The 2007 Supply Chain Trading Agent Competition - Procurement Challenge

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April 2007
CMU-ISRI-07-106

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Abstract

This document contains the specifications of the 2007 Supply Chain Trading Agent Competition – **Procurement Challenge** (**SCM-PC-07**). 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 short-term, spot-market procurement orders. As such, the SCM-PC-07 Challenge complements the current "baseline" TAC-SCM scenario by extending the space of procurement options available to supply chain trading agents.

This work has been supported by the National Science Foundation under ITR Grant 0205435 as well as by a grant from SAP Research. The e-Supply Chain Management Laboratory would like to thank members of the TAC-SCM research community and the TAC-SCM advisory board for many insightful comments and would also like to acknowledge the help provided by the Swedish Institute of Computer Science.

Keywords: Autonomous Agent, Electronic Commerce, Trading Agent

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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. 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. 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).
- Short-term contracts. These are the same one-off contracts negotiated on a daily basis as 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 10 different supplier agents (the challenge is adding two new CPU supplier agents to the baseline scenario). 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 short term contracts. This risk management is consistent with practices found in many actual supply chains, where long-term contracts are complemented by spot market procurement [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_{min}^{lts}, the manufacturer agent commits to purchasing.
- A maximum weekly quantity, Q_{max}^{lts}, of ordered components the manufacturer agent can procure at the same set price. $Q_{max}^{lts} = (1 + \alpha) * Q_{min}^{lts}$. 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 $Q_{max}^{lts} * p_{res}$.
- 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 $Q_{min}^{lts} \leq q \leq Q_{max}^{lts}$, where q is the actual quantity ordered by the manufacturer agent in a given week, it will pay the supplier agent $Q_{max}^{lts} * p_{res} + q * p_{exec}$.

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

To ensure that each game presents manufacturer agents with a mix of long-term and short-term contract options, we assume that each component is available from two different supplier agents: one that only offers long-term contracts and one that only sells in the spot market.

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 long-term supplier agents. The negotiation protocol between manufacturer agents and long-term supplier agents is as follows:

1. Each long-term 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 long-term supplier agent. This bid is of the form: $< Q_{max}^{lts}, p_{exec} >$.
   Example:

   Table 1: Quantity Flexible Bids

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

3. The long-term contract supplier agent allocates 100% of its weekly nominal capacity C_{week}^{nom} to the bidding manufacturer agents. Quantities are allocated based on requested Q_{max}^{lts} 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 long-term 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

At the beginning of any given week, each manufacturer agent decides how much to actually order under its long-term contracts.

- If the total quantity of a given component requested by the manufacturer agents is less than the quantity the long-term supplier agent has available, all manufacturer agents get the full quantities they requested.
- If the total quantity requested by the manufacturer agents exceeds the quantity available, the long-term supplier agent computes the ratio R of demand it can satisfy based on its actual capacity. Each manufacturer agent receives a quantity $q' = R * q$ (where q is the actual demand requested by a manufacturer agent for the given week). In other words, all manufacturer agents with long-term contracts are treated equally and receive the same fraction of their actual demand that week.

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 Products and Components

The products to be manufactured are the same personal computers (PCs) as the baseline game (see table 5 in [2] - Bill of Materials). Table 2 presents the component catalog with information about each component, their base price and the supplier that produce them.

Table 2: Component Catalog

Component	**Base price**	**Supplier**	**Description**
100	1000	Pintel(S), LPintel(L)	Pintel CPU, 2.0 GHz
101	1500	Pintel(S), LPintel(L)	Pintel CPU, 5.0 GHz
110	1000	IMD(S),LIMD(L)	IMD CPU, 2.0 GHz
111	1500	IMD(S),LIMD(L)	IMD CPU, 5.0 GHz
200	250	Basus(S), Macrostar(L)	Pintel motherboard
210	250	Basus(S), Macrostar(L)	IMD motherboard
300	100	MEC(S), Queenmax(L)	Memory, 1 GB
301	200	MEC(S), Queenmax (L)	Memory, 2 GB
400	300	Watergate(S), Mintor(L)	Hard disk, 300 GB
401	400	Watergate(S), Mintor(L)	Hard disk, 500 GB

(S) - The supplier only offers short-term supply contracts
(L) - The supplier only offers long-term supply contracts

5 Implementation Details

This section provides the pseudocode for all the agent types in the SCM-PC (except the manufacturer agents and short-term contract supplier agents - the latter is described in [2]):

- Customers
- Long-Term Contract Supplier Agent

5.1 Pseudocode for the Long-Term Contract Supplier Agent 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 $< Q^{lts}_{min}, Q^{lts}_{max}, p_{exec}, p_{res} >$.

5.2 Pseudocode for the Long-Term Contract Supplier Agent 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.: $payment = Q^{lts}_{max} * p_{res} + R * q_i * p_{exec}$).

5.3 Pseudocode for the Long-Term Contract Supplier Agent 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.

   All orders are scheduled for delivery on day $cday + 5$. This gives the supplier agent a week to fulfill the orders.

   (b) Add the quantities of all orders received.

   $Q = \sum q_i$.

3. Calculate the daily production capacity C_d^{ac} (the same way as the baseline game [2] - section 4.3, formula 3).

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

4. Produce components and add them to inventory (NB: Inventory level is I and quantity ordered by all manufacturer agents is Q):

   if $C_d^{ac} \leq Q$ then

   $I = I + C_d^{ac}$

   $Q = Q - C_d^{ac}$

   else

   $I = I + Q$

   $Q = 0$

5. If current day ($cday$) is the first day of the week ($cday = n * 5 + 1$, where $n \in \{1, 2, 3, \ldots\}$) then deliver components:

   (a) The supplier agent has an inventory level I.

   (b) Each manufacturer agent placed an order on day $cday - 4$ with a quantity q_i (where $Q_{min}^{lts} \leq q_i \leq Q_{max}^{lts}$).

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

   if $\sum q_i \leq I$ then

   Deliver q_i components to each manufacturer agent by the beginning of the next day.

   Receive payment from manufacturer agent (update manufacturer agent's bank account).

   (N.B.: $payment = Q_{max}^{lts} * p_{res} + q_i * p_{exec}$)

   else

   Compute ratio: $R = \sum q_i / I_{init}$.

   Deliver $R * q_i$ components to each manufacturer agent by the beginning of the next day.

   Receive payment from manufacturer agent (update manufacturer agent's bank account).

   (N.B.: $payment = Q_{max}^{lts} * p_{res} + R * q_i * p_{exec}$)

5.4 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 $[lt_{min}, lt_{max}]$.

      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).

6 Parameters used in the game

Table 3: 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
Nominal Capacity of supplier agent assembly lines (CPUs)	C^{nom}	137 components / day
Nominal Capacity of supplier agent assembly lines (motherboards, memories and hard drives)	C^{nom}	275 components / day
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 (short-term 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 short-term contract suppliers) are assumed to have the same value.

7 Additional Support Materials

Additional support for entering the Procurement Challenge is available on the web [4]. 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 short-term, sport-market supplier model [2].

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