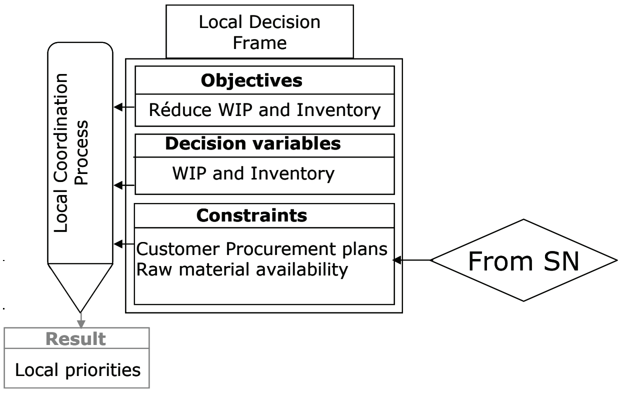

Figure 17. Lily coordination mechanisms

Primula:
This company has a strong power in the SN, as it is a critical operation in aeronautic industry, without real local competitors (the capacity is limited in the region). The long term coordination process concerns general management topics (human resources, new investments, new technologies, etc.) and basically remains independent from the SN requirements, even if customers try to negotiate capacity reservations.
At short term, the coordination process is purely oriented on local optimization (see Figure 18). The decision variables are the priorities of the orders (Primula does not support product costs, since they are the property of the customer), while the constraints taken into account are basically the technical process requirements.

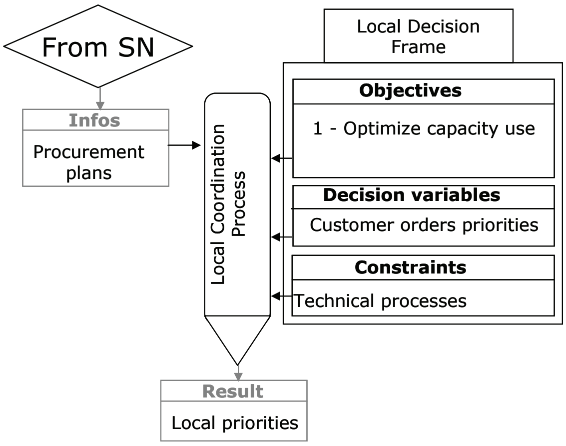

Figure 18: Primula coordination mechanisms

These considerations are a first step, the final objective of the study being to identify the most relevant approach to support information processing for a complete SN.

6.2 Coordination mechanism: application to a complete SN

A survey of the main approaches proposed in the literature regarding SN coordination has been presented in section 2.
Based on the GRAI decision model and according to the collaboration environment, we are able to describe and understand the coordination process along the SN, with a synthetic view on the context.
In this section is provided a first attempt for relating information processing techniques to these specific coordination mechanisms. In that purpose, we propose to create a generic SN, based on our case studies, which illustrates various possible configurations.

Then, according to these various configurations, we will propose a first classification of information processing tools.

To illustrate our work, we consider a large enterprise named PILOT, playing the role of SN pilot. The suppliers are the following: a constraining partner (like Primula for example) named CONST, 3 dependent suppliers named DEPEN 1, DEPEN 2 and DEPEN 3, 1 non strategic partner (named SUPPL), and finally, 2 strategic partners: STRAT 1 and STRAT 2. This SN is illustrated Figure 19.

Each partner of the SN has its own decision frame, and may belong to other SNs. In this example, the description of the information and data required to perform the coordination has been simplified, in order to focus the study on the coordination elements i.e.: objectives, decision variables and constraints.
Only the operational coordination process in this SN has been described and analysed. The same model could be built for the long term coordination process of the SN.

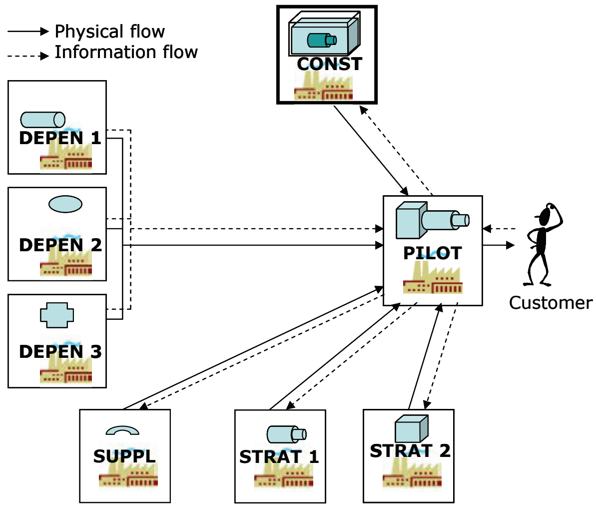

Figure 19. Generic example of SN: the PILOT SN

In Figure 20 are described the coordination mechanisms with the GRAI coordination model, depending on the collaboration situation. In this scheme, the SN coordination process performed by PILOT has been detailed, splitted in different steps, related to these collaboration situations.

