The 2008 Supply Chain Trading Agent Competition - Procurement Challenge

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Abstract

This document contains the specifications of the 2008 Supply Chain Trading Agent Competition – **Procurement Challenge** (**SCM-PC-08**). The Challenge revolves around a PC assembly scenario, where trading agents developed by different teams compete for components required to assemble different types of PCs. The Challenge requires agents to manage supply chain risk by negotiating long-term, quantity flexible procurement contracts and supplementing these contracts with one-off procurement orders. As such, this challenge complements the current "baseline" TAC-SCM scenario by extending the space of procurement options available to supply chain trading agents. By and large, the 2007 SCM-PC validated the model and showed that it was a viable scenario. In 2008, we have decided to allow each supplier to offer both one-off and long term contracts, rather than restricting each supplier to offer only one type of contract. This is consistent with practices found in many actual supply chains and also slightly more challenging.

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Keywords: Autonomous Agent, Electronic Commerce, Trading Agent

Contents

1 Overview

The TAC SCM Procurement Challenge aims to reflect the importance of long-term procurement contracts, such as quantity flexible contracts, in many actual supply chains [3]. It complements the current "baseline" TAC-SCM scenario [1, 2] by extending the space of procurement options available to manufacturer agents and allowing them to enter long-term contracts with supplier agents. In contrast to the 2007 SCM-PC supplier model [4], we have decided to allow each supplier to offer both one-off and long term contracts, rather than restricting each supplier to offer only one type of contract. This is representative of how most suppliers operate in the real world. Specifically, manufacturer agents will rely on a combination of:

- Long-term "quantity flexible" contracts. These contracts specify minimum component quantities a manufacturer agent commits to purchasing weekly (at a fixed price) from a given supplier agent and include options to increase these quantities by up to some percentage (at the same fixed price).
- One-off contracts. These are the same supply contracts as the ones negotiated in the baseline TAC-SCM scenario [2].

The TAC-SCM Procurement Challenge (or "SCM-PC") game simulates D days of operation (where $D = 100$ days). It features n manufacturer agents (where $n = 3$) competing for supply contracts from 8 different supplier agents (the same suppliers as the baseline TAC-SCM scenario). In SCM-PC-08, every supplier offers both long-term and one-off contracts. Long-term contracts are negotiated at the start of the game, and last for the game's full duration. Each week, manufacturer agents may decide to order more than the minimum quantities they committed to up to a pre-specified max quantity. Each day, they may also decide to procure additional components outside of their long-term procurement contracts (specifying quantity and delivery date).

The SCM-PC server will simulate the supplier agents and provide banking, production and warehousing services to the manufacturer agents. It will also randomly generate the demand and require each manufacturer agent to satisfy an equal part: this allows entrants to ignore the customer bidding dimension of their supply chain, making SCM-PC simpler than the baseline game. In SCM-PC, manufacturer agents are only expected to focus on procurement decisions. At the end of the game, the manufacturer agent with the most money in the bank is declared the winner.

In summary, the SCM-PC Procurement Challenge differs from the baseline TAC SCM game in two significant ways: (i) manufacturer agents don't have to worry about customer bidding, and (ii) manufacturer agents are now required to manage risk across a combination of long-term and one-off contracts. This risk management is consistent with practices found in many actual supply chains [3].

2 Long-term Contracts

Quantity flexible contracts are used to distribute risk between supplier agents and manufacturer agents. The manufacturer agent commits to purchasing a minimum quantity from the supplier agent on a weekly basis for the duration of the game. The supplier agent in turn commits to delivering this minimum quantity at a set price. Each week, the manufacturer agent has the option of increasing its weekly order by up to a set percentage over the minimum quantity with the price per component remaining fixed.

Formally, an SCM-PC quantity flexible contract between a manufacturer agent and a supplier agent is defined by:

- A minimum weekly quantity, Q^{lts}_{min}, the manufacturer agent commits to purchasing.
- A maximum weekly quantity, Q^{lts}_{max}, of ordered components the manufacturer agent can procure at the same set price. $Q^{lts}_{max} = (1 + \alpha) * Q^{lts}_{min}$. α changes from one game to another and is announced at the start of each game (e.g. $\alpha \in [0.05, 0.30]$).
- A unit reservation price p_{res} such that, each week, independently of how much it actually orders, the manufacturer agent commits to paying the supplier agent $Q^{lts}_{max} * p_{res}$.
- An execution price p_{exec} that the manufacturer agent has to pay for each unit it actually purchases from the supplier agent.

