Modeling and decision tools for supply chain control

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Abstract: Supply Chain Management implies a greater integration of model and decision tools. First transport models and production manufacturing models must be considered jointly and not separately. Second new Supply Chain structures, such as Extended Enterprises and Virtual Enterprises, induce negotiations concerning costs, delays and quality and exchange of knowledge and data, between various partners, who can have been in strong competition and want to keep some data quite secret while sharing other data with some partners of the Supply Chain. Some flow exchanges have been currently regulated by contracts with penalty systems; a more general control system needs to be designed. In consequence, new decision tools must be proposed at each level of the hierarchical decision structures: strategic, tactic and operational levels. In particular, new decision systems must be designed for the planning level including several partners of the Supply Chain and new scheduling tools generalizing classical scheduling models with new constraints and criteria linked to just-in-time strategies and to negotiation approaches.

Keywords: supply chain management, global and local control modeling, decision tools, enterprise network, planning and scheduling models.

1 General information to the participants of ILS 06

This session is neither a tutorial, nor a state of the art, nor a series of papers on the considered subject. The aim is to present matters by an introductory presentation followed by spontaneous participations and then to open a discussion on the subject.

We could have ended this paper by a long list of references taken from works of our PhD students or from numerous papers already written and published on the subject. We voluntarily do not put them, because the aim is not to list, what is already made or not made but to discuss the realism of various models (without discussing if the model of this particular author is more or less realist and interesting than the model of another one). We attempt to introduce the need of new concepts, new models and new approaches.

In order to give an idea of this presentation and to convince participants to join this session, we present only two examples, which can open the discussion.

2 Problems linked to the holding cost and/or transportation cost consideration at the planning level

We consider a virtual enterprise in which the nodes (denoted by VEN, Virtual Enterprise Node) are independent partners, whose financial interests are in competition, but who has decided to participate to the virtual enterprise and to try to play win-win in order to get globally more money.

We consider a very simple virtual enterprise, which contains:

- two suppliers denoted by A and B,
- a transport enterprise denoted by θ,
- two customers denoted by 1 and 2,

and we consider only one type of component x, which can be produced by A and B, which is transported by θ and which is used by 1 and 2.

Suppliers A and B and customers 1 and 2 are located, in the most general case, in different locations, which induces non-negligible and non-identical transportation times and costs.

We assume that ([1]):

- The two customers 1 and 2 have already built their forecasting production planning on a given medium term horizon and therefore computed at what instants they need component x and in which quantities.

- The two suppliers A and B have already built their forecasting production planning on a given medium term horizon and therefore computed at what instants they deliver component x and in which quantities.

- The transport enterprise θ is now forecasting how he will moved the quantities required by customers A and B from suppliers 1 and 2, under the following complementary hypotheses:

- Customers must received the asked quantities of component x before they need them,

- Customers cannot received the asked quantities too earlier before the instants they need them because of limited capacity for their warehouses,

- Suppliers cannot deliver components before they are produced,

- Suppliers cannot keep components too long after they are produced because of limited capacity of their warehouses,

- Each truck used by the enterprise θ has a limited capacity (identical to simplify the problem),

- The enterprise θ is able under this set of constraints to build vehicle tours in order to minimize the transportation costs.

Under the imposed environment, this approach seems correct in the framework of a win-win approach. Furthermore, it is possible to compute, at any time period, the inventory level of component x of each partners: suppliers A and B and customers 1 and 2. But in the model, there is a question without answer: to whom must be assigned the holding costs? If we change the transportation solution, the inventory levels of component x varies for the various partners, while the total inventory costs is constant if the unitary holding costs are assumed to be the same for the different partners!

[1] It is only one of the multiple models, we can consider.

Obviously the problem become more and more complex, if we assume some partners can change their forecasting planning in order to decrease either the inventory cost or the transportation cost, but it does not change the fact, you do not know to whom the inventory costs must be assigned.