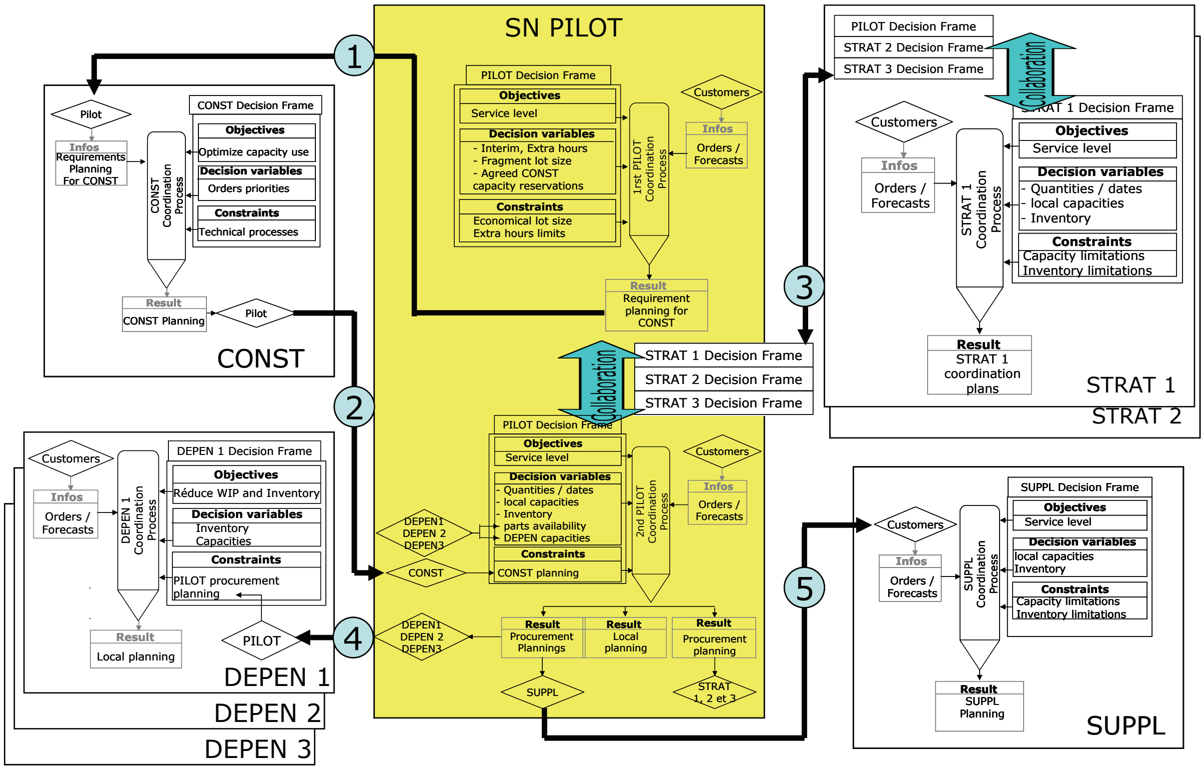

Figure 20. Various steps of the coordination process in the PILOT SN

The first coordination step aims at taking in account the constraining partner in the SN coordination (flows 1 and 2 on Figure 20).

The second step aims at collaborating with the strategic partners (STRAT 1 and STRAT 2) for the best compromise (flow 3 on Figure 20).

The third step aims at optimising the requirements for the dependent partners (flow 4 on Figure 20).

Finally, the last step is the simple transmission of the procurement planning to the non strategic suppliers (flow 5 on Figure 20).

The purpose of this study is now to specify the more relevant information processing methods or technique to support the coordination process. In reference with the survey presented in part 2, we are able to specify which tools, systems or techniques should be used in each situation.

On the same example, we present some of these specifications.
For the first coordination step, handling *constraints* is the key problem: management techniques like TOC (Theory Of Constraints), or algorithms and solvers based on constraints propagation or programming can be used (see Ilog solvers[2], CHIP[3], ECLIPSE[4]...)
The second step requires interactive systems to support collaborative coordination: web based support system, E-collaboration, information system integration may provide means for this interactive step, locally supported by decision support systems allowing to quickly analysing the consequences of a proposal from the partner. It can be noted that this negotiation process can also be simulated by Multi-Agent systems (MAS).