In other words, given $Q^{lts}_{min} \leq q \leq Q^{lts}_{max}$, where q is the actual quantity ordered by the manufacturer agent in a given week, it will pay the supplier agent $Q^{lts}_{max} * p_{res} + q * p_{exec}$.

We also define $p_{res}/(p_{res} + p_{exec}) = \beta$, where β changes from one game to the next and is announced at the beginning of each game (e.g. $\beta \in [0.10, 0.20]$).

2.1 Negotiation Protocol for the Long-Term Contracts

On game start, the manufacturer agents have the option of negotiating quantity flexible contracts for each component. These contracts are awarded based on second price auctions run by the supplier agents. The negotiation protocol between manufacturer agents and supplier agents is as follows:

1. Each supplier agent first announces a reserve price, α and β for each of the components it sells.
2. Each manufacturer agent can submit a single quantity flexible bid for each of the components offered by the corresponding supplier agent. This bid is of the form: $< Q^{lts}_{max}, p_{exec} >$. Example:

Table 1: Quantity Flexible Bids

Manufacturer Agent	$\mathbf{Q^{lts}_{max}}$	$\mathbf{p_{exec}}$
1	1000	850
2	800	950
3	1200	870

3. The supplier agent allocates 100% of its weekly nominal capacity C^{nom}_{week} to the bidding manufacturer agents. Quantities are allocated based on requested Q^{lts}_{max} quantities, starting with the highest bidder. Each manufacturer agent's long-term contract has a price p_{exec} that is computed as the next highest price below its own bid ("second highest price" rule). The allocation proceeds until there are no bids left or until the supplier agent has run out of capacity

(based on its weekly nominal capacity). In the latter situation, the last manufacturer agent to receive a contract may end up with a Q^{lts}_{max} that is less than what it had requested.

Example:
In the above example, if we assume that $C^{nom}_{week} = 2695$ (and the supplier agent's reserve price is 800):

- Manufacturer agent 2 gets 800 units/week with $p_{exec} = 870$,
- Manufacturer agent 3 gets 1200 units/week with $p_{exec} = 850$,
- Manufacturer agent 1 gets only 695 units with $p_{exec} = 800$, namely the supplier agent's reserve price.

2.2 Supply Allocation Under Long-Term Contracts

After the long-term contract negotiation has been completed, the supplier adds a weekly "placeholder" order for each of its quantity flexible long-term contracts. The placeholder order for each contract has requested quantity equal to the maximum that the supplier may be asked to supply for that contract, Q^{lts}_{max}. At the beginning of each week, the manufacturer agents decide what fraction of the quantity flexible long-term contracts to actually request for that week, and the placeholder orders are updated to reflect this information. On any given day, the suppliers compute the capacity that they have available for one-off contract negotiation based on the capacity that they have remaining after scheduling enough capacity to fill all of the "placeholder" orders and all previously committed one-off orders (this is the same as the process described in Section 4.4 of baseline scenario specification [2]).

In times when a supplier is "under capacity" (i.e., when the supplier's actual capacity is smaller than what it has previously committed), the supplier may be unable to complete some of its orders by their due dates. Missed orders are queued for delivery on the next possible date, however *priority is given to the long-term orders* and then the most overdue orders from one-off contracts.

3 Customer Demand, Production and Delivery

In SCM-PC the customer demand awarded to each agent, production of products and delivery are all performed by the server in the following way. On each day, manufacturer agents receive the exact same set of orders from customers representing $1/n$ of the total demand that day (where n is the number of manufacturers in the game).

On each day, d, the server attempts to produce and deliver orders with due date d in a greedy fashion (giving priority to orders with higher revenue). When an order reaches the top of the queue the server checks whether or not each agent has enough components to produce it. Those agents with enough components exchange them for the revenue associated with the order. Agents without enough components miss the opportunity to fill the order, but are *not charged a penalty* for missing the order. Unlike the baseline game, orders cannot be filled after their due date.

4 Implementation Details

This section provides the pseudocode for the following agent types in the SCM-PC (the one-off contract negotiation, production and delivery of supply orders is described in [2]):

- Customers
- Supplier Agent (Only the long-term contract negotiation)

4.1 Pseudocode for the Long-Term Contract Negotiation on Game Start - *Day -1* (for each component type)

1. Select a reserve price ρ, where ρ is a random variable chosen from a uniform distribution on the interval $[\rho_{min}, \rho_{max}]$.
2. Select the quantity flexible parameter α, where α is a random variable chosen from a uniform distribution on the interval $[\alpha_{min}, \alpha_{max}]$.
3. Select the parameter β (used for computing the reservation price), where β is a random variable chosen from a uniform distribution on the interval $[\beta_{min}, \beta_{max}]$.
4. Send ρ, α and β to each manufacturer agent.
5. Wait for bids (the supplier agent waits for t_0 seconds).
6. The set of bids (where each bid is of the form: $< Q^{lts}_{max}, p_{exec} >$) is sorted by p_{exec} in decreasing order.