3 Problems linked to holding costs, transportation constraints and/or delays negotiation at the scheduling level

A lot of new scheduling models are now arising in the framework of supply chain management and surely we need good states of the art on the subject. Nevertheless, it is not our goal here. Our aim is to discuss the realism of proposed models and to list some questions about them. It is again only a list of remarks in order to open the discussion.

Numerous authors introduce holding costs in their models. They use for scheduling models the same definition of holding costs as the one used for the planning models. Is it correct? At the planning level, the products are kept during a long interval and if you decrease the level of the inventory in average, surely you will gain money on your holding costs. At the scheduling level, you organize the production at a given phase of the manufacturing system of the enterprise network, you can only use the components, which are assumed to be available and you deliver the finish product under constraints fixed by the downstream production or delivery system. What is the meaning of minimizing a sum of weighted completion times of the finish products at the scheduling level? In what case can we consider the customer pays the finish products, as soon as they are delivered or as soon as they need them? Probably the sum of weighted completion times of the machine utilization are more interesting, because they can correspond to overtime hours (but not to holding costs).

Crossing production and transport at the scheduling level is a promising way to provide interesting decision tools inside the supply chain. A lot of models are more and more investigated. Authors begin with very simple models, some of them are polynomial and others are unfortunately already NP-hard, and add more and more realistic constraints and criteria. The transport constraints induce batch scheduling in the simplest cases, bin-packing constraints in the medium difficult cases and vehicle routing models in the more general cases. One of the numerous open questions is how to extend, for example, the $\alpha/\beta/\gamma$ classification very useful to researcher in the scheduling area?

Another source of new scheduling models is linked to the variation of the need of the partners of the supply chain due to the uncertainties arising at the scheduling level (variation of the demands of the external customers with a non-negligible difference from forecasted demands, breakdown of various resources, estimated transportation or production times, manpower absences…). In consequence, the production schedules and transportation schedules must be prepared in advance (predictive schedules), but must be also corrected regularly (reactive schedules). In the framework of a supply chain involving independent partners, some data, which are generally considered as fixed in most of the scheduling models can be considered as "negotiated", with the possibility of being "re-negotiated" several times at the predictive level, within a sliding plan approach, and at the reactive level. In consequence, the dead lines must be replaced by a series of negotiated due dates, but also the release date must be replaced by a series of negotiated component delivery dates. The negotiation of product due dates and component delivery dates can be prepared by using schedule models including penalty costs associated to the series of already considered negotiated due dates and delivery dates. This provides us with new earliness-tardiness criteria, which are not regular criteria (left-shifted set of schedules are no more dominant). Various research works have already been published on earliness-tardiness criteria associated to due dates. In some particular cases of single machine environment, they permit to also model earliness-tardiness criteria associated to delivery dates, but it is not true in the general case.

4 Partial conclusions

Surely combining realist formulas for holding costs, complex constraints for transportation models and new earliness-tardiness criteria for delays negotiation inside the supply chain will provide the whole scheduling community an enormous quantity of interesting and realist models to be considered.

Another very important problem is linked to the centralization or semi-decentralization or decentralization of the decisions in the framework of a supply chain including independent partners. We presented here decision tools, which can help the global process of negotiation by analyzing local decision problems under constraints representing the interests of the other non represented partners, but it remains to define a convergent decision system of negotiations, to decide who can act as mediator if there exists at least a semi-decentralization approach and an enormous problem evocated in the abstract: What pieces of information can be exchanged between the competitive partners in order to play win-win as much as possible but without giving involuntary sensible strategic pieces of information?

5 Biography

Marie-Claude PORTMANN is professor in Computer Sciences and Operations Research at the Institut National Polytechnique de Lorraine and teaches at the Ecole des Mines de Nancy. She is head of the MACSI research team of the INRIA-LORRAINE and of the LORIA. Her main research interests are nowadays development and evaluation of decision tools for planning and scheduling in the framework of the supply chain.