[2] http://www.ilog.com
[3] http://www.cosytec.com/production_scheduling/chip/optimization_product_chip.htm
[4] http://eclipse.crosscoreop.com/

The third step concerns the network of dependent partners. In this collaboration situation, the use of centralized tools becomes possible: multi-site optimisation using an APS, or even a centralized ERP process (as presented for Orchid) can be used. More generally, optimisation techniques through optimal methods, heuristics or meta-heuristics, or even simulation, can be used for managing this part of the SC where few degrees of freedom are left to the sub-contractors.
Finally, the last step is closer to the classical point to point relationships between SN partners: an independent ERP / MRP system can be used, processing customer requirements to generate procurement plans sent then to the suppliers.

This possible matching between collaboration situation and information processing techniques is summarized on the example in Figure 21.

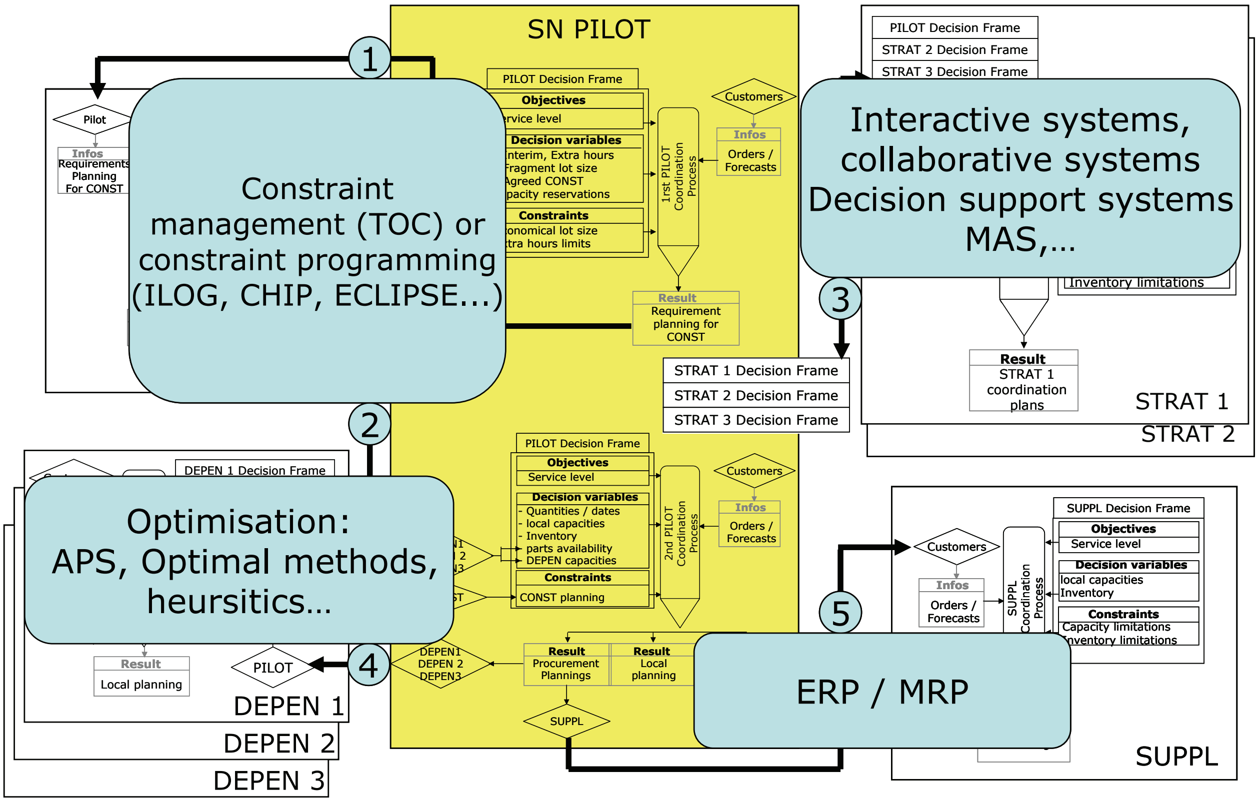

Figure 21. Information processing techniques related to coordination situations

7. Conclusions and perspectives

Providing an efficient coordination of the partners involved in a Supply Chain is a key industrial problem, which importance is still increased by the ongoing process of externalisation. Such coordination requires to be able to propagate through a Supply Network a set of consistent Procurement Plans allowing to balance service to the customer and cost minimisation.