   Supplier agent will not consider bids with a $Q^{lts}_{max} \leq 0$ or a $p_{exec} < \rho$.
7. Each of the specific long-term contract parameters are calculated as follows:

   (a) The supplier agent has an available capacity *acap* to offer to the manufacturer agents:
   $acap = C^{nom}_{week}$ (where $C^{nom}_{week} = 5 * C^{nom}$, and C^{nom} is the same nominal capacity of the baseline game [2]).

   N.B.: The nominal capacity of each supplier assembly line has changed (see table 3 in Section 5).

   (b) For each bid $< Q^{lts}_{max}, p_{exec} >$ in the sorted set (step 6), and starting with the highest bid:

   i. The unit reservation price p_{exec} is allocated based on the next highest price in the sorted set.

   N.B.: the value is equal to the reserve price when it is the lowest bid in the set.

   ii. The maximum weekly quantity is allocated based on requested Q^{lts}_{max}, but this value must not exceed the available capacity *acap*:

   if $Q^{lts}_{max} < acap$ then
   $acap = acap - Q^{lts}_{max}$
   (N.B.: Q^{lts}_{max} remains the same value as requested!)
   else

$Q^{lts}_{max} = acap$
$acap = 0$

iii. The minimum weekly quantity Q^{lts}_{min} is calculated based on Q^{lts}_{max}:
$Q^{lts}_{min} = Q^{lts}_{max}/(1 + \alpha)$.

iv. The unit reservation price p_{res} is calculated based on p_{exec}:
$p_{res} = \beta * p_{exec}/(1 - \beta)$.

8. Send contract details to each manufacturer agent $< Q^{lts}_{min}, Q^{lts}_{max}, p_{exec}, p_{res} >$.

9. Add a weekly "place-holder" order for each of the supplier's long-term contracts with requested quantity equal to the maximum that the supplier may be asked to supply for that contract, Q^{lts}_{max}.

4.2 Pseudocode for the Supplier Agent - Processing Long-Term Contract Orders on First Day - *Day 0* (for each component type)

1. Wait for orders.

2. An initial inventory level I_{init} is randomly drawn from a uniform distribution on the interval $[I_{min}, I_{max}]$.

3. Deliver the components ordered:

   (a) Each manufacturer agent with a long-term supply contract has to order a quantity q_i of components (where $Q^{lts}_{min} \leq q_i \leq Qmax$). If q_i is outside this range, it is clamped into the range.

   (b) The supplier agent delivers the components based on its inventory levels:

   if $\sum q_i \leq I_{init}$ then
   Deliver q_i components to each manufacturer agent by the beginning of day 2.
   Receive payment from manufacturer agent (update manufacturer agent's bank account).
   (N.B.: $payment = Q^{lts}_{max} * p_{res} + q_i * p_{exec}$).
   else
   Compute ratio: $R = \sum q_i / I_{init}$.
   Deliver $R * q_i$ components to each manufacturer agent by the beginning of day 2.
   Receive payment from manufacturer agent (update manufacturer agent's bank account).
   (N.B.: $payment = Q^{lts}_{max} * p_{res} + R * q_i * p_{exec}$).

4.3 Pseudocode for the Supplier Agent - Processing Long-Term Contract Orders after First Day - *Day* $>$ *0* (for each component type)

1. Receive orders from manufacturer agents

   (a) Each manufacturer agent with a long-term supply contract can place an order for q_i components (where $Q^{lts}_{min} \leq q_i \leq Q^{lts}_{max}$). If q_i is outside this range, it is clamped into the range.

(b) Previous orders will be replaced by new arrivals.

2. If current day ($cday$) is the second day of the week ($cday = n * 5 + 2$, where $n \in \{0, 1, 2, \ldots\}$) then:

   (a) Process orders from the manufacturer agents.
   Every placeholder order that is due on $cday + 5$ is changed from Q^{lts}_{max} to q_i.

   N.B.: The production and delivery of orders is described in [2].