Whereas the industrial reality still mainly focuses on point to point MRP-based relationship, many methods and techniques have been suggested in the research literature for improving this coordination process. Methods as different as linear programming, distributed simulation, constraint propagation, system dynamics, heuristics, meta-heuristics, or multi-agent systems have been suggested and tested in numerous papers on the subject.

In spite of some exceptions, like (Hua et al., 2006), the industrial habits so that most of these studies consider implicitly that the way to process information in order to build these Procurement plans is independent from the type of relationship between partners.

Through some examples based on real companies, we have shown that information exchanges between partners are much more complex than it can be expected. For us, the problem is not in that context to judge whether the companies have the "good" behaviour, but to find how to efficiently support these operational coordination processes.

We have suggested as a first step to only consider the SC Power on a partner and the Company Power on the SC as main features for defining a typology of coordination. The GRAI tools have provided us a simple and efficient way to model coordination situations, with a clear positioning of key concepts like objective, constraint, decision variable or information. The obtained framework has allowed us to simply model the situations described in the examples, which could appear at very different at a first glance.

Some prospective findings have been given in order to show that the obtained coordination models may now help us to go further in the choice of the method or tool best adapted to a given situation. In that perspective, the problem of defining how to process information for defining procurement plans within a supply chain is not anymore to choose a method or tool, but to analyse the coordination mechanisms and deduct from this analysis the specification of an ad-hoc distributed heterogeneous information system.

Of course, this study is only at a preliminary stage, and the feasibility of defining such distributed information system is linked to the well known problem of interoperability, recognised as a key issue for SC coordination.

Our perspectives are now oriented on two main directions.
The first one is to go further in the analysis of the requirements concerning information processing tools and methods, on the base of a more accurate coordination typology. The development of a first software prototype is in progress in order to show the feasibility of an opportunistic connexion of pieces of information systems allowing to balance the satisfaction of global and local objectives in a Supply Network.

The second one is oriented on the diagnosis and improvement of the coordination in a Supply Network. The classical GRAI method includes rules aiming at the identification of inconsistencies in the production management system of a company. After more exhaustive tests in modelling real supply chains using our reference model, we do believe that it should be possible to define such rules, allowing to assess the consistence of the coordination mechanisms all along a Supply Network. From this diagnosis, it should then be then possible to draw directions of improvement: some comments in section 6.1 were already oriented in this direction.

8. References

Albino V., Carbonara N., Giannoccaro I., 2007, Supply chain cooperation in industrial districts: A simulation analysis, *European Journal of Operational Research*, 177(1), 16, pp. 261-280.

Archimède, B., Charbonnaud, P., Mercier, N., 2003, Robustness evaluation of multisite distributed schedule with perturbed virtual jobshops, *Production Planning & Control,* 14(1), pp. 55-67.

Beamon B. M., 1998, Supply chain design and analysis: models and methods. *International Journal of Production Economics*, (55), pp. 281-294*.*

Bernstein, F., Chen, F., Federgruen, A., 2006, Coordination Supply Chains with Simple Pricing Schemes: The Role of Vendor-Managed Inventories, *Management Science*, 52(10), pp. 1483-1492.

Berrah, L., Clivillé, V., Harzallah, M., Haurat, A., Vernadat, F., 2001, PETRA : Un guide méthodologique pour une démarche de réorganisation industrielle, Activity Report of LGPIM, December.

Cachon, G.P., Fisher M., 2000, Supply chain inventory management and the value of shared information, *Management science,* 46(8), pp. 1032-1048.

Cachon, G.P., Lariviere, M.A., 2005, Supply Chain Coordination with Revenue Sharing Contracts: Strenghts and Limitations, *Management Science*, 51(1), pp. 30-44.

Carlsson, S., Hedman, J., 2004, From ERP Systems to Enterprise Portals. In "Future of ERP systems: Technological Assessment" (Adam ed.), Hersey, PA, Idea Group Publishing, pp. 254-277.

Christopher, M., 1992, Logistics and Supply Chain Management, London: Pitman Publishing.

Chung, W.W.C., Leung, S.W.F., 2005, Collaborative planning, forecasting and replenishment: a case study in copper laminate industry, *Production Planning & Control*, 16 (6), pp. 563-574.

CIMOSA Association, 1996, CIMOSA Technical Baseline, Version 1.6, CIMOSA Association, e.v., D-71034, Böblingen, Germany, April.

Demeter K, Gelei A., I. Jenei, 2006, The effect of strategy on supply chain configuration and management practices on the basis of two supply chains in the Hungarian automotive industry, *International Journal of Production Economics*, 104(2), pp. 555-570.