4.4 Pseudocode for the Customers

Customers are classified into three segments (same as the baseline game [2]). These steps represent the daily activities of each customer segment:

1. The number of orders N is calculated (same as the baseline game [2], Section 5.1).

   N.B. 1: Customer demand is expressed as orders, and not the RFQs of the baseline game.

   N.B. 2: The average number of customer orders in the high, mid and low range markets has changed (see table 3 in Section 5).

2. Each manufacturer agent receives the exact same $\lceil N/n \rceil$ orders, where N is the customer demand and n is the number of manufacturer agents.

   (a) Each order consists of:

   i. A product type that is randomly selected from the available types (see Bill of Materials in Table 5 - Baseline game [2]).

   ii. A price p_c per unit, where p_c is calculated as follows:

   - $avgprice_c = \frac{N - N_{min}}{N_{max} - N_{min}}.(P_{max} - P_{min}) + P_{min}$
     N_{max} - the maximum value of the customer demand.
     N_{min} - the minimum value of the customer demand.
     P_{min} - the minimum price of a PC.
     P_{max} - the maximum price of a PC.
   - The price p_c selected from a uniform distribution on the interval $[avgprice_c - p_{min}, avgprice_c + p_{max}]$.
     (N.B.: If p_c is outside the range ($P_{min} \leq p_c \leq P_{max}$), it is clamped into the range)

   iii. A lead time lt , where lt is a random variable chosen from a uniform distribution on the interval $[lt_{min}, lt_{max}]$.

   N.B.: For the SCM-PC 2008 competition, the last day of the game is day 99, the total number of days being 100. The last due date (due date = curent date + lead time) for the orders is day 98. This gives the customer agent one day (day 99) to issue the last payments and cancel the missed orders. The lead times are randomly selected from a uniform distribution (as above). However, every due date that is greater than 98 is truncated to 98. This keeps the customer demand at the same level during the last days of the game. Remember that agents are not penalized for late deliveries.

iv. A quantity q_c, where q_c is a random variable chosen from a uniform distribution on the interval $[q_{min}, q_{max}]$.

3. Send the same $\lceil N/n \rceil$ orders to each manufacturer agent.

4. All orders with due dates smaller than the current day are processed as follows (a greedy procedure is used to schedule the orders):

   if manufacturer agent has enough inventory (components) and capacity to fulfill

   the entire customer order then:

   - The manufacturer agent's inventory is used to schedule this order for production and the order will be delivered on the following day.
   - Payment is made on the due date to the manufacturer agent's bank account (update manufacturer agent's bank account).

5 Parameters used in the game

Table 2: Parameters used in the SCM-PC Game

Parameter	Symbol	Standard Game Setting
Length of game	E	100 days
Response time (real) for manufacturer agents in the negotiation process of the long-term contracts	t_0	10 seconds
Real time for each day	t_{day}	10 seconds
Initial supplier agent inventory (per component)	$[I_{min}, I_{max}]$	75% - 125% of the nominal capacity (per week)
The supplier agent reserve price	$[\rho_{min}, \rho_{max}]$	50% - 75% of nominal price of component
The amount of flexibility given to the quantities in the orders	$[\alpha_{min}, \alpha_{max}]$	[0.05, 0.30]
The parameter for computing the reservation price	$[\beta_{min}, \beta_{max}]$	[0.10, 0.20]
The noise added to the average price of a PC	p_{min}, p_{max}	90% - 110% of the average price of the PC
Average number of customer orders in the High and Low range markets	$[Q_{min}, Q_{max}]$	12 – 50 per day
Average number of customer orders in the Mid range market	$[Q_{min}, Q_{max}]$	15 – 60 per day
Range of quantities for individual customer order	$[q_{min}, q_{max}]$	[1,20]
Range of lead time (due date) for individual customer orders	$[lt_{min}, lt_{max}]$	3 to 12 days from the day the order is received
Minimum price of a PC	P_{min}	75% of nominal price of components
Maximum price of a PC	P_{max}	125% of nominal price of components
Daily reduction in supplier (one-off contract) available capacity for long-term commitments	z	1.0%

N.B.: All parameters of the baseline game [2] that are not listed in this table (e.g. parameters of the one-off contract suppliers) are assumed to have the same value.

6 Additional Support Materials

Additional support for entering the Procurement Challenge is available on the web [5]. This includes:

- Downloadable code to run the Procurement Challenge Server
- Downloadable agentware to help teams build an agent for the challenge
- a User's Guide with detailed instructions for running the server and building an agent

In addition, the reader is referred to the specification of the baseline game for details on the one-off contract negotiation model [2].

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