Doumeingts, G., Chen, D., Vallespir, B., Fénié, P., 1994, GRAI Integrated methodology (GIM) and its evolutions: a methodology to design and specify advanced manufacturing systems, *IFIP Transactions B: Computers Applications in Technology*, B-14, pp. 101-117.

Durango-Cohen, E., J., Arai Yano, C., 2006, Supplier Commitment and Production Decisions Under a Forecast-Commitment Contract, *Management Science*, 52(1), pp. 54-67.

Garcia-Dastugue, S.J., Lambert Douglas, M., 2003, Internet-enabled coordination in the supply chain, Industrial Marketing Management, 32 (3), pp. 251-263.

Génin, P., 2000, Le Plan Industriel et Commercial : Recherche de Pratiques Optimales du Processus d'Elaboration, Master Rapport of Marne-La-Vallée University / National School of Ponts et Chaussées.

Geunes, J., Pardalos, P.M., 2003, Network optimization in Supply Chain Management and Financial Engineering: an annotated bibliography, *Networks*, 42(2), pp. 66-84.

Haffmans L., van Weele, A., 2003, How suppliers can become innovative, in: Proceedings of IPSERA 2003 Conference, pp. 645-654.

Hua Z., Li S., Liang L., 2006, Impact of demand uncertainty on supply chain cooperation of single-period products, *International Journal of Production Economics*, 100(2), pp. 268-284.

Kelle, P., Akbulut, A., 2005, The role of ERP tools in the supply chain information sharing, cooperation, and cost optimization, *International Journal of Production Economics*, 93-94, pp. 41-52.

Kok, T.G., Fransoo, J.C., 2003, Planning Supply Chain Operations: definition and comparison of planning concepts. *In: Handbooks in OR & MS*, edited by A.G. de Kok and S.C. Graves, Elsevier B.V., pp. 597-675.

Lauras M., Telle O., Lamothe J., Thierry C., 2003, Référentiel de l'entente industrielle ; trois approches dans le domaine de la gestion des chaînes logistiques, in Proceedings of the 5th Congress of "Génie Industriel", Québec, Canada, October.

Lee, H.L., Ng, S.M., 1997, Introduction to the special issue on global supply chain management, *Production and Operations Management*, 6 (3), pp. 191-192.

Malone, T.W., 1987, Modeling coordination in organizations and markets, *Management Science*, 33 (10), pp. 1317-1332.

Nissen, M.E. 2001, Agent-based supply chain integration, *Information Technology and Management*, 2, p. 289-312.

Orlicky, J., Plossl, G., 1994, Orlicky's Material Requirement Planning, McGraw Hill Text, 2nd Edition.

Parrod N., Thierry C., Fargier H., Cavaille, J.B., 2007, Cooperative subcontracting relationship within a project supply chain: A simulation approach, *Simulation Modelling Practice and Theory*, 15(2), pp. 137-152.

Prahinski C., Benton W. C., 2004, Supplier evaluations: communication strategies to improve supplier performance, *Journal of Operations Management*, 22(1), pp.39-62.

Sahin, F., Powell, R.E., 2005, Information sharing and coordination in make-to-order supply chains, *Journal of Operations Management*, 23 (6), pp. 579-598.

Scheer, 1999, ARIS Toolset documentation. Saarbrücken, Germany.

Schragenheim E., Dettmer H.W., 2001, Manufacturing at Warp Speed: Optimizing Supply Chain Financial Performance. St. Lucie Press/Apics Series on Constraints Management.

Stadtler, H., Kilger, C., (Ed.), 2005, *Supply Chain Management and Advanced Planning,* 3rd ed., Springer: Berlin.

Stock, G.N., Greis, N.P., Kasarda, J.D., 1998, Logistics, strategy and structure. A conceptual framework, *International Journal of Operations & Production Management*, 18 (1), pp. 37-52.

Thomas A., Lamouri S., 2000, The new problem with sales, inventories and operations planning in a supply chain environment, SPIE (International Society for optical Engineering), Intelligent System and Manufacturing III, Boston, pp. 321-329.

Thonemann, U.W., 2002, Improving supply-chain performance by sharing advance demand information. *European Journal of Operational Research*, 142, pp. 81-107.

Ulieru, M., Brennan, R.W., Walker, S.S., 2002, The holonic enterprise: a model for internet-enabled global manufacturing supply chain and workflow management. *Integrated Manufacturing Systems*, 13(8), pp. 538-550.

Williams T.J., 1994, The Purdue Enterprise Reference Architecture, *Computers in Industry*, 24(2-3), pp. 141-